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# BENCHMARKING THE STATE-OF-THE-ART INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) INFRASTRUCTURE SUPPORTING MANAGEMENT OF MAJOR-SIZED ENGINEERING AND CONSTRUCTION PROJECTS

*Engineering and construction projects, also called EPC projects, formed a pioneering application area of project management, and are characterized by such features as absolutely larger financial sizes of the projects under investment; high complexity and global nature of operations; required high accuracy of contractual delivery on time and budget demanded by the maturity of the industry; and high dependency on robust information and communication technology (ICT) on a global scale. An ICT platform for a company dedicated to operating in the EPC projects requires a unique combination of tailor-made, robust ICT systems and industry de-facto project management software, and must support both, project planning and execution, and project controls and management. This paper benchmarks characteristics and the typical structure of a the project-related ICT platform of Japan's super engineering and construction company in which 2 authors have working experience of 40+ years.*

***Keywords: Benchmarking, ICT, engineering and construction projects, infrastructure***

*Інжинірингові й будівельні проекти, які часто називаються EPC-проекти, сформували новаторський стиль застосування управління проектами, який характеризується такими особливостями, як: великі обсяги фінансування проектів у рамках інвестиційної діяльності; висока складність і глобальний характер операцій; висока точність поставок за договорами в часі і в межах бюджету, висока технологічна зрілість галузі; висока залежність від надійної інформаційно-комунікаційної технології (ІКТ) в глобальному масштабі. Визначено орієнтири характеристик і типову структуру проектів, пов'язаних з ІКТ в платформі супер інженерно-будівельної компанії Японії.*

***Ключові слова: Бенчмаркінг, ІКТ, інжиніринг, будівництво, інфраструктура***

*Инжиниринговые и строительные проекты, которые часто называются EPC-проекты, сформировали новаторский стиль применения управления проектами, и характеризуются такими особенностями, как: большие объемы финансирования проектов в рамках инвестиционной деятельности; высокая сложность и глобальный характер операций; высокая точность поставок по договорам во времени и в рамках бюджета, высокая технологическая зрелость отрасли; высокая зависимость от надежной информационно-коммуникационной технологии (ИКТ) в глобальном масштабе. Определены ориентиры характеристик и типичная структура проекта, связанные с ИКТ в платформе супер инженерно-строительной компании Японии.*

***Ключевые слова: Бенчмаркинг, ИКТ, инжиниринг, строительство, інфраструктура***

 

## Characteristics of Engineering and Construction Projects

An engineering and construction project, also called almost alternatively a “capital project”, the objective of this paper, is a project to conceive, plan, design, and deliver – through translation of its design into materials procurement and physical construction, production, processing, storage and distribution plants and facilities. The industry branches that host capital projects are typically the “process industry” such as oil and gas, chemical and petrochemical, power generation, and manufacturing industries pertaining to the owner companies, and the “engineering and construction” industry in which contactor companies are main players and a variety of suppliers are secondary ones (Tanaka, 2012). Monetary sizes of investment in single capital projects range from US$20 million to US$5 trillion which signifies that globally operating first-tier prime contractors must have capability and capacity to execute and manage projects up to in excess of 1 trillion US$.

There are diverse versions of definitions for project management in the industry. For instance, Project Management Institute (PMI®) indicates the definition of project management as “Project management is the application of skill, tools, and techniques to project activities to meet the project requirements” in its A Guide to the PROJECT MANAGEMENT BODY OF KNOWLEDGE (PMBOK® GUIDE) Fifth Edition (PMI®, 2013). While this definition is universal, one needs to share a more specific definition for heavy project industries. If we look at a common denominator of those definition versions generally used in capital projects, we would arrive at the following most practical definition (Tanaka, 2012).

"Project Management is the application of a systems approach to the management of a series of interrelated, technologically complex tasks for engineering, procurement and construction of a new, expanded or revamped facility, normally described as a project, whose objectives are explicitly stated in terms of time, cost and quality performance parameters, and whose tasks terminate when those objectives are met. For attaining the stated objectives of the project, a sponsoring organization (owner) and a project executing organization (contractor) utilize resources in a planned and controlled manner. Furthermore, to meet the need for concentrated attention to highly specific project requirements whose satisfaction is pressed by time, project management lets functional personnel (vertical hierarchy) be assigned to a specifically organized project team (horizontal hierarchy). Project management incorporates the processes of planning, directing, monitoring, analyzing, problem solving and communicating, as in general management, for integration of diverse activities and optimization among constraints or competing objectives”.

