7. Concept Model of Information Flow

7.1. Introduction

The **construction process** is subject to the influence of highly variable and sometimes unpredictable factors. The **construction team**, which includes architects, engineers, subcontractors, and others, changes from one job to the next. All the complexities belonging to different construction sites, such as subsoil conditions, surface topography, weather, transportation, material supply, utilities and services, local subcontractors, labour conditions and available technologies are inherent to construction.

Consequently, construction projects are typified by their complexity and diversity and by the non standardized nature of their production. The use of factory-made modular units may somehow diminish this individuality, but it is unlikely that field construction will ever be able to adapt completely to the standardized methods and product uniformity of assembly line production. On the contrary, many manufacturing processes are moving toward 'one of' production and adopting many of the project management tools originating in the construction industry (Clough et al. 2000).

From this situation, a huge amount of **organizational information** is formalized in unstructured documents. Due to their intrinsic characteristics, management of unstructured documents presents critical issues: difficult information search and retrieval, poor interoperability among information systems, poor reuse of content, as well as of business information, related to the context of use of documents in organizations (i.e. business processes and organizational schema).

In order to cope with the issues of document indexing, search and retrieval and reuse of documented business information, the process of classification and metadata specification is focused on the selection of a set of labels representing contents as well as context-related properties of documents. Content properties relate to what the document contains or is about, thus providing to users and applications useful hints to help document search and retrieval and to improve the reuse of documented information. Context-related metadata express the 'by whom, where, how, under which constraints and for which purpose' a document is being accessed, transmitted and modified. Thus the business information related to the practices of documents use is made explicit, promoting formalization, exchange and reuse of this valuable information.

The first question that arises is **how information in Electronic Document Management Systems should be classified.**

In DMS these two dimensions of unstructured document properties can be represented, by distinguishing three main parts or modules:

- The *Process Model*, which specifies the life cycle of the document.

- The *Descriptive Information Model*, i.e. the set of properties, which describes and identifies the document (e.g. title, author, date and subject).

- The *Collaboration Model*, which formalizes how the organizational resources are structured (the organizational model) and how access to information resources is regulated (the access right policy), on the basis of the organizational roles or responsibilities of individuals. This model is based on the tools and services that support or enable the communication

This chapter states an analysis of different theories defining **the life cycle of a construction project**, the **actors-roles of the partners** involved in a project, the **documents generated** in each stage of the life cycle (Process Model), and **other additional information** of each document (Descriptive Information Model) that can be useful for a better management of the project and a better organization of all the companies that take part in a construction project. In this chapter we will analyze different methodologies to classify information taking into account the life cycle, the actors who play any role, and any other additional information called metadata, so as to be able to create a database of all the documents of a construction project depending on different factors.

DMS organizational model and access right policy will not be treated in this chapter because it's not the aim of this thesis.

7.2. Life cycle of a construction project

Although in every country and for all researchers and developers, the life cycle of a project is similar, there are some distinctions that make it harder to reach a global agreement. In order to define the life cycle of the 'Concept Model for Information flow', different theories together with the Project Management theories described in Chapter two will be analyzed:

7.2.1. Royal Institute of British Architects Plan

RIBA Plan of work (RIBA 2000) is a standard method of operation for the construction of buildings and is widely accepted as an operational model throughout the AEC industry. It represents a logical sequence of events that should ensure that sound and timely decisions are made. RIBA Plan of Work defines the following Stages:

- **Appraisal Identification of Client's requirements** and possible constraints on development. Preparation of studies to enable the Client to decide whether to proceed and to select probable procurement method.

- **Strategic Briefing Preparation** of Strategic Brief by, or on behalf of, the client confirming key requirements and constraints. Identification of procedures, organizational structure and range of consultants and others to be engaged for the project.

- **Outline proposals**. Commence development of strategic brief into full project brief. Preparation of outline proposals and estimate of cost. Review of procurement route.

- **Detailed proposals**. Complete development of the project brief. Preparation of detailed proposals. Application for full development control approval.

- **Final proposals**. Preparation of final proposals for the Project, sufficient for to co-ordinate all the components and elements of the Project.

