

2. The evolution of Project Management in Construction Projects

2.1. Introduction

Project management and *projects* are not new concepts. Throughout history, vast projects of different magnitudes have been successfully undertaken across generations. Project management first emerged in the early fifties on large defense projects (Peters 1981). Gradually smaller organizations took to adapting the idea and currently the smallest construction firms are known to operate project management in some way. A great deal of project management involves avoiding problems, tackling new ground, managing a group of people and trying to achieve very clear objectives quickly and efficiently (Reiss 1995).

Project management is essentially about managing a project from its conception to its completion and needs to be discussed in terms of various stages of a project life cycle. A project could be viewed as a system, which is dynamic and ever changing from one stage to another in a life cycle, considering a generic project, its status changes from that of an idea or a concept through to feasibility studies, execution and finally completion (Peters 1981). But projects are nowadays far more complicated than ever before. They involve larger capital investments, and embrace several disciplines, widely dispersed project participants, tighter schedules, stringent quality standards, etc. Coupled with high speed developments in ICT, these factors have influenced project management practices to take a new turn taking advantage of newly developed management tools and the latest technology.

Next, different definitions of Project Management and its functions and requirements from a life cycle point of view are stated. The challenges and problems facing current project management practices to fulfil these requirements are discussed. However, the stress is put in the communication and information management, which are Project Management functions that are having different treatment with the impact of the latest advances in technology and especially, with the emerging paradigm of performing project management over the web.

2.2. The definitions of Project Management

After World War II, the complexities of projects and a shrinking wartime labour supply demanded new organizational structures. Program Evaluation and Review Technique (PERT) charts and Critical Path Method (CPM) were introduced giving managers greater control over massively engineered and extremely complex projects.

These techniques spread to many industries as business leaders sought new management strategies and tools to handle their growth in a quickly changing and competitive world. This trend was enhanced by the availability and sophistication of advanced software packages, which are fully capable of addressing these techniques coupled with the ease to use interfaces. Thus, project management was taken up initially by large companies, later on by smaller firms, and now even the smallest ones are known to operate project management to a certain extent. There are many definitions for project management. However irrespective of the nature of the project or the type of project in question, it is defined as the management of the project from its initial conception to its ultimate completion and its maintenance. Nevertheless, in construction the term is frequently used to refer to site or construction management rather than taking a holistic view of the project from the conceptual stage (preparation of the client brief) to its ultimate completion and maintenance (facilities management).

Walker (1984) provides a comprehensive definition for construction project management.

“Construction Project Management is the planning, control and coordination of a project from conception to completion (including commissioning) on behalf of a client. It is concerned with the identification of the client’s objectives in terms of utility, function, quality, time and cost, and the establishment of relationships between resources. The integration, monitoring and control of the contributions to the project and their output, and the evaluation and selection of alternatives in pursuit of the client’s satisfaction with the project outcome are fundamental aspects of Project Management.”

The Code of Practice for Project Management for Construction and Development (Chartered Institute of Building 2003) describes the Project Management as an emergent professional discipline which separates the management functions of a project from the design and execution functions and defines Project Management as

“the overall planning, coordination and control of a project from inception to completion aimed at meeting a client’s requirements in order to produce a functionally and financially viable project that will be completed on time within authorized cost and to the required quality standards.”

The Project Management Institute (PMI 2000) defines Project Management as:

“the application of knowledge, skills, tools, and techniques to project activities to meet project requirements.”

The PMI definition stresses the achievements of predetermined project objectives, which normally refer to scope, quality, time, cost and participant satisfaction, and directly links them to the project life cycle. A construction project goes through various stages along the path to completion. In a typical project, the status changes from that of an idea or concept, through to feasibility studies, execution and final completion.

According to the Royal Institute of British Architects (RIBA 2000), the project life cycle is divided into a number of stages each of which has assigned project management practices and project managers with defined responsibilities. In general, the following stages are defined: Inception, Feasibility studies, Schematic design, Detail Design, Production Information, Bills of Quantities, Tendering, Project Planning, Construction and Project Completion.

RIBA (2000) has well defined the roles of the different participants such as architects, engineers, surveyors, planners, project managers, contractors and sub contractors in each of the aforementioned stages. These roles are focused on **managing and co-ordinating the project information and the flow among the various participants** with the aim of satisfying the objectives of each stage.

“The overall role of project management, in this scenario, is to harmonize the functions of **planning, communicating, monitoring and control** in order to meet the project’s overall objectives as defined by the **scope, time, cost, quality and client satisfaction**.”

Project management has three essential **requirements: thinking ahead, communicating and evaluation**

According to Peters (1981) half the value of project planning is to provide the opportunity and motivation, simply to get people to *think ahead about the project* that they are undertaking. This process tends to reveal problems, which helps to find solutions at early stages of a project.

Communication, on the other hand, deals with producing, issuing and transmitting reports/documents, and with holding occasional meetings among the project participants so that the proposed timing, method and strategy are made available and understood. In essence, the collaboration of the various participants in a project is measured by how effectively the communication channels were managed.

Evaluation of the outcomes are critical to improve current practices. Communicating and feeding back information and messages to the project team is also essential to the achievement of the project goals by all the participants. Thus, the effectiveness of the project manager to communicate with, evaluate, and feedback to the rest of the project team during each stage of the life cycle determines how efficiently the project's goals will be achieved.

Traditional project management practices have evolved over time as the requirements for managing and controlling construction projects unfolded. Nonetheless, with the advances of management techniques and information and communication technology, traditional practices have proven to be insufficient in meeting the new project requirements.

Construction Projects are being designed by diverse number of designers (which may well be placed at different geographical locations), procured and managed by new partnering strategies, materials are purchased and delivered through strategic alliance with suppliers, etc.

The common point of all the Project Management definitions is to consider PM as

“planning, coordination and control of a project along the whole life cycle of the project to meet the client's requirements.” This is the definition to be used in this research.