Suppose an oil company constructs a 50,000 BPSD (barrel-per-stream-day) grassroots refinery in Ukraine, a typical EPC project costing some US$3 billion, the undertaking of constructing this new refinery presents the following management profiles:

- This undertaking is designed to create new business value to attain an increase in the capacity and stability in oil product supply in the country – this is a social benefit - and the oil company’s business benefits such as increased margin and market share;
- This undertaking is temporary, as it will end when a refinery is successfully completed and its commercial operation is started;
- The undertaking is unique in that a refinery will have a unique configuration of process units and ancillary facilities, each with designs unique for this refinery, and it will be located at a new site which offers unique local conditions;
- The undertaking is a typical system consisting of systems of material and energy processes, and human systems, for converting crude oil (input resources) to a variety of petroleum products with added value (output resources);
- This undertaking might most probably involve a syndicated loan of supplier’s loan and commercial banks’ loan;
- The undertaking is constrained by a defined budget, supportive infrastructure or the size of an owner organization’s project team;
- This undertaking would involve such processes as project feasibility analysis, project development and planning, project definition (front-end engineering design), engineering, materials procurement, construction, and commissioning, as well as project management which will integrate and optimize all the other processes; each of these processes, in turn, comprises numerous sub-processes;
- This undertaking draws on selected, commercially proven process technology, a full spectrum of professional engineering methods, a set of project management and control systems and internationally qualified quality management systems; and,
- For carrying out this undertaking, the owner organization establishes a dedicated project team and a contractor, or contractors, will be hired by the owner.

## Life Cycle of a Capital Project

Figure 1 depicts the life cycle of a project as seen from an owner organization (Tanaka, 2006; Tanaka 2012).

A typical capital project can be divided into three major phases: Project Development Phase, Front-end Planning Phase, and Project Execution Phase.

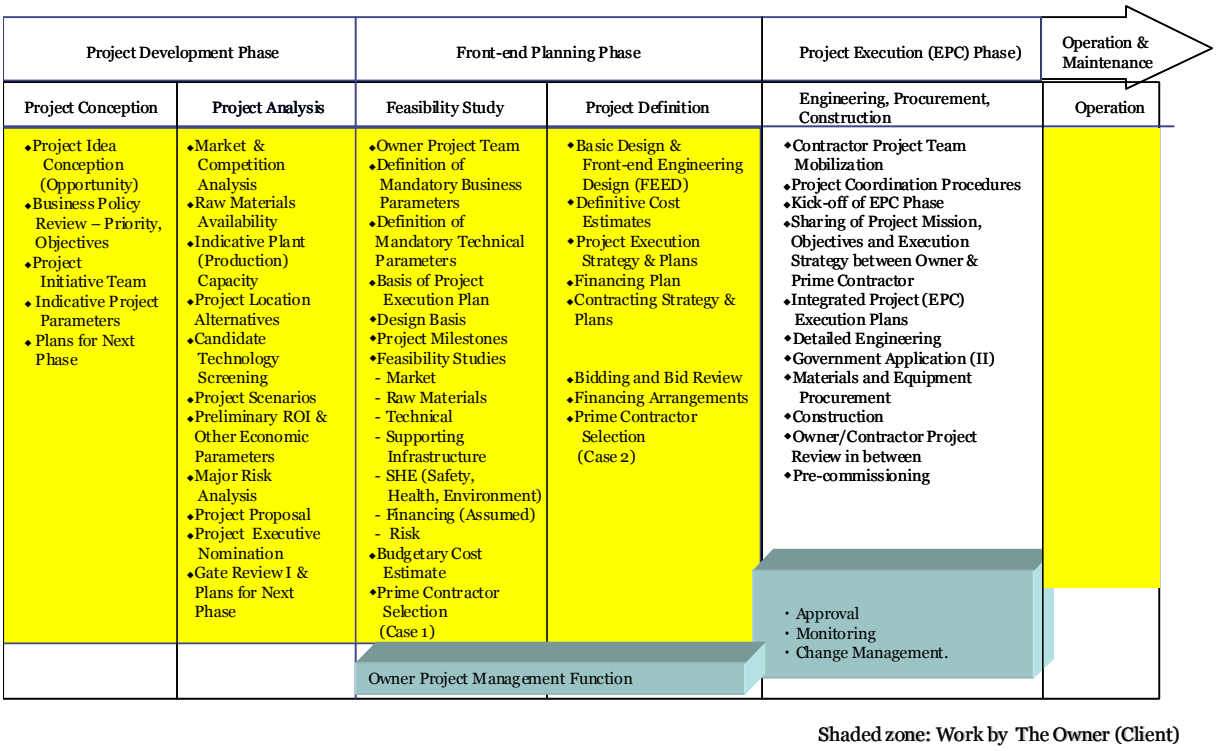


Figure 1. Life Cycle of a Capital Project (Process Plant Case)