- **Production information.** 1: Preparation of production information in sufficient detail so as to enable a tender or tenders to be obtained. Application for statutory approvals. 2: Preparation of further production information required under the building contract.

- **Tender documentation**. Preparation and collation of tender documentation in sufficient detail so as to enable a tender or tenders to be obtained for the construction of the Project.

- **Tender action**. Identification and evaluation of potential contractors and/or specialists for the construction of the project. Obtaining and appraising tenders and submission of recommendations to the client.

- **Mobilization.** Letting the building contract, appointing the contractor. Issuing of production information to the contractor. Arranging site handover to the contractor.

- **Construction to Practical Completion**. Administration of the building contract up to and including practical completion. Provision of further information to the contractor, as and when reasonably required.

- **After Practical completion**. Administration of the building contract after practical completion. Making final inspections and settling the final account.

7.2.2. Generic Design and Construction Process Protocol

Another method is the **Generic Design and Construction Process Protocol** (GDCPP 2004), created by the *University of Salford* in 1998 in an attempt to improve the prevailing situation. It is a high-level process map that aims to provide a framework to help companies achieve an improved design and construction process. The map draws from principles developed within the manufacturing industry that include stakeholder involvement, teamwork and feedback, and reconstructs the design and construction team in terms of Activity Zones -rather than in terms of disciplines- to create a cross-functional team. Such zones may consist of a network of disciplines created to enact a specific task of the project, allowing the 'product' to drive the process rather than the function as in a sequential approach.

Using manufacturing principles as a reference point, a framework of common definitions, documents and procedures was developed to help construction project participants work together seamlessly. Furthermore, industry interest and acceptance of the Process Protocol provided further funding to develop the sub processes of the original protocol and a Tool to aid its implementation. The Toolkit is composed of a Process Map Creation Tool and a Process Information Management Tool, to help users create their own project process map based on the Process Protocol framework, and to manage the project information based on the process created by the Creation Tool.
The Process Protocol is a common set of definitions, documentation, and procedures, that provides the basics to allow the wide range of organizations involved in a construction project to work together seamlessly. The Process Protocol consists of 10 phases.

- **Demonstrating the Need**. It is important to establish and demonstrate the client's business needs, which are defined in detail so as to make provision for problems. Identifying the key stakeholders and their requirements will enable the development of the Business Case as a part of the client's overall business objectives.

- **Conception of Need.** The initial statement of need becomes increasingly defined and developed into a structured brief. To this end, all the project stakeholders need to be identified and their requirements captured. Because of this, the purpose of this phase is to answer the question: "What are the options and how will they be addressed?"

- **Outline feasibility.** Many options could be presented as possible solutions to the identified problem. The goal of this phase is to examine the feasibility of the project and narrow down the solutions that should be considered further. These solutions should offer the best match with the client's objectives and business needs.

- **Substantive Feasibility Study & Outline Financial Authority.** The decision to develop a solution or solutions further will need to be informed by the results of the substantive feasibility study or studies. The purpose of this phase is to finance the 'right' solution for concept design development and outline planning approval.

- **Outline Conceptual Design.** The end of this phase is to translate the chosen option into an outline design solution according to the project brief. A number of potential design solutions are identified and presented for selection. Some of the major design elements should be identified.

- **Full Conceptual Design.** The conceptual design should present the chosen solution in a more detailed form to include architecture, etc. A number of buildability and design studies might be produced to prepare the design for detailed planning approval.

- **Coordinated Design, Procurement & Full Financial Authority.** The goal of this phase is to ensure the co-ordination of the design information. The detailed information provided should enable the predictability of cost, design, production and maintenance issues, amongst others. Full financial authority will ensure the enactment of production and construction works.

- **Production Information.** The detail of the design should be determined to enable the planning of construction, including assembly and enabling works. Preferably no more changes in the design should occur after this stage. Every effort should be made to optimize the design after consideration of the whole life cycle of the product.

- **Construction.** Design fixity and a careful consideration of all the constraints, both achieved at the previous phase, should ensure the 'trouble-free' construction of the product. Any problems identified should be analyzed to ensure that they do not re-occur in future projects.

