



## The Implementation of Enterprise Resource Planning Systems for Roads and Infrastructure Construction Companies in Developing Countries

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### Abstract

Construction Enterprise Resource Planning (CERP) systems started to infiltrate the construction world after ERPs became crucial in modern enterprises. In simple terms, CERP integrate and keep track of the various processes within construction companies. As a minimum, these possess include management of general contractors, subcontractors, financial work, accounting, payroll, logistics, workflow processes ... data related to different processes are stored within one unique database. Despite this intuitive objective, developing and standardizing CERP systems to fit the needs of all construction companies is not a straightforward course. This research focuses on the development of a framework that integrates the minimum required modules to be included within a CERP, specifically for road and infrastructure construction companies. This objective is achieved based on literature review on CERP despite its shortage, in-depth interviews with construction professionals requiring CERP, and the results of a structured questionnaire filled by CERP users and developers. The developed framework identifies the procurement module linked to the on-site deliveries as the first stone that should be developed and implemented. Then, budgeting and work progress modules must be added. After that, timesheet and equipment follow-up modules need to be implemented. Limitations encountered highlighted the main considerations to be considered in future work such as the cost, the company's size, development and implementation period, and type of work.

**Keywords:** CERP; ERP systems; ERP modules; ERP framework

### 1 Introduction

The origins of Enterprise Resource Planning (ERP) systems go back to the mid-20<sup>th</sup> century when the industrial sector used the Material Requirements Planning (MRP) system to plan and help in the decision-making of the production process. ERP systems included different integrated modules to help to manage and integrate the full business process. An important feature of the modules is that the data entered in one module is automatically routed to the other modules. So, all data are immediately updated and available to all functional areas (Stevens, 2018). The advantage of an ERP system is its capacity to provide financing, manufacturing, supply chain management, purchasing, selling, and planning in one single system (CFI Education Inc, 2021). These systems succeeded in the industry. Statistics show that the ERP software market around the world is more than \$25 billion with a growth rate of 10% to 20% per year (Roul, 2021).

One major sector of the industry is construction where the challenges and complexities are unique. The execution of any construction engineering project passes by several stages. The larger the scale of the project is, the more complicated and interrelated the processes become, and the more critical management is required. Completing the scope construction projects on time and within budget remains the foremost challenge all over the world, specifically in developing countries. Lack of proper planning, collaboration, execution, and monitoring are identified as main reasons for not achieving these targets. Hence, the incorporation of the ERP systems within the construction field is increasingly recognized as the solution to these challenges with the main objective of avoiding failure of project completion in terms of quality, cost, and time. Findings show that Construction Enterprise Resource Planning (CERP) systems are a must but at the same time their proper implementation is very crucial. Several companies tried to implement CERP systems, however; varying success rates resulted after the implementation of CERP. The absence of standardized work in the construction field as well as the large cost of CERP can lead to improper implementation strategy of CERP. Moreover, the pandemic worldwide increased the need to prioritize the implementation of a system that reduces the contact between the engineers and decreases the papers transmittals while encouraging real-time follow-up remotely.

## **2 Objective and Methods**

CERP system might include all the following modules: budgeting, cost control, procurement management, work progress management, revenues, inventory management, site operation, estimating and tendering, subcontractor management, asset management, document control, planning and scheduling, logistics, etc. Which modules to implement in your CERP depends on several strategic aspects: How can the CERP improve the business performance? How long will the CERP implementation project take? How will the CERP affect current business processes? What is the CERP total cost and what are the hidden costs of the CERP ownership (Stevens, 2018)? Other operational aspects include the size of the company, the number of employees, the type of construction, the operational need of the modules, the legislation in the country, the education and technical level of the users, and most importantly, the phases of implementation and deployment.

While being in the transition phase from an old system to a newer ERP, deep-rooted practices will remain an obstacle for most of the users until they get used to and accept the change. Hence, implementing the system in different phases is very critical while the choice of the correct modules to be implemented in each phase is also another predicament. During transitioning, the efficiency of the work that is being achieved cannot decrease, the mistakes should be minimized, the construction will continue, and the loss of data is not accepted. Thus, following a good strategy in the deployment of the correct modules at the correct time is a matter to be well-studied and investigated.