## Project Development Phase

The Project Development Phase aims at project conception as business and strategic analysis of the project value. During this phase, a sponsoring organization, namely, a plant owner or its higher controlling organization (hereafter collectively called the Owner) carries out basic data gathering, project need screening against the corporation's business strategy, and evaluating basic conditions for materializing the potential project. This Project Development Phase culminates in the identification or confirmation of the mission, objectives and goals of the project; preliminary plant/facilities scheme, technology alternatives, plant location and raw materials logistic alternatives; economics and competitive position of the project plan; identification of the Owner's core project initiative team as well as stakeholders participating in the project; risk level associated with the project; and strategy for project development and execution. In performing this, the Owner roughly estimates resources required for the project and prepares a slate of alternative scenarios. When the work for this phase is completed and there are good indications of project feasibility, the Owner project initiative team presents a project proposal to the management of the sponsoring organization to obtain approval for proceeding with the next phase.

## Front-end Planning Phase

The Front-end Planning Phase is a preamble to project execution and intended to explore detailed feasibility and later definition of the project. To proceed with this phase, the first important step is to organize the Owner's key project team. The first half of this phase is that of project feasibility studies which, against the mandatory business and technical parameters as well as project strategy of the owner, the Owner project team assesses the feasibility of the candidate project is assessed in terms of market outlook, raw materials availability, plant scheme alternatives, supporting infrastructure, HSE or health, safety and environment aspects and risk involved in the project concept. Capabilities on technological and engineering assessment, scenario analysis, economic studies and budgetary cost estimating are essential for this work.

Project definition work, in the second half of this phase is normally undertaken with the Owner employing a consulting firm or an international engineering and construction company broadly experienced in this type of work for project development; such a company works in a joint team with the Owner. The Owner, assisted by a consultant, carries out front-end engineering which produces specifications for end products quantified in meaningful

measures; product quality standards to be met; definition of production processes and supporting utility and offsite facilities in such forms as a project definition (front-end engineering design) package; resources required; and, project milestones and key activities in the project. Based on this, the Owner establishes project budget and cash flow forecast, project work breakdown structure (WBS) or project work and deliverables dictionary, project master execution plan, and, policies to be adhered/procedures to be employed. Also, contracting strategy for the Project Execution Phase (EPC Phase) is developed.

By this time, the Owner will have completed an overall project definition package of a grade suitable for judging capital investment or otherwise, together with a more accurate risk assessment. If, happily, the Owner has justified the project in all the essential aspects, the Owner team will seek senior management's approval to proceed with the project for implementation. When the project is authorized to proceed to the Implementation Phase, prime contractor selection is done through contract negotiation or international bidding.

Here again, there are cases where a project, once taken up in the previous phase, is judged to be infeasible in the light of finer definition or changes in economic environment.

## Project Execution Phase

The Project Execution Phase is the phase during which, based on the project basic planning and definition documents produced so far, the project gradually takes on physical shapes in terms of engineering design documents, procured equipment and materials, and erected facilities. Most of the work in this phase is carried out by a prime contractor (the Contractor) hired by the Owner. The Owner and the Contractor start by setting up project organizations and communications channels.

Then, the Contractor carries out project execution planning and develops the project's work breakdown structure (WBS) and resulting work packages from contractual scope of work. Various resources are mobilized to the planned capacity and work packages are executed. In many cases, this stage is referred to as the engineering-procurement-construction phase, or simply the EPC phase, and the following are included:

- Follow-up on project definition package (front-end engineering design package);
- Planning and analytical engineering (engineering flow diagram plot plans, etc.);
- Production engineering and design;
- Procurement of equipment, materials and services, and;
- Field construction.

Project management processes are most intensively deployed during this phase to direct, monitor, forecast and control work scope, quality, project schedule, costs, and, stakeholder satisfaction. The Contractor resolves problems encountered, as well as reporting and evaluating monthly progress of the project to the Owner.

Now, the project is around the final corner and into the home stretch. A project is not considered successful if it fails to attain the predetermined objectives.