In general terms, the responsibilities of the Project Management are to plan, coordinate and control the overall project. Such duties can be performed through a good communication and information management, and must be studied in depth.

2.3. Project Management theory

2.3.1. Life cycle of Project Management

The Project Management Institute (PMI 2000) defines the Project Life cycle (PLC) as

“the steady progression of a project from its beginning to its completion”.

The Life cycle of a project is divided into phases and then into stages. However, some phases of most projects involve iterations to a greater or lesser degree depending on the type of project.

At its most basic, it is generally accepted that a typical PLC consists of two broad periods each of two major phases (i.e. four in all). The first period involves conceptualizing and validating with a business case. Then planning and developing a project brief or charter. The second period involves implementation, i.e. detailed design and construction of the product followed by product transfer to the intended customer.

Many Project Management researches (de Cos 1995, Gomez-Senet 1997) give different definitions to Project Life cycle and describe different phases of the PLC. These phases are known by different names in different project environments but from the traditional view these phases are divided into:

- Phase 1: Conception of an idea. Sense of vision, big picture.
- Phase 2: Development of the idea into a practical plan. Listening, analysis, alignment, planning, commitment.
- Phase 3: Plan execution. Production work, coordination, cooperation, testing.
- Phase 4: Project completion. Transfer of product and information, review, closure.

In general, the activities within each phase tend to be quite distinct, requiring different levels of management attention and different skill sets.

Depending on the size, complexity, risk, sensitivity and so on, these typical phases may be broken down into sub-phases, and a variety of different stages or iterations depending on the project and its type. These will be specific to the project, and will depend on the overall accomplishment strategy.

If we focus on construction, projects are intricate, time-consuming undertakings. The total development of a project normally consists of several phases requiring a diverse range of specialized services. In progressing from initial planning to project completion, the typical job passes through successive and distinct stages that demand input from such disparate areas as financial organizations, governmental agencies, engineers, architects, lawyers, insurance and surety companies, contractors, material manufacturers and suppliers, builders, etc. During the construction process itself, even a modest structure involves many skills, materials, and literally hundreds of different operations. The assembly process must follow a natural order of events that constitutes a complicated pattern of individual time requirements and restrictive sequential relationships among the structure's many segments.

Essentially, a project is conceived to meet market demands or needs in a timely fashion. As a general idea, typical Project Management researches give the following description of a construction project. When starting a project, various possibilities may be considered in the conceptual planning stage, and the technological and economic feasibility of each alternative is assessed and compared in order to select the best possible project. The financing schemes for the proposed alternatives must also be examined, and the project is programmed with respect to the timing for its completion and for available cash flows. Once the scope of the project is clearly defined, detailed engineering design provides the blueprint for construction, and the definitive cost estimate serves as the baseline for cost control. In the procurement and construction stage, the delivery of materials and the erection of the project on site must be carefully planned and controlled. After the construction is completed, there usually is a brief period of start-up or shake-down of the constructed facility when it is first occupied. Finally, the management of the facility is turned over to the owner for full occupancy until the facility lives out its useful life and is designated for demolition or conversion.

On this ground, the main stages for construction project management are:

- **Market Demands or Perceived Needs.** The aim of this stage is to define project objectives and scope. Once an owner has identified the need for a new facility, the owner must define the requirements and delineate the budgetary constraints. It involves establishing broad project characteristics such as location, performance criteria, size, configuration, layout, equipment, services and other owner requirements needed to establish the general aspects of the project.
- **Conceptual Planning and Feasibility Study.** Conceptual planning stops short of the detailed design, although a considerable amount of preliminary architectural or engineering work may be required. The definition of the work is basically the responsibility of the owner, although a design professional may be called in to provide technical assistance and advice.

- **Design and Engineering.** The objectives of this stage are Construction Plans and Specifications. This phase involves the architectural and engineering design of the entire project. It culminates in the preparation of final working drawings and specifications for the total construction program. In practice, design, procurement, and construction often overlap, procurement and construction beginning on certain segments as soon as the design is completed and drawings and specifications become available.
- **Procurement and Construction** Procurement refers to the ordering, expediting and delivering of key project equipment and materials, especially those that may involve long delivery periods. This function may or may not be handled separately from the construction process itself. Construction is, of course, the process of physically erecting the project and putting the materials and equipment into place, and this involves providing the manpower, construction equipment, materials, supplies, supervision, and management which are necessary to accomplish the work.
- **Start-up of occupancy.** After the construction is completed, there usually is a brief period of start-up or shake-down of the constructed facility when it is first occupied. When the occupancy permit is issued and the facilities are accepted, then the occupancy is allowed.
- **Operation and maintenance.** Finally, the management of the facility is turned over to the owner for full occupancy. This stage is focused on the use of facilities and the maintenance of the whole building. In this stage the possible renovations of the building are also included.
- **Disposal of facility.** When the facility lives out its useful life and is designated for demolition or conversion. This stage refers to the demolition and possible recycling of the facilities and parts of the building.