- **Operation and Maintenance.** The facility is handed over to the client as planned. The post-project review should identify any areas that need more careful consideration in future projects. The emphasis should be on creating a learning environment for everybody involved. As built designs are documented and finalized, information is deposited in the Legacy Archive for future use.

Initiatives such as 'Process Matrix' use the organization of project Stages set down in the Generic Process Protocol (Wix et al 2003). Process Matrix is neither a process model nor a project schedule. In simple terms, it can be seen as a multi-dimensional table that sets down a series of reference activities and, for each activity, identifies the project participants (actors) sending and receiving information. Activities are organized by project Stage.

7.2.3. Industry Foundation Classes

The International Alliance for Interoperability (IAI 2004; BLIS 2002), as explained in Chapter 4, is developing the Industry Foundation Class (IFC) standard. IFCs are a high-level, object-oriented data model for the AEC industry, and model all types of AEC project information such as parts of a building, geometry and material properties of building products, project costs, schedules, organizations, etc. Information from almost any type of computer application that works with structured data about AEC building projects can be mapped into IFC data files. In this way, IFC data files provide a neutral file format that enable AEC computer applications to efficiently share and exchange project information.

IFCs deal with data that are fully structured according to a common standard. However, most information available on AEC projects is unstructured or semi-structured documents (e.g., Word documents, spreadsheets, photographs, etc.). To fully address the IT interoperability needs of the AEC industry, IFC-based approaches must find ways of integrating the structured model-based and the unstructured document-based worlds (Kosovac et al. 2000).

Industry Foundation Classes created *IfcTask* which is an identifiable unit of work to be carried out independently of any other units of work in a construction project. Work is identified as tasks (i.e. IfcTask) that are capable of either containing other tasks or being sub-items of other tasks. A task can be used to describe a process for the construction or installation of products.

Nevertheless, IFC don't expose a typical construction structure based on the life cycle. It only exposes the relations among different information, and will be explained below, when introducing document metadata.

7.2.4. Web based Project Management Systems

As it's been exposed in the fifth chapter, there are plenty of WPMS. Most of them don't have a specific folder structure, and clients must organize their information in their own way. Others give assistance to the client to do so, but very few provide a folder structure for document management that can be customized.

As an example we can mention ProjectNet (2002) that provides a folder structure for whatever construction project. It is mainly organized by categories rather than by the life cycle of the project. The main folders are:

A. Client, B. Consultants, C. Designer, D. Programmes, E. Progress, F. Meetings, G. Handover, H. Miscellaneous, I. Budgets, J. Quality Records, K. Health Safety Environment, L. Cost Management, M. Design Management, N. Works Contracts Files.
For example, for the Folder B. Consultants, many different subfolders are available:
B. Consultants: B01. Architect, B02. Cost, B03. Mechanical and Electrical, B04. Structural, B05. Drawing Register.
For each subfolder you can have other subfolders related to drawings and to specifications.

From this example and from the study of other WPMS, it can be concluded that there is no standardized organization of folders and documents. Each platform and each project partners should create their own one causing a real mess when starting a project and while they are working with information during the project. It's very important for all the actors taking part of a project to know where to store the information and where to find it. If there is no folder and document organisation, the communication and information management can end up with a real disaster and the objectives of the projects might not be achieved.

7.2.5. ISO 12006-2 Building construction - Organization of information about construction works

As exposed in Chapter 4, *ISO 12006 Building construction - Organization of information about construction works* defines methods of organizing the information associated with the construction and affiliated industries, and promotes a standard method of approaching this organization.

ISO 12006-2 defines a framework and a set of recommended titles table of classification of information about the construction works, supported by definitions, identifying classes for the organization and the relation to these classes. It applies to the complete life cycle of construction works, including design, production, maintenance and demolition, and to both building and civil engineering. It is intended for use by organizations which develop and publish classification systems and tables on a national or regional basis.