To smoothly complete a project, the Contractor finalizes the project product, or in this case, a plant, so that the Owner can accept the plant.

Henceforth, final accounts are settled and product responsibility is transferred to the Owner. Both the Owner and the Contractor evaluate the project and document its results in order that project file is readily available for future projects; in fact this is a very important step to enhance an organization's competitiveness. Finally, resources tied to the project are released and redirected to new projects or functional activities.

## Requirement for Information and Communication Technology Infrastructure on Major Sized Engineering and Construction Projects

Major-sized global EPC projects impose challenges on contractor project information and communication technology (ICT) infrastructure. Tanaka (Tanaka, 2006) discussed such challenge and this paper updates the challenges in view of the recent development of the mega project industry based on the feedback obtained by the first author (Tanji):

- A unique combination of project management systems de-facto to the EPC industry, e.g. PRIMAVERA P6® software for planning and scheduling, and home-made project execution and management systems in which knowhow of handling bulk materials (such as piping materials, civil and structural materials, and electrical/controls materials that represent 25 to 35% of the total project costs) is a key to competitiveness;
- The total system must be built on the philosophy of project relational database (specific project and roll-up to division-wide data), on powerful relational database management systems (RDBMS) such as Oracle®;

- Robust systems structure that allows handling of the vast amount of data generated by multi-hundred-million-to billion-US dollar projects;
- Systems configuration that enables or facilitates data transfer from project execution such as engineering, procurement and construction (EPC) and to project management with a minimum of human intervention and synchronization of data among component project execution and management information systems;
- High-speed transactions and data transfer for transnational project operations connecting multiple project operations centers distributed around the world; note that some 60% in terms of projects' prices delivered are earned by international joint ventures or consortia among Japanese, US, Italian, French and Korean prime contractors; and that in most mega-sized projects clients are also joint ventures, (Tanaka, 2007; Tanaka 2014;
- Remote accessibility to home office systems, usually using Web technology, to support construction site teams and other distant participant offices;
- Flexibility in tailoring output to absorb project-specific requirements, and connectivity with counterpart systems of partner contractor organizations under a joint- venture or consortium structure.

A typical project execution support and project management and controls system is presented in Table and Figure 1 by the courtesy of JGC Corporation, Japan's leading and one of the top five global engineering and construction company (http://www.jgc.co.jp.)

Table lists component ICT systems forming the total project execution support and project management and controls systems to support the total phases of engineering, procurement, construction and project management (EPC-PM) and Figure 2 depicts the interface of the major systems.

*Table*

**Global Project Execution Support and Project Management and Control Systems**

JGC Corporation Project Execution Support and Project Management and Control Systems