The objective of this paper is to present a developed framework for elaborating on the minimum required modules for road and infrastructure construction companies that can be adopted to reach a successful CERP transition and implementation.

The framework is established based on the results of three approaches: a review of the existing literature and existing CERP systems, structured questionnaire, and in-depth interviews with potential CERP clients. The questionnaire respondents and the interviewees are practitioners working and using CERP systems or professionals that participated in developing the system. Moreover, technical observation by the author is conducted through being part of a CERP development team and implementation team.

### 3 Background and Literature Review

In the last century, in their effort to organize and optimize their work, manufacturing industries based their production on systems known as the Material Requirement Planning (MRP). It was built to organize the storage and allocation of production materials. Then, this system was expanded to include the allocation of production equipment and labor, which represents the manufacturing process. This evolution turned the system to be called Manufacturing Resource Planning or *MRPII*. As MRP II evolved, the addition of several modules such as purchasing, financials, human resources, and other front-office applications improved the management of different operations and led to the creation of Enterprise Resource Planning (ERP) systems (Jingsheng Shi & Halpin, 2003). The ERP systems provide a platform for different departments in an industry to share data and communicate through a fast process. Additionally, the information is stored under a common database (Vlachopoulou & Manthou, 2006). The main idea of ERP systems is to create a standard and synchronized base of information to improve the efficiency of the company (Chung, Skibniewski, Lucas Jr. & Kwak, 2008). Similarly, construction industries are searching for several solutions to improve their scheduling and planning and reduce their cost. Jingsheng Shi & Halpin (2003) and Nitithamyong & Skibniewski (2004) agreed that in opposition to the standard system within typical industries, construction firms are so diverse and differ in strategies applied. The main specificities in construction is recognized in the literature as varying durations, required resources, as well as the lack of the necessary technical staff and technical knowledge (Windapo, 2013). Moreover, remaining a strong competitor in the market demands continuity, technological innovations and sustainable solutions (Al Marri, 2014), along with the proper management of resources (Sutar, Kashid & Deshmukh, 2016) and integration of operation flows using information technology (Estébanez, Trigo & Belfo, 2016).

Several large ERP vendors can be named such as SAP, Oracle, PeopleSoft, JD Edwards, Microsoft Dynamics, Infor ERP, etc. However, these packages were mainly designed for manufacturing industries, hence; they were not able to succeed within the construction field (Tatari, Castro-Lacouture & Skibniewski, 2008). Furthermore, Shi and Halpin (2003) acknowledge that construction companies require specific functions: scheduling, planning, procurement, project-oriented, open, expandable, remotely accessible, etc. As a result, some ERP suppliers' companies developed construction ERP systems (Tatari, Castro-Lacouture & Skibniewski, 2008).

Hewavitharana and Perera (2019) established a logical framework that combines the organizational processes and ERP processes for construction companies, after studying the gap between construction and ERP procedures. The largest gap belongs to inventory management while the lowest belongs to sub-contractors' management. The major reasons leading to the largest gap are the variety of item codes, the incorrect process of purchasing procedures, unplanned payment methods, and the absence of a re-order level.

One of the most important features to take into consideration is to customize the ERP system, however; higher cost and longer time might be required to reach the implementation stage of the system (Mirian & Osvaldo, 2012). Furthermore, higher success rates are seen when the implementation of ERP modules is deployed in sequences not as a full bulk at a time (Hallikainen, Kivijärvi & Tuominen, 2009). Thus, Hadidi et al. (2016) suggested a decision model for ERP modules implementation in Saudi Arabia that helps in choosing the best sequence for ERP modules in construction firms. The results show that the highest CERP benefits are decision-making criteria and then improved efficiency, better information quality, cost reduction, improved flexibility, and user

satisfaction, respectively. The top three modules to be implemented at the first stage are ordered as follows: inventory control and logistics, procurement, project finance, and accounting. In addition to the results concluded by the literature stating the gaps among different modules (Hewavitharana & Perera, 2019) and the importance of implanting the ERP system in different stages (Hadidi, Assaf & Alkhiami, 2016), it is stated by the latter that the first three modules to be implemented in construction companies are inventory management, procurement, and accounting modules.