ISO 12006-3 Organization of information about construction works - Part 3: Framework for object-oriented information exchange implements the basic approach of *12006-2* but uses the entries on these tables as the defining points (or characteristics) for object-oriented information organization. The 'object-oriented' approach describes the characteristics of things without a grouping preference or an ordering by specialization. In the object-oriented approach the object is central, acting as a container of characteristics. It is also known as 'product modelling'. An object can be grouped using classification systems that take one or more of its characteristics for the grouping.

ISO 12006-2 classifies the project stages into:

- Inception / procurement
- Feasibility
- Outline proposals, programme preparation
- Scheme design / costing
- Detail design / costing
- Production information and bills of quantities preparation
- Tender action
- Construction preparation
- Construction operations on site
- Completion
- Feedback

7.2.5.1. Overall Construction Classification System and Construction Industry Project Information Committee

Both the *Overall Construction Classification System* (OCCS, 2004) of North America and the *Construction Industry Project Information Committee* (CIPIC, 2004) of the UK, were designed to comprehend and organize the entire universe of knowledge within the AEC Industry, throughout the full life cycle of the built environment, from conception to demolition, encompassing all forms of construction and attempting to follow these *ISO 2006* standards in establishing the table structure that comprises the system.

The *OCCS* Development Committee believes that following these standards will promote the ability to map worldwide developed classification systems. It's the Committee's hope that other organizations in other countries, pursuing initiatives similar to the *OCCS* will do likewise. As stated by *ISO* in the *12006-2* text, 'Provided that each country uses this framework of tables and follows the definitions given in this standard, it will be possible for standardization to develop table by table in a flexible way. For example Country A and Country B could have a common classification table of e.g. elements, but different classification tables for work results without experiencing difficulties of 'fit' at the joints.

As aforementioned, both *Uniclass* and *Omniclass* draw their table definitions and the table concept from *ISO DIS 12006-2*. *Omniclass* defines the process phase as the time dimension of a constructed entity. A constructed entity has a physical and useful life that has identifiable phases. During its life, a constructed entity is built, modified, and terminated through the execution of projects and each project has identifiable phases. The sequences of phases that occur during the lifetime of an object or endeavour are referred to as life cycles. While a life cycle generally has a defined beginning and end, the phases are usually not a single-pass, straight line – a constructed entity is usually modified and recycled many times with ongoing changes and improvements.

Within the life cycle of a built environment, projects are temporary endeavours with a defined beginning and end for the ideation, creation, modification, or termination of the built environment. In the built environment life cycle, only operation is typically not a project endeavour. Each phase of the project life cycle yields one or more deliverables or outputs that become resources or inputs for the following phase. The deliverable may be a requirements document, a plan, a design document, a model and so on. Project life cycle phases are recursive; this means that each project phase may be in itself a project that produces a deliverable but not the final built environment. For instance, the ideation phase has a life cycle including planning for ideation, executing the ideation process, and closure of the ideation phase (e.g., completion of a requirements document).

- **Ideation/Origination:** Given overall requirements of the project, alternative concepts for its performance are evaluated and an optimal performance strategy is selected. Strategic performance requirements for the project are established.

- **Planning:** Project plans are developed that address the strategic requirements and selected performance strategy.

- **Execution:** Project plans are implemented through the execution of planned project activities.

- **Closure:** The built-environment or intermediate deliverable is reviewed, tested, verified, validated, and turned over to the customer or owner. Learning and information for future use in ideation are documented.

7.2.6. CIB W78 Information Technology in Construction

CIB stands for '*Conseil International du Bâtiment pour la Recherche, l'Étude et la Documentation*' or in English '*International Council for Building Research Studies and Documentation*'. Since 1953 *CIB* has been a forum for cooperation and a unifying force in construction worldwide, fostering innovation and the creation of workable solutions to technical, economic and social problems.

Membership is predominantly institutional with almost 500 members around the world. Recently, 150 Universities and Polytechniques, as well as important professional associations and government agencies have joined *CIB*. Moreover, many large or medium sized multinational contractors and multi-disciplinary professional practices in the fields of consultancy, surveying, and provision of financial and legal services, have also joined *CIB*. *CIB* is the unique catalyst and vehicle that promotes worldwide cooperation in building research. It deals with construction problems by channelling the unrivalled collective expertise of its member organizations through a network of Working Commissions and Task Groups.