| | Name of the System | Code | User Disciplines | Primary management and control functions to support |
|---|---|---|---|---|
| ■ Project Management and Controls System | | | | |
| | Cost Estimating System | CES | Cost Engineering | High accuracy cost estimating |
| | Profit and Cash flow Management System | ProCash | Project Management/Cost Engineering | Project cost management |
| | Integrated Document Management System for Global Collaboration | INDRA | Project Management | Documents management |
| | JGC Correspondence Tracking System | J-COTS | Project Management | Correspondence management |
| | JGC Supply Chain Management System | JSC | Design, Procurement and Project Management | Materials management (from materials take-off to delivery from warehouses) to support site construction planning as well |
| | | | | |
| ■ Engineering Management System | | | | |
| | Tagged Equipment Management System | TAMA | Rotating Machinery, Equipment Engineering | Management of equipment lists |
| | Materials Take-off and Control System | MACS | Piping, Civil, Electrical Engineering | Materials specification generation, materials take-off, bills of quantity tabulation |
| | Engineering to Procurement Interface Management System | EPIC | Piping Engineering | Materials list generation for piping materials |
| | | | | |
| ■ Supply Chain Management System | | | | |
| | Integrated Vendor Information System | IVIS | Procurement | Global vendor information database |
| | Inquiry Supporting System | ISS | Procurement | Supporting inquiry to vendor work |
| | Inquiry and Bid Evaluation System | BIDS | Procurement | Bid tabulation for piping materials |
| | JGC Procurement e-Solution System | JPLUS | Engineering, Procurement | e-Workplace for inquiry/quotation documents exchange on secure websites between JGC and vendors |
| | JGC Purchase Order Commitment System | PCOM | Corporate | To generate purchase orders to globally |
| | Payment Schedule Management System for Project Operations | PAY | Procurement, Finance Department | Auto-generation of payment schedules on purchase orders |
| | JGC PROCUREMENT E-SOLUTION SYSTEM (FOR APO) | JPLUSP | Procurement | e-Workplace for exchange on secure websites for project specific documents and globally located vendors |
| | Expediting & Traffic System | ETRS | Procurement | Logistics management |
| | Procurement Tracking & Controls System | PTCS | Procurement | Procurement milestone management |
| | QC STATUS CONTROL SYSTEM | QCS | Quality Management | Support the total flow of quality management on equipment and materials on order |
| | | | | |
| ■ Construction Management System | | | | |
| | Construction Management System (including 4-D CADD) | CMS | Construction | Overall management of site construction operations: 4D CAD is for visualizing construction planning by 3D plant models with construction work simulation |
| | COCOS | COCOS | Construction | Construction work cost estimating |
| | TOMAS | TOMAS | Construction | Supporting plant systems turnover to the client |
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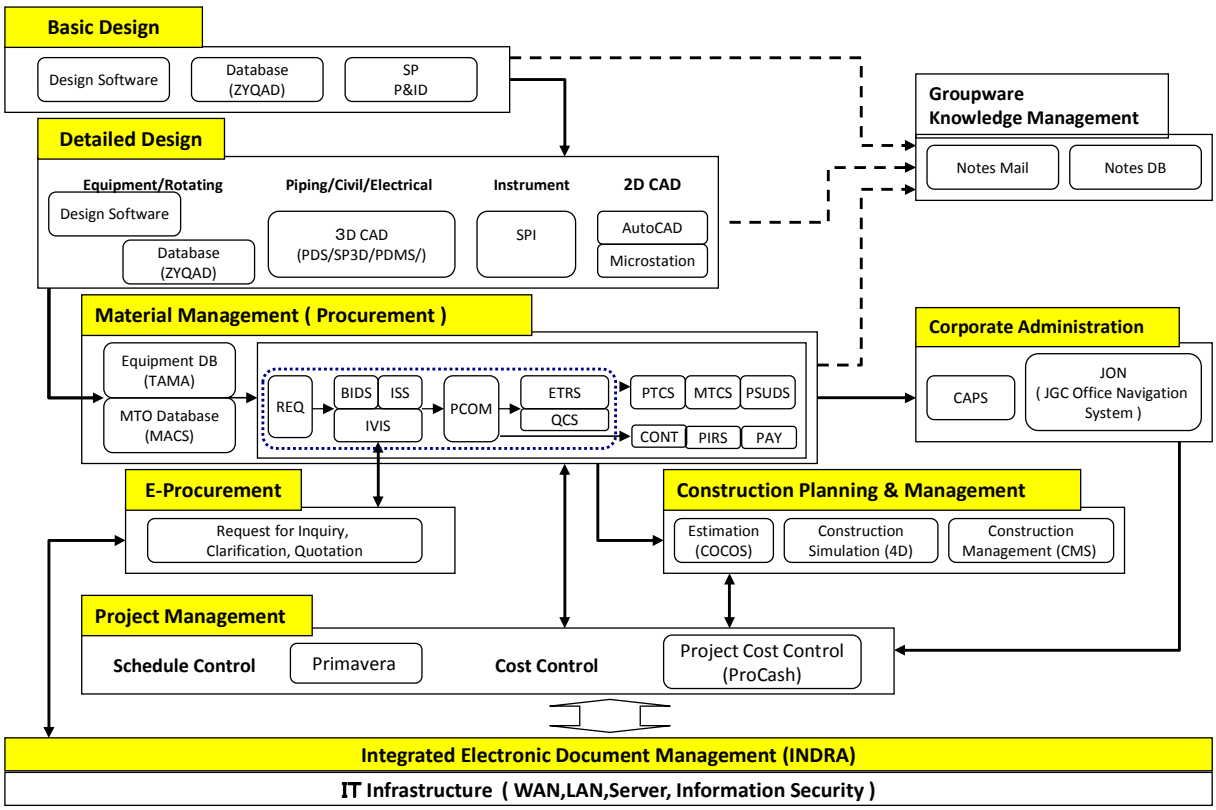


Fig. 2. System Configuration Flow of the Global Project Management System

## Conclusion

While project directors and project managers are not necessarily knowledgeable on the latest ICT, considering that reliable and efficient ITC utilization is vital for global projects, they should include a project ICT manager (or consultant) in the project team during the planning and build-up phase to help the project director make informed decisions on the smart selection of project IT components utilized in their project and subsequent surveillance of systems functionality and trouble shooting.

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