2.3.2. Actors / roles of a Construction Project

Basically, Project Management theories define many different roles in a construction project, e.g. Building Owner, Design and Technology manager, Planning manager, Technical assistant, Contractor, Project manager, Supply manager, Site manager, Other services subcontractor, Mechanical services subcontractor, Fire services subcontractor, Transportation subcontractor, Electrical services subcontractor, etc. All these roles can be joined into only three categories of actors. Then each actor can develop as many roles as necessary:

- The **owner**, whether public or private, is the instigating party that gets the Project financed, designed, and built. Public owners are public bodies of some kind, and range from the federal government down through state, county, and municipal entities to a multiplicity of local boards, commissions, and authorities. Public projects are paid for by appropriations, bonds, or other forms of financing, and are built to perform defined public functions. Public owners must proceed in accordance with applicable statutes and administrative directives pertaining to advertising for bids, bidding procedure, contracts and other matters relating to the design and construction process. Private owners may be individuals, partnerships, corporations, or various combinations thereof. Most private owners have the structure built for their own use, business, habitation, or otherwise. However, some private owners do not intend to be the end users of the constructed facility; rather, they plan to sell, lease or rent the completed structure to others.
- The **Architect-Engineer**, also known as the design professional, is the party or firm that designs the project. Since such design is architectural or engineering in nature, or often a combination of both, the term ‘architect-engineer’ is used to refer to the design professional, regardless of the applicable specialty or the relationship between the architect-engineer and the owner. The Architect-Engineer can occupy a variety of positions with respect to the owner for whom the design is undertaken. Many public agencies and large corporate owners maintain their own in-house design capability. In such instances, the architect-engineer is the design arm of the owner. In the most common arrangement, the architect-engineer is a private and independent design firm that accomplishes the design under contract with the owner. Where the ‘turnkey project arrangement’ type of contract is used, the owner contracts with a single party for both design and construction. In such cases the architect-engineer is a branch of the construction contractor.
- The **General Contractor** is the firm that is in prime contract with the owner for the construction of a project, either in its entirety or for some designated portion thereof. Under the single-contract system, the owner awards construction of the entire project to one prime contractor. In this situation, the contractor brings together all the elements and inputs of the construction process into a single, coordinated effort, and assumes full, centralized responsibility for the delivery of the finished job, constructed in accordance with the contract documents. The prime contractor is fully responsible to the owner for the performance of the subcontractors and that of other third parties to the construction contract. When separate contracts are used several independent contractors work on the project simultaneously, and each of them is responsible for a designated portion of the work. Each contractor is in contact with the owner and operates independently of the others. Hence, each of these contractors is a prime contractor. Responsibility for coordination of these contractors may be undertaken by the owner, the architect-engineer, a construction manager, or one of the prime contractors who is paid extra to perform certain overall job management duties.

2.3.3. Influences with contractual arrangements

The various contractual arrangements reflect fundamental differences in the allocation of responsibility to match the characteristics of different projects. Many actors take part assuming different roles; therefore, contractual arrangements must be given strategic consideration.

An owner may have in-house capacities to handle the work in every stage of the entire process, or may seek professional advice and services for the work in all stages. Understandably, most owners choose to handle some of the work in-house and to outsource professional services for other components of the work as needed. By examining the project life cycle from an owner's perspective we can focus on the proper roles of various activities and participants in all stages, regardless of the contractual arrangements for different types of work.

The owner may choose to decompose the entire process into more or less stages based on the size and nature of the project, and thus obtain the most efficient result in implementation. Very often, the owner retains direct control of work in the planning and programming stages, but increasingly outside planners and financial experts are used as consultants because of the complexities of projects (Hendrickson & Au 2003).

Taking into account the Spanish practice, the contractual arrangements can be broadly classified under three headings (Heredia 1998). Each method has its own variations. No method is the best in all circumstances.

2.3.3.1. *Traditional procurement arrangement*

The **traditional procurement arrangement** involves three main participants: client, designer, and contractor. In this procurement protocol, the client has a direct contractual relationship with most of the participants.

For ordinary projects of moderate size and complexity, the client often employs a designer (an architectural/engineering firm) which prepares the detailed plans and specifications for the contractor (a general contractor). The designer also acts on behalf of the owner to oversee the project implementation during construction. The general contractor is responsible for the construction itself even though the work may actually be undertaken by a number of specialty subcontractors.

The client usually negotiates the services fees with the Architectural and Engineering (AE) firm. In addition to the responsibilities of designing the facility, the AE firm also exercises to some degree the supervision of the construction as stipulated by the owner.

Traditionally, the AE firm regards itself as design professionals representing the client who should not communicate with potential contractors to avoid collusion or conflict of interests. Field inspectors working for an AE firm usually follow through the implementation of a project after the design is completed and seldom have extensive input in the design itself. Because of the litigation climate in the last two decades, most AE firms only provide observers rather than inspectors in the field. Even the shop drawings of fabrication or construction schemes submitted by the contractors for approval are reviewed with a disclaimer of responsibility by the AE firms.

The client may select a general contractor either through competitive bidding or through negotiation. Public agencies are required to use the competitive bidding mode, while private organizations may choose either mode of operation. In using competitive bidding, the owner is forced to use the designer-constructor sequence since detailed plans and specifications must be ready before inviting bidders to submit their bids. If the owner chooses to use a negotiated contract, it is free to use phased construction if it so desires.

The general contractor may choose to perform all or part of the construction work, or act only as a manager by subcontracting all the construction to subcontractors. The general contractor may also select the subcontractors through competitive bidding or negotiated contracts.

Although the traditional procurement arrangement is still widely used because of the public perception of fairness in competitive bidding, many private owners recognize the disadvantages of using this approach when the project is large and complex and when market pressures require a shorter project duration than that which can be accomplished by using this traditional method.

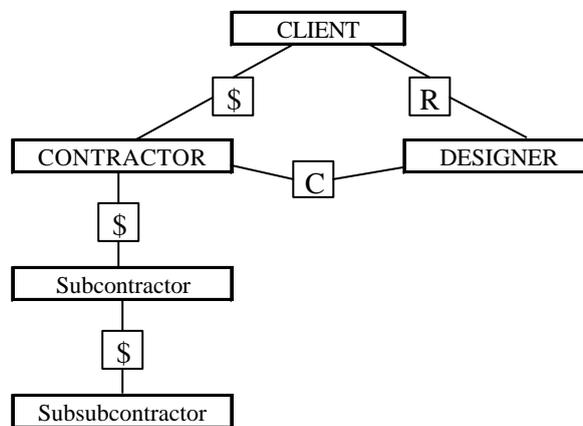


Figure 2. Traditional procurement arrangement

2.3.3.2. Turnkey project arrangement

Some clients wish to delegate all the responsibilities of design and construction to outside consultants in a turnkey project arrangement. A contractor agrees to provide the completed facility on the basis of performance specifications set forth by the owner. The contractor may even assume the responsibility of operating the project if the owner so desires. In order for a turnkey operation to succeed, the client must be able to provide a set of unambiguous performance specifications to the contractor and must have complete confidence in the capability of the contractor to carry out the mission.