## 4 Results

### 4.1 Questionnaire's results

A structure questionnaire was created online using google forms and distributed to professionals working either as ERP users, developed, implementer, or manager. The first part of the questionnaire collected general information about the respondent and the company. The questionnaire was answered by 50 respondents where 29 out of them have used ERP systems during their career. The outcome identifying whether the ERP system utilized is customized or not is respectively 75.9% and 3.4%, while 20.7% of the respondents don't know. The departments where the respondents have worked are transportation and infrastructure engineering – contracting, cost control and planning, accounting, project control, operations, IT, estimation, and procurement department. The respondents' years of experience varied between 2 and 17 years and most of them are civil engineers. Currently 97% of the respondents are working. The average age is 29 years old and the different regions where the respondents have worked are Saudi Arabia, Egypt, Sultanate of Oman, UAE, Lebanon, Jordan, Nigeria, Congo, Ivory Coast, Europe, and Africa.

The second part of the questionnaire inquired about the CERP modules that the users have used along with the earliest year they have worked on the module. The highest percentage belongs to work progress module (96.55%) while the lowest to the tendering module (51.72%). The earliest module utilized was the procurement module in year 2005, followed by planning and scheduling, and document control modules in 2006 and 2007, respectively (**Table 1**). The user activity varied among different modules, however; the modules that are used the most, are based on the questionnaire results, respectively, work progress module (96.55 %), budgeting, site operations, and inventory management modules (82.76%), procurement and document control modules (75.86%), accounting module (68.97%), planning and scheduling module (58.62%), and tendering module (51.72%).

**Table 1:** Usage of Each Module

Module	%	Earliest Year
Work Progress	96.55	2008
Budgeting	82.76	2008
Inventory Management	82.76	2010
Site operations	82.76	2008
Procurement	75.86	2005
Document Control	75.86	2007
Accounting	68.97	2010
Planning and scheduling	58.62	2006
Tendering	51.72	2010

## 4.2 Summary of the Main Results from the in-Depth Interviews

Six in-depth interviews were conducted with construction professionals who are considering the adoption of CERP. The discussions tackled their experience, opinion, and goals from using the CERP. These interviewees were construction companies' owners/managers who are working in developing countries in specific Lebanon, Egypt, Morocco, Ivory Coast, Togo and Benin. The construction companies range between small to large and some specialized in buildings while others were involved in roads and infrastructure projects. Also, among these companies, two companies had limited implementation of CERP. Based on the discussions, first-time adopters are mainly interested in procurement and on-site deliveries. Timesheets and workforce monitoring comes next, inventory/stock management as well as equipment tracking, and logistics are identified as next modules by companies that have a limited CERP in place. Linking to budgeting and cost control/accounting was acknowledged by all interviewees with varying opinions on when to be implemented. The transitioning from established processes and systems—especially accounting—to a new system surfaced as the main concern. All interviewees agreed on the need for real-time data collection and tracking ultimately.

### 5 CERP Proposed Framework

After synthesizing the information collected from the three approaches while taking into consideration the differences among construction company's types, a framework suggesting the minimum required module adapted for roads and infrastructure engineering companies is presented below along with the order of integration of these systems. Figure 1 presented the suggested framework divided in three phases. The first phase includes the module for procurement and on-site deliveries. The second phase includes budgeting module and work progress module and the third phase includes the workforce timesheet module and equipment module.