The work commission *CIB W78-IT in Construction* (2004) deals with Information Technology, Building documentation and information management and transfer, which occupy a highly prominent role in CIB. The objectives of CIB W78-IT are: to foster, encourage and promote Research & Development in the application of *integrated IT* throughout the *life-cycle of* the design, construction and occupancy of buildings and related *facilities*; to encourage use of IT in Construction through *demonstrating* capabilities developed in *collaborative research projects*; and to organize *international cooperation* in such activities and to promote the *communication* of

these activities and their results. The majority of the research results are published in the journal www.itcon.org. From the study of the researches of the CIB *W78-IT* members and the reviews of W78 work, a very general organization of the life cycle of a construction project can be drawn.

- Conception of needs
- Team selection
- Briefing and design
- Construction
- Facilities management

7.2.7. Conclusions

Once different models and methods were analyzed, a summary of the classification of Phases and Stages in a Construction project from the different classification methods used by different researchers are shown in Table 8.

Table 8. Summary of the classification of Stages in a Construction Project

RIBA	Process Protocol	PM theories	ISO 12006-2	CIB W78			
	Demonstration of the need	Perceived needs			**Conceptual definition**	CONCEPTION	*Includes: demonstration the need and conception of the needs*
	Conception of the need	Conceptual planning	Inception / Procurement	Conception of needs			
Appraisal of Client's requirements	Outline feasibility	Feasibility study	Feasibility		**Feasibility study**		
	Substantive feasibility Study						
Strategic Briefing Preparation	Outline Financial Authority						
				Team selection	***not necessary***		
Outline proposal	Outline Conceptual Design		Outline proposal / programme preparation	Briefing and design	**Outline proposal**	TECHNICAL DESIGN	
Detailed proposal			Schema design / costing		**Detailed proposal**		

Final proposal	Full conceptual Design	Design and Engineering	Detail design / costing		**Final proposal**		
	Coordinated Design, Procurement & Full financial Authority				***included in the other stages***	**PURCHASE AND CONTRACTINGS**	
Production of information	Production information		Production information preparation		**Production of information for tender**		*The Production of information Stage is divided into two: For tender and For construction, because of the different needed and produced information of each stage of the project*
					Production of information for construction		
			Bills of quantities preparation		***included in the other stages***		
Tender documentation					**Tender documentation**		
Tender action			Tender action		**Tender action**		
Mobilization		Procurement			**Contractings**		*It could be part of the construction stage but, due to the great quantity of information generated, we have separated it into a different stage*
			Construction preparation				
Construction to practical completion	Construction	Construction	Construction operations on site	Construction	**Construction**	**EXECUTION**	
					Construction delivery		
		Start-up for Occupancy	Completion				
After practical completion	Operation and Maintenance	Operating and Maintenance		Facilities management	**Maintenance**	**DESACTIVATION**	*Includes: Desactivation, Maintenance and Facilities Management*
		Disposal of facility					
			Feedback				

Concluding, the life cycle of a Construction Project must be organized by Phases and Stages.

> "A **project phase** is defined as a period in the duration of a construction project, identified by the overall character of the processes which occur within it."

> "A **project stage** is a sub-process of the project phase in which new build, refurbishment, repair or demolition work is executed."

There are many different stages in the construction project throughout its life cycle. Some of them can be included in others and some are not relevant. The light grey column shows the final Stages considered in this thesis. Some of these stages are related to each other so they can be grouped into the so named Phases. These stages are shown in the dark grey column of the table.

In the following table there is a description of each phase. Actually, these phases and stages can overlap, so the idea of organizing the information into the project life cycle doesn't mean that one stage goes after the other; it's only a way of defining processes into the construction project.

Table 9. Phases of a construction project

Phase	Description
Conception	Throughout the conception phase, the client's requirement is progressively defined and assessed with the aim of determining a construction project to meet this requirement.
Technical Design	In this phase, the defined client's requirement is developed into an appropriate design solution. At the end of this phase, the aim is to secure full financial authority to proceed.
Purchase and Contractings	This phase is based on producing the final information about the project and tendering.
Execution	This is where the benefits of coordination and communication earlier in the process may be fully realized. Theoretically, any changes in the client's requirements will be minimal.
Desactivation	Upon completion of the construction phase the process continues into the post-construction phase, during which the maintenance requirements of the constructed facility will be continually monitored and managed.