This approach is the direct opposite of the traditional procurement arrangement in which the owner wishes to retain the maximum amount of control for the design-construction process.

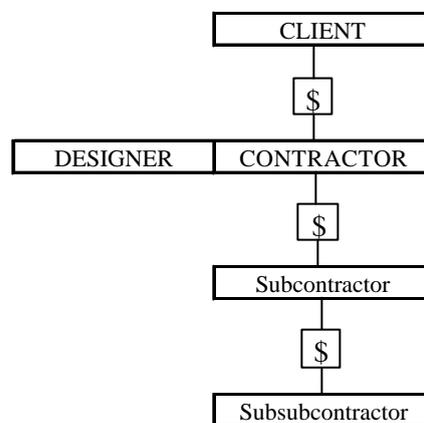


Figure 3. Turnkey project arrangement

2.3.3.3. Professional Construction Management arrangement

In the Professional Construction Management arrangement there is no main contractor interposed between the owner and the various specialist subcontractors. The construction manager becomes the principal consultant coordinating the entire procurement process.

Professional construction management refers to a project management team consisting of a professional construction manager and other participants who will carry out the tasks of project planning, design and construction, in an integrated manner.

Contractual relationships among the team members are intended to minimize adversarial relationships and contribute to greater response within the management group. A professional construction manager is a firm specialized in the practice of professional construction management which includes:

- Work with owner and the AE firms from the beginning and make recommendations on design improvements, construction technology, schedules, and construction economy.
- Propose design and construction alternatives if appropriate, and analyze the effects of the alternatives on the project cost and schedule.
- Monitor subsequent development of the project in order that these targets are not exceeded without the knowledge of the owner.
- Coordinate procurement of material and equipment, and the work of all construction contractors, and monthly payments to contractors, changes, claims, and inspection for conforming design requirements.
- Perform other project related services as required by owners.

Professional construction management is usually used when a project is very large or complex.

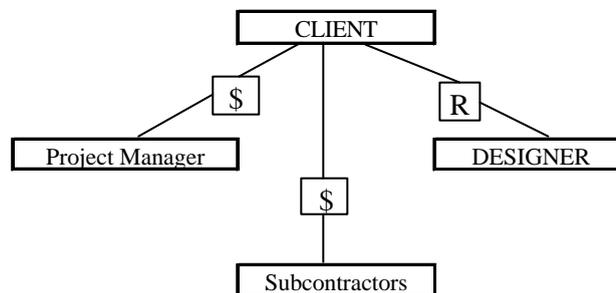


Figure 4. Professional Construction Management arrangement

\$ means that there is a contractual relationship between the two participants

R means that the relation between the parts is merely legally representative

C means that the relation between the parts is merely to control

2.3.4. Major types of constructions

The construction industry is a conglomeration of quite diverse segments and products. In planning for various types of construction, the methods of procuring professional services, awarding construction contracts, and financing the constructed facility can be quite different. For the purpose of discussion, the broad spectrum of constructed facilities may be classified into four major categories, each with its own characteristics (Hendrickson & Au 2003).

2.3.4.1. Residential Housing Construction

Residential housing construction includes single-family houses, multi-family dwellings, and high-rise apartments. During the development and construction of such projects, the developers or sponsors who are familiar with the construction industry usually serve as surrogate owners and take charge, making necessary contractual agreements for design and construction, and arranging the financing and sale of the completed structures. Residential housing designs are usually performed by architects and engineers, and the construction executed by builders who hire subcontractors for the structural, technical, electrical and other specialty work. An exception to this pattern is for single-family houses which may be designed by the builders as well.

2.3.4.2. Institutional and Commercial Building Construction

Institutional and commercial building construction encompasses a great variety of project types and sizes, such as schools and universities, medical clinics and hospitals, recreational facilities and sports stadiums, retail chain stores and large shopping centres, warehouses and light manufacturing plants, and skyscrapers for offices and hotels. The owners of such buildings may or may not be familiar with construction industry practices, but they usually are able to select competent professional consultants and arrange the financing of the constructed facilities themselves. Specialty architects and engineers are often engaged for designing a specific type of building, while the builders or general contractors undertaking such projects may also be specialized in only that type of building.

2.3.4.3. Specialized Industrial Construction

Specialized industrial construction usually involves very large scale projects with a high degree of technological complexity, such as oil refineries, steel mills, chemical processing plants and coal-fired or nuclear power plants. The owners usually are deeply involved in the development of a project, and prefer to work with designers-builders so that the total time for the completion of the project can be shortened. They also want to pick a team of designers and builders with whom the owner has developed good working relations over the years.

2.3.4.4. *Infrastructure and Heavy Construction*

Infrastructure and heavy construction includes projects such as highways, mass transit systems, tunnels, bridges, pipelines, drainage systems and sewage treatment plants. Most of these projects are publicly owned and therefore financed either through bonds or taxes. This category of construction is characterized by a high degree of mechanization, which has gradually replaced some labour intensive operations.

2.4. Functions of Project Management

Project management is a broad subject dealing with every aspect of managing an ongoing project. It includes: leading, communicating, negotiating, problem solving and influencing the organisation (PMI 2000).