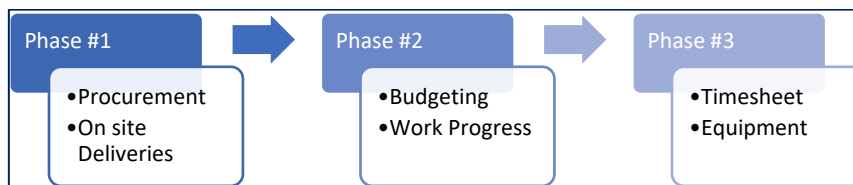
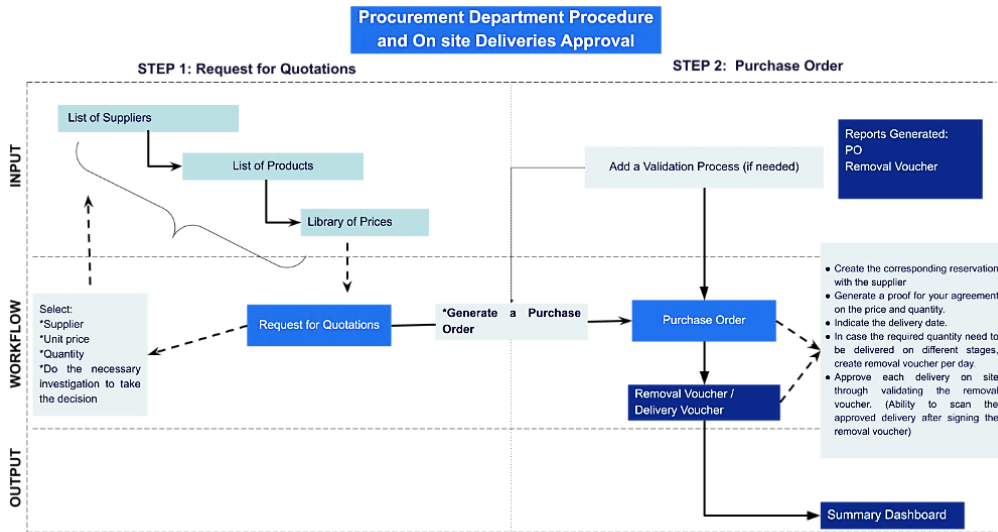


Fig. 1: Suggested Framework

### 5.1 Procurement and on-site Delivery Modules

One of the major activities in managing projects is procuring of resources. To this end, project managers send their requests of resources to the procurement department where a request for quotation and purchase orders are processed. The procurement manager searches for the required material to be purchased for all the company's projects while aiming to get the best offer and reach the most cost-effective and appropriate product. The more this task is properly handled, the more the project becomes cost-effective and profitable. The job does not end at the level of the orders, however; the procurement management team must ensure that the deliveries are achieved on time and within the specifications listed. The procurement department should be aware of the deadlines and lead times and ensure that the purchases will not delay any work. In the construction field, most of the time, the purchase orders are done from the offices while the deliveries are on-site. Two-way communication must be achieved within the two teams (on-site and procurement department) to make sure that the order has reached the site with the requested quantities and quality.



**Fig. 2:** Procurement and Delivery Module

Three main pillars contribute to this process:

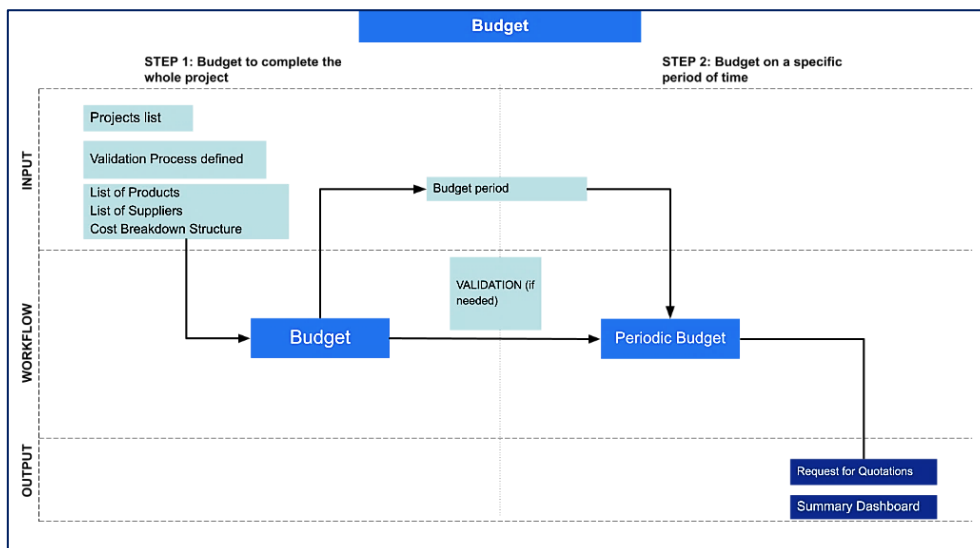
1. The project’s planning and required material.
2. The history of similar material previously purchased.
3. The on-site deliveries.

Figure 2 illustrates the suggested module for procurement procedures and on-site deliveries different where required input, workflow, and output are divided into two steps: request for quotations and purchase order processing.