Numerous studies have shown that the data flow between the parties to a construction project is a major component of project management activity. Munday (1978) and Karlen (1982) confirm that managers involved in the construction activity spend nearly half of their working time on tasks devoted exclusively to the transmission of information. The work is made up of information processing and management. Bishop (1980) and Ball (1980) have also suggested that the construction industry is unduly fragmented and that this has hindered progress and innovation and has adversely affected the way the industry and its clients view itself and its service.

In a profound sense, the management of construction projects is about **managing the project communication and information flow**. And managing project information is about managing the documentation generated in a particular project.

2.4.1. Project communication and information flow

Poor **communication** has long been a problem in the Project Management. Part of the trouble is the way the industry is organized. The project team is made up of people from many different firms. Their contributions vary and a lot of information has to pass among them. This requires a well-organized network of communication. Even when this network exists, communication still breaks down at a personal level, because people fail to keep their messages simple; they pass on too much information or too little; the information they give is inaccurate or misleading (Fryer 2002).

On the receiving end, people are flooded with paperwork they haven't time to read, yet often they cannot get the information they want. Estimates may be wrong, drawings out-of-date, descriptions ambiguous. Meetings go on for too long and people stop listening.

The sheer number of parties that require coordination to bring a project to completion is a challenge. In order to do so, the industry has relied on traditional communication methods, typically time and labour intensive that have resulted in higher costs and inefficiencies (Figure 5).

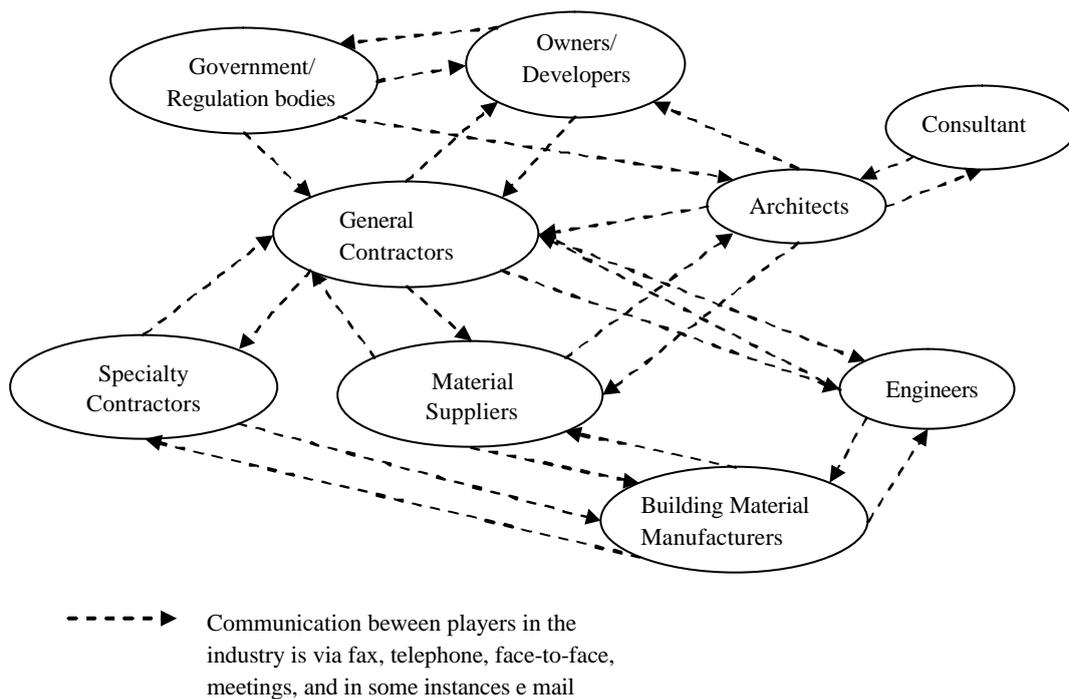


Figure 5. Traditional chaos in the communication and workflow of AEC industry

Coordinating the numerous parties involved to take a project from initiation through construction is often a daunting experience. Owners, architects, engineers, general contractors, subcontractors, material suppliers, government, and regulatory bodies, have all traditionally communicated using methods such as fax, face-to-face meetings, e-mail, etc., to exchange ideas, provide progress updates, schedule labour, deliver documents and make supply requests.

The complex process required to turn around a RFI (Request For Information) illustrates some of these inefficiencies: today, a RFI is hand-written by a subcontractor, faxed to the general contractor, reviewed/rewritten and faxed to the architect. The architect may fax it to a sub-consultant (electrical, structural, mechanical) for review, who in turn may fax it to a sub-sub-consultant (lighting, acoustical) for input. The response is formulated, documented and sent back to the sub-consultant for review, and then faxed back to the architect. Assuming no further

clarification is needed, the architect faxes the RFI back to the general contractor and the owner. Once approved by the owner, the RFI is faxed back to the subcontractor with action items. Finally, the general contractor needs to ensure that the response is received on the job site by foremen, staff, subcontractors, suppliers, project managers and administrators, all in their respective office locations.

In the construction industry, there are typically 50 to 250 organizations involved in the execution of building contracts, (construction professionals, contractors, specialist contractors, suppliers, statutory authorities, health and safety, highways agencies, etc). Traditional paper based administrative systems mean that for every document issued, there is need to copy (sometimes in part, sometimes whole) and pass 'down' the supply chain sometimes for information, sometimes for comment and return and usually in accordance with some level of contractual obligation.

Bearing in mind the number of organizations in a typical project supply chain, two major problems can be inferred:

- the system is inherently challenging in terms of effective communication and
- the administrative burden is tedious and expensive.

Ineffective communication and poor administration lead to bad management.

Furthermore, AEC projects can generate enormous amounts of documentation. Over the life cycle of a project the main contractor receives a continuous stream of documents from the client, subcontractors, etc. and creates letters, reports and so on.

The effective management of all the information needed for a construction project, from the conception Stage to the construction and maintenance of the building, is a basic requirement for the success of the project. All the participants of construction projects know the impact caused on overall construction costs by delays, missing or contradictory information, mistakes, etc.

Information flows in construction are numerous, unstructured and very complex. The amount of data flow is exhausting and requires volumes of documentation. It is a wonder how much valuable human effort, time and resources have been spent in major construction projects for monitoring, tracking and controlling data flows. Retrieving documentations from the racks and racks of project file stores is a daunting and time-consuming task. The disputes arising from improper documentation are numerous and they cannot be amicably or fairly resolved due to lack of substantial documentation or many missing links. The extent and sources of information overload of construction project managers vary throughout the stages of a project. The

construction stage has the highest probability of information overload, followed by the design stage. The main sources of information overload are the project participants contributing the key expertise in each stage. In the design stage, the key contributors are architects and consultants, and in the construction stage, contractors and subcontractors. Architects' and consultants' contributions to information overload during the construction phase show a similar pattern through the project duration, as do those of contractors and subcontractors. The importance of proper information tracking and document control is paramount in the last phase of the construction, commissioning and final account settlement.

It is clear from the above discussion that developing a full-fledged information system to encompass all types of construction projects, project organizations, and contracts of a construction company is a very difficult task. Information flow in a major construction project is even more complex in internationally executed projects due to the involvement of different entities from different countries, and project participants from different cultures, with diverse local regulations and requirements. The environment must be flexible in order to acknowledge the specifics of each construction project, as well as to support individual expertise and preferences and changing requirements. At the same time, additional functionality is needed to enable the participants to make efficient use of the environment. This apparent conflict between flexibility and efficiency can be resolved through the development of a common system with critical information flows and allowing the participants to adopt the additional functionalities when and where appropriate (Stouffs 2000).

Despite these complexities, it is possible to identify and substantiate the critical information flows and to select the essential and critical ones. Among the various systems developed for construction, on-site information flow processing application is not available (Dado & Tolman 1999). Hence, if we succeed in identifying the basic on-site information elements for most construction projects and develop an adaptable and scalable information system, it might enable us to optimize, improve, and better control over critical project information flows, ultimately resulting in better project performance.

Accordingly, construction project participants cannot perform effectively without an adequate, accurate and timely flow of information. For this reason, each participant in the construction process has responsibility for transmitting information and communication. Also, the nature, volume, direction, and timing of the flow of information vary considerably and, hence, this demands its effective coordination, control and dissemination to ensure its proper utilization.

2.4.2. Production and use of project information

All construction information produced, utilized and shared among project participants is intended to contribute to the success of a particular project. Under the traditional procurement method (where design and construction functions are separated), the main producers of construction information and stages of production may be summarized in Table 1 (Kwakye 1997).

Table 1. Production and use of project information

Information producer	Project phase	Form of information	Information user
Client	Conception	Brief	Architect
Architect	Feasibility	Report	Client
	Design	Drawings	Client, Quantity Surveyor, engineer, contractor
	Construction	Revised drawings	
	Commissioning	As-build drawings	Client
Engineer	Design	Drawings	Architect, Quantity Surveyor, contractors
	Construction	Revised drawings	
	Commissioning	Operating / Maintenance Manual	Client /Ultimate users
Quantity surveyor	Design	Cost estimates and Bills of quantities	Architect, client
	Construction	Cost Report. Final Account	Architect, client, contractor
Contractor	Construction	Progress report. Contractual claim	Architect, QS, client
	Commissioning	Maintenance manual	Architect, client
Material suppliers	Construction	Material availability and supply report	Contractor

Moreover, this table demonstrates that construction information is produced and utilized in all the design and production phases by the project participants.

Generally, information is whatever meaningful data; but, when talking about Project Management, information is basically limited to documentation and communication.

2.4.3. Intra and inter organizational coordination

Construction activity, unless designed and constructed by the same company, is undertaken by specialist participants from several establishments organized into a temporary group over an agreed timescale.

In this sense, depending on the flow and access of the information three different kinds of information can be established:

- **Specific to a project:** Particular to that project and available only to those engaged in it. For example: client's brief, drawings, conditions of contract, correspondence.
- **General:** Not particular to the project but applicable to any project, and available to everybody. For example: Codes of practice, manufacturer's catalogues, building regulations, etc.
- **Specific to an organization or firm:** Available only to members of particular firms engaged in the project, but partially relevant to other projects. For example: office standard details, cost and output records, manufacturing techniques, etc.

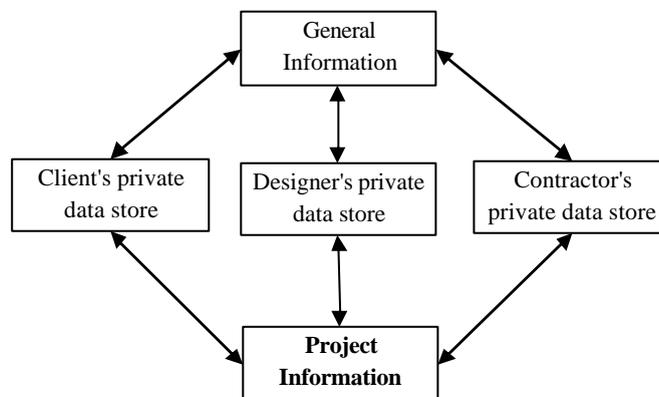


Figure 6. Interchange of different type of information between different actors

The flow between these three categories clearly is the most challenging purpose. Experience of a particular project contributes to office standard details, research reports to project drawings, etc. Project information may become general information on completion of the project and be fed back to data stores. There is also interchange within a particular data store: between client's brief and production drawings, between manufacturers catalogues and building regulations, and so on.

Accordingly, there is a need for coordination of information at intra- and inter-organizational levels to ensure the success of the project.