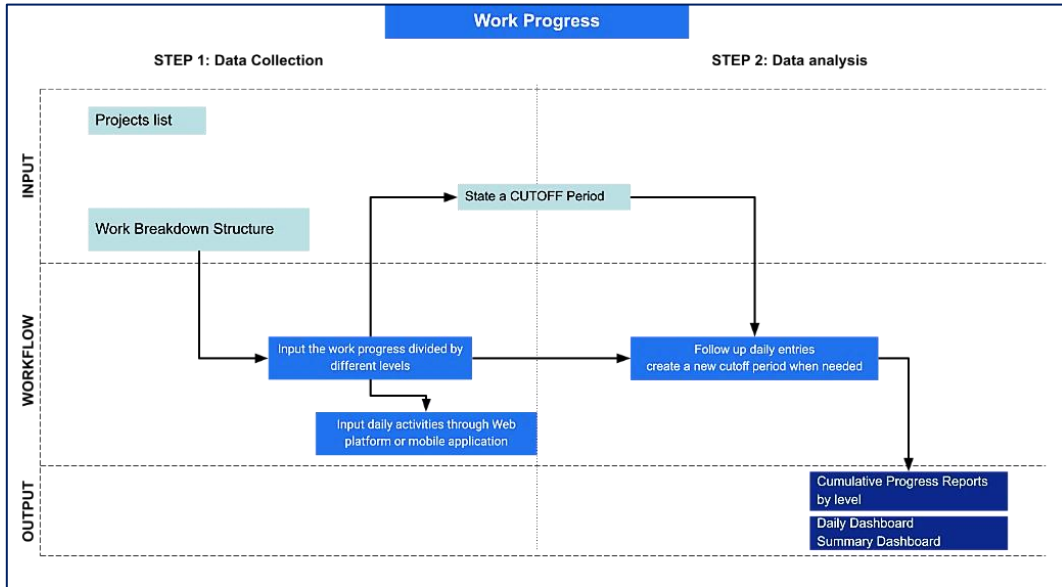
## 5.2 Budgeting and Work Progress Modules

Comparing the projected and actual progress is very critical to measure some key performance indicators such as schedule performance indicator and cost performance indicator. A suitable budget makes it feasible to get a good cost estimation of the project. Also, a list of priority results for each project leads to better decision-making and more effective project management. Collecting regular data from the site helps measure the progress more accurately and allows the project manager to detect whether the project is behind schedule or not.

**Figure 3** and **Figure 4** show respectively a plan for the budget and work progress modules.



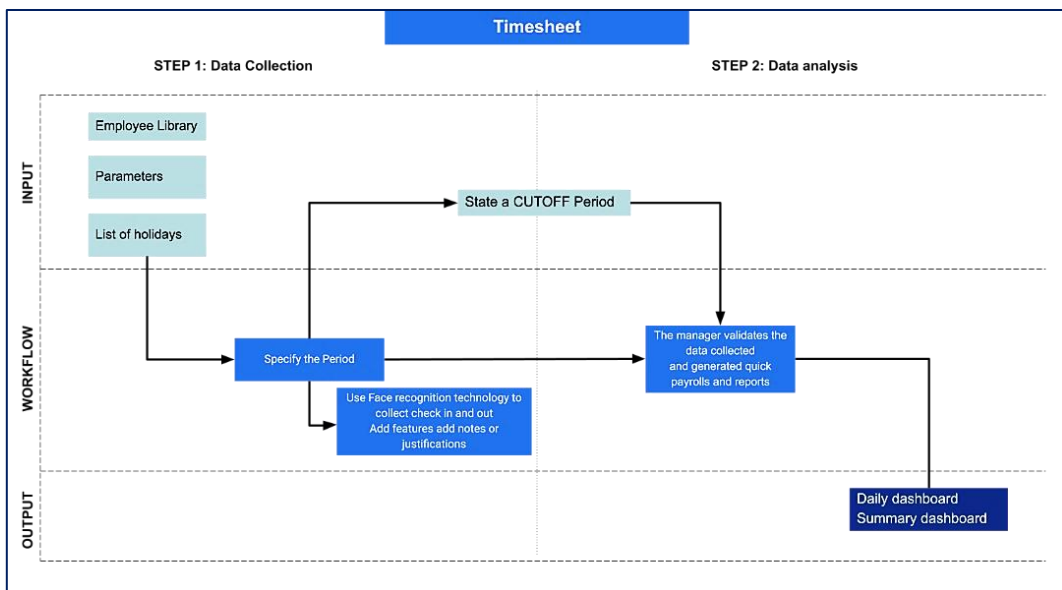
**Fig. 3:** Budget Module



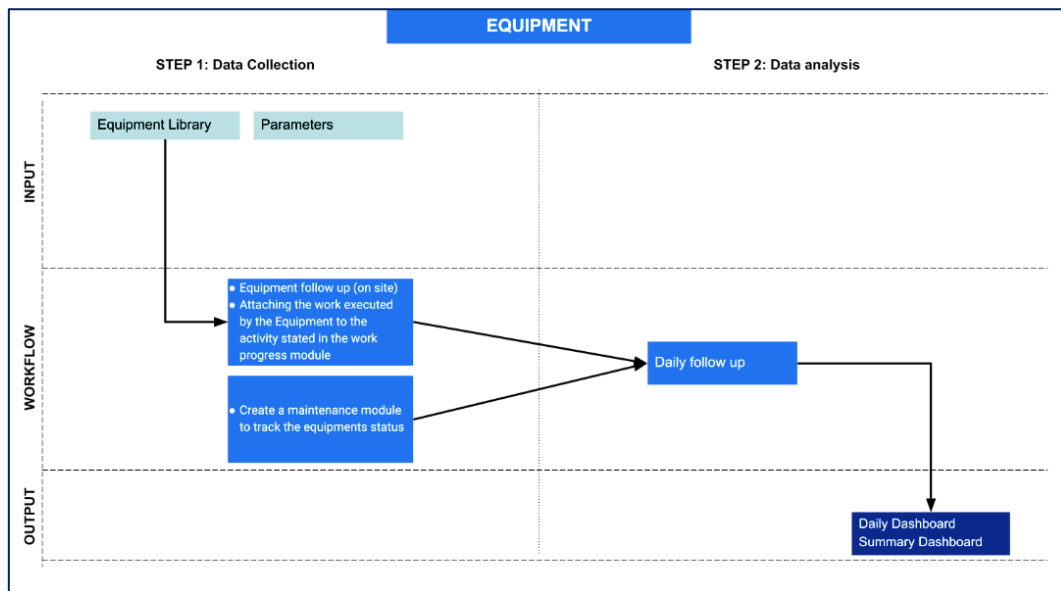
**Fig. 4: Work Progress Module**

### 5.3 Site Operations: Workforce Time sheet and Equipment Tracking Modules

Recording the workforce on-site on large-scale projects need to be well monitored to minimize any extra costs due to personnel mismanagement. It also helps track the lack of personnel in specific areas. Most importantly this work will be achieved in real-time. Moreover, due to improper equipment assignment among several projects, an operation on-site might be delayed or stopped due to a lack of equipment. Hence, it is very important to track all the equipment and make sure this equipment will reach the site on time. Also, collecting the working hours or working kilometres for each piece of equipment is needed to ensure project-based and activity-based costing. Figure 5 and Figure 6 present Workforce Timesheet modules and equipment tracking modules, respectively.



**Fig. 5: Timesheet Module**



**Fig. 6:** Equipment Tracking Module

## 6 Conclusions

To conclude, this research is imperative for the modern management of construction companies successfully where this remains a challenge particularly in developing countries. Moreover, optimizing the resource allocation, cost, and time are the key elements of a good strategy design, but having the necessary tools to manage these resources across different departments and functions will guide any project to success. Hence, the role of CERP systems arises and the need for specific phased modules to be implemented will be in demand. Choosing the best framework to adopt and to prepare your company for the obstacles that might be faced will facilitate the integration of these systems. The outcome of this research presents a framework composed of three main phases including the following modules: procurement, delivery, budget, work progress, timesheet, and equipment. These results are observed from in-depth interviews with experts in the field, a survey distributed among users, and technical observations. However, further consideration might be taken in terms of cost, implementation time, size of the company, and the type of work achieved by the company.

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