2.4.3.1. *Intra-organizational coordination*

To function effectively and remain in business, managers of companies must coordinate the activities of their personnel in order to the achievement of the common specific goal. Above all, there is also a need to exercise coordination of construction information to ensure that:

- Information flow is adequate, continuous and uninterrupted.
- Information flow is simplified, improved and controlled.
- Information is analyzed and communicated to the right personnel.
- Information is released at the appropriate time.

Furthermore, the production, coordination, and communication of construction project information should assume a proper place in the company to enable it to make an effective contribution to the economies of production. The neglect of intra-organizational information coordination could result in one or more of the following:

- Lack of ideas between construction projects and clients.
- Absence of feedback on completed construction projects and perpetuation of inherent defects and expensive mistakes from one project to another.
- Deficiency of knowledge on company policies and practices.
- Abortive work and/or duplication of efforts.
- Failure to communicate essential construction information to the right person at the right time.
- Conflict of construction information such as that shown on the architect's and engineer's drawings.

2.4.3.2. *Inter-organizational coordination*

The temporary organization structure formed for the execution of a particular construction project, consists of specialist participants from different establishments and, therefore, demands the effective coordination of information to ensure that the efforts of all the participants are directed to the needs of the project. A lack of coordination in design, for example, results in one or more of the following:

- Discrepancies between architect's and engineer's drawings.
- Conflict of architect/engineer's drawings with those of services engineer.
- Conflict of services engineer's drawings with those of another services engineer.
- Architect/engineer unaware of the level of details or construction information required by the site production staff.
- Improper channels for distribution of construction information.

In addition, the following are the consequences of uncoordinated construction project information:

- Discrepancies between item descriptions in bills of quantities and details shown on architect/engineer's drawings.
- Inclusion of inappropriate and/or out-of-date information in contract documentation.
- Contract documents which disagree with each other due to inconsistencies, ambiguities and/or omissions.
- Late issue of information.
- Site management spending much of their time sorting out discrepancies and/or ambiguities in contract documentation. This robs them of valuable time that could otherwise have been used more beneficially in supervision/monitoring the quality aspects of the works.
- Uncontrollable variations, delays, disputes, increased cost, claims, and consequential uncertainty of the final cost of the construction project.
- Completed product of poor quality with technical defects and the resultant increased occupancy cost.

2.5. Challenges facing Project Management

Traditional project management practices have evolved over time as the requirements for managing and controlling construction projects unfolded. However, with the advances of management techniques and ICT, traditional practices have proven to be insufficient in meeting the new project requirements.

Construction Projects are being designed by diverse number of designers (which may well be placed at different geographical locations), procured and managed by new partnering strategies, materials are purchased and delivered through strategic alliances with suppliers, etc. These changes have highlighted a number of weaknesses in the traditional project management practices some of which are discussed in the following section.

Government, industry and clients are all seeking to bring about a change in the construction industry to improve quality, competitiveness and profitability, and to increase value to clients. Where the emphasis has traditionally been on the need to manage the interface between the project and the client's organization, it is now shifting towards the need to manage the flow of activities through the whole life cycle of the project, concentrating on those activities that actually add value.

The Egan report (1998) stresses the need for project managers to integrate projects' phases (from conception to final delivery) leading to performance improvement, and for designers to develop greater understanding of how they can contribute value in the project process and the supply chain. This pace of change is introducing a new climate, which has highlighted the limitation of current project management practices in meeting the new requirements.

The changing construction environment is also influenced by other factors, which are interrelated and interdependent. Examples of such factors are:

- **Globalization of the marketplace;** many industries are facing a lot of pressures due to this factor. Tariff barriers are virtually falling and labour has become more mobile. Further, due to productivity improvements and advantages in economies of scale, some foreign firms are capable of competing with local firms on price, quality and delivery. The impact of these pressures befalls on project management too (Walker 1984).
- **The economical forces;** this factor may significantly affect the client organization and, subsequently, can impact the initial objectives of their projects.
- **Increases in project complexity;** project complexity has increased due to extent of scope and fragmented parties around the world having to communicate with one another for efficient project execution. The complexity of the projects is reflected by the large number of specialists contributing to the decision making process.
- **The need to achieve faster results with the given resources;** this factor places severe time pressures on the entire project team.
- **Rapid changes to project scope to expand benefits;** some scope changes take place very rapidly before even realizing the benefits of the changes.
- **New procurement practices;** the emergence of new procurement practices changes the way in which team members interrelate. For example, procurement schemes such as Private Finance Initiative and 'partnering' have impacted construction project management. Such schemes bring the Government and the private sector firms together in large-scale infrastructure projects in which very high quality standards, tight schedules, and cost targets are aimed at. With the government's greater involvement in standardizing contractual procedures for Private Finance Initiative schemes, the commitments of all the parties have become clearer and more visible.

- **Client sophistication;** this has become a major driver for productivity improvements in construction. Clients demand higher quality final products and services at lower price. This has created a buyers market whereby firms compete for projects at lower margins, and hence demands better project management practices to enforce tighter control on the projects' activities.

2.6. Limitations of the existing Project Management in terms of achieving the functions and requirements

In facing up to the aforesaid challenges, current project management practices have many limitations to efficiently deal with these demands. These limitations can be categorized into the following groups:

2.6.1. Lack of adequate communication

Current project management practices are often isolated and are concerned with managing problems related to the individual stages of the projects. The following examples are caused by such a problem:

- Additional expenditure due to reworking

Problems of reworking occur due to conflicting information and information not received in time to the parties concerned. The main cause is the lack of consistency in the flow of information between the different parties involved in the construction project. Up to 30% of construction rework is attributable to process related problems. For example, architects/clients make changes to designs quite frequently, and they do not effectively communicate these changes to the contractors and the subcontractors in time for them to be implemented efficiently, resulting in rework. This imposes a lot of strains on the client's budget. Rework in this fashion predominates most of the construction sites.

- Lack of Integration within the Supply Chain

Current ordering, purchasing and invoicing practices, have a lot of shortcomings in terms of delays in the reception of supplies, less collaboration with manufacturers and suppliers, and low integration of purchasing with accounts software.

For instance, many delays result out of implementing current material procurement systems which do not integrate well with project plans and schedules. The lack of a fully integrated procurement system tends to impact on stock control policies (e.g. carrying a high quantity of stock) of construction firms, due to the inability to make accurate predictions of resource requirements for the project. The main reason for this is the poor communication and coordination among the supply chain partners, and the overall lack of an integrated system to cater to this need.

2.6.2. The introduction of automation into management practices

In the 1990s there have been significant developments in technology, which have resulted in the production of very powerful software packages for the construction industry. The ‘ad hoc’ deployment of such packages have resulted in improvements at their local level of implementation, such as planning, estimating, design, etc., that will be treated in depth in Chapter 3, but have had added limited benefits at the project level. The following examples are caused by such a problem:

- **Electronic copies vs. hard copies**

Although many construction organizations are using IT to improve specific processes/applications, the construction industry still traditionally holds the view of issuing hard copy documentation as against electronic forms for auditing and record purposes. Deng et al. (2001) show how communication in the construction industry is complicated by its structural problems.

“When drawings are amended, the revised drawings or instructions need to be in hard copy form confirmed with the architect’s chop or signature and the receipt of the drawings be acknowledged by the contractors in writing. Therefore sending these documents electronically cannot complete these endorsement procedures.”

The mixing of electronic and hard copies in organizations make it difficult for project managers to process the right information as and when required.

- **Lack of software integration**

A high percentage of the project management systems (software) that are available today, focus on specific tasks such as project planning and monitoring, cost control, risk management, scheduling, etc. These isolated applications have resulted in a broad spread of stand-alone

applications packages with no or 'fixed' communication links. The industry lacks an integrated comprehensive system, which facilitates the smooth flow of information between the various stages of the project (Alshawi 2000, Faraj & Alshawi 2000).

- Lack of international standards for information exchange

The incompatibility between hardware and software has raised a serious 'technical' problem which has prevented project managers to easily access and manage project information. These problems are caused by the lack of a standardization of project information, such as to facilitate the information flow between incompatible hardware and software. Consequently, IT systems that are available and currently used by the industry do not consider the needs of widely dispersed participants in large construction projects (Underwood & Alshawi 1997).

- Lack of Proper Decision-Making Tools for Project Planning

Planning is a lengthy process and needs contributions from the entire project team. It is also context dependent. This process can be significantly improved if appropriate decision making tools are incorporated into their structure. Comprehensive Systems have not yet been developed in this direction.

2.6.3. Lack of standard processes for project management

Although there are some initiatives to standardize Project Management processes such as the PMI (2002), projects are normally managed according to the experience of the project managers who are specifically appointed for this task. Each project manager, even within the same organization, prefers to follow his/her own experience, which has been developed over a long period. These practices lead to large variations in management practices and thus can create a significant impact on the capability of coordinating and controlling project information (Hunt 1995).

- Lack of support provided to users.

As a matter of fact, most SMEs cannot afford research and development and in new technologies, but access to project webs must be gained for them to be competitive. They are, however, indirectly obliged to do so if they take part in a complex project in which all the other participants are using collaboration tools for the management of their companies and also for the management of the project.

It is obvious that there is a clear need for rules or guidelines for SMEs to use these WPMS and to organize their information and communication systems in an easier way that is likewise more compatible with these cooperative spaces. (Forcada et al. 2002).

Particularly, there is a need to redesign traditional working procedures to facilitate the exchange of data, so as to be able to take advantage of the new opportunities offered by a project web, so that working procedures are better and more efficient. A fundamental change is necessary in what constitutes a document, from paper-based to digital versions.

2.7. Possible solutions

Where the emphasis has traditionally been on the need to manage the interface between the project and the client's organization, it is now shifting towards the need to manage the flow of activities across the life cycle, concentrating on those activities that actually add value.

In doing that, electronic data exchange, in particular WPMS, has tremendous potentials not only in adding value to the internal performance of an organization, but also to the whole life cycle and therefore to the client.

In order for the construction industry to successfully embrace WPMS, at a large scale, it must equally consider technology, process, people, procurement, legal issues, and knowledge management. The efficiency of current processes must be carefully addressed and re-engineered to take advantage of the latest advances in technology. Industry should work towards minimum common standards to facilitate the flow of information across the life cycle. Such standards will add significant value up the chain by allowing exchanged information to be fully integrated with business processes. People must have the necessary skills and the rewarding environment to harness the benefits of the Internet.

2.8. Summary

Construction Projects have been managed since time immemorial, but in the 1990s there have been significant developments in technology which have resulted in the production of very powerful software packages for the construction industry that have changed the way Construction Projects are managed. The emergence and technological development of personal computing has itself revolutionized the way many people work.

Management of construction projects is about managing the project information and communication flow.

New ways of working, like using e-mail, have changed the interaction between partners and has increased the difference between parties using IT tools and Small Enterprises who don't.

Associated technologies development has caused revolutionary changes in organizational communication. Information is now available to managers and other employees in a faster and reliable way, and in larger quantities than ever before. Information now has to be systematically managed and information networks carefully designed and monitored.

The influence of information technologies exceeds the flow, speed and reliability of information; they are making a major impact on planning, decision-making and control.

Some big companies are investing in new technologies for the management of the company and for that of construction projects. Other companies like SMEs can't afford investing such amounts of money and tend to still use paper based project management with the consequent duplication, loss and organizational difficulties.

There is a special need to redesign traditional working procedures for the Communication and Information Management. This is to take advantage of the new possibilities of a project web, so that working procedures are better and more efficient.