7.3. Activities and subactivities of a construction project

Once each part of the life cycle is defined, the type of information and the area of the project where a piece of information belongs should also be considered.

For example, the *Process Protocol* maps the design and construction process into eight sub-processes (***Activity Zones***): Development, Project, Resource, Design, Production, Facilities, Health & Safety, Statutory and Legal, and Process Management.

The *OCCS* defines ***Process Services*** as the processes and procedures relating to the construction, design, maintenance, renovation, demolition, commissioning, decommissioning, and all other functions occurring in relation to the life cycle of a constructed entity. They are divided into:

- Facility Conception: Planning, Feasibility, Programming and Designer Selection
- Facility Design: Architecture, Engineering, Consultants, Project Management and Control
- Surveying & Construction
- Facility Management & Operation: Leasing, Management, Operation and Maintenance
- Planning
- Other construction-related disciplines, Geographical Information System other disciplines.

The *PMI* (2000) defines ***Project Management knowledge Areas*** that describe project management knowledge and practice. These areas are: Integration, Scope, Time, Cost, Quality, Human Resource, Communications, Risk and Procurement.

To define the characteristics related to the type of information and the area of the project where a piece of information belongs, *ISO 9000:2000* (ISO 2000) definitions are revised.

From ISO 9000:2000 a ***process*** is a set of interrelated or interacting activities which transforms inputs and outputs; a ***project*** is a unique process consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including the constraints of time, cost and resources; and, finally, an ***aspect*** is a set of requirements of special importance to the process or project.

Therefore, to adapt these definitions to the specific problem, the following terms are defined:

> "An **activity** is defined as a working area of the project".
>
> "A **subactivity** is defined as the type of information of special importance hin a project".

The type and character of each activity and/or subactivity vary in accordance with its temporal location within the life cycle of the project. Activities or subactivities generally overlap and are interactive. The information contained by each activity and subactivity is next described:

Table 10. Activities of a construction project

Activity	Description
Advance	Project progress management to ensure that all the required work is included.
Changes	Project modifications management to cope with unforeseen circumstances or with changes desired by an owner in the facility function.
Contractings	Project bidding agreements between the different companies.
Costs	Project cost management to identify needed resources and maintain budget control, financial transactions, resource utilization and accounting during a project.
Environment	Project environment management to identify the environmental policy to be fulfilled, describe environmental impact and control during the site and environmental aspects during the operation and maintenance.
Programming	Project time management to provide an effective project schedule and planning.
Project	Specific documentation for project control and record keeping.
Quality	Project quality management to ensure that functional requirements are met and to insure conformance to the original design and planning decisions.
Risks	Project risk management to analyze and mitigate potential risks.
Safety & Health	Project Safety and Health management to prevent accidents and general safety risk.

Table 11. Subactivities of a construction project

Subactivity	Description
Communication	Project communications management to ensure effective internal and external communications.
Documentation	Information to support references or records. .
Logistics	Operation that involves providing labour and materials to be supplied.
Monitoring and control	Information to manage, verify or exert control over something
Organization	Information to arrange responsibilities, authorities and relationships between people.
Purchasing	Project procurement management to obtain necessary resources from ext ernal sources.
Studies	Documents (Studies and Plans) specifying the quality, safety & health, environment management system of a project .

7.4. Actors of a construction project

In this thesis, actor, agent, stakeholder, participant, company, etc., will have the same meaning.

> "An **actor** is who carries out the processes occurring in relation to the life cycle of a project".

In most current models, when defining the actors of a construction project they are normally identified by discipline. In contrast, another way of defining them is considering that communication occurs between actors that perform roles, whereby the same actual actor may play multiple roles; communication at the role level is the aspect of interest.

There are different roles that the specific norms compel to be assumed by specific actors. In Figure 17 there is a representation of the actors involved in a construction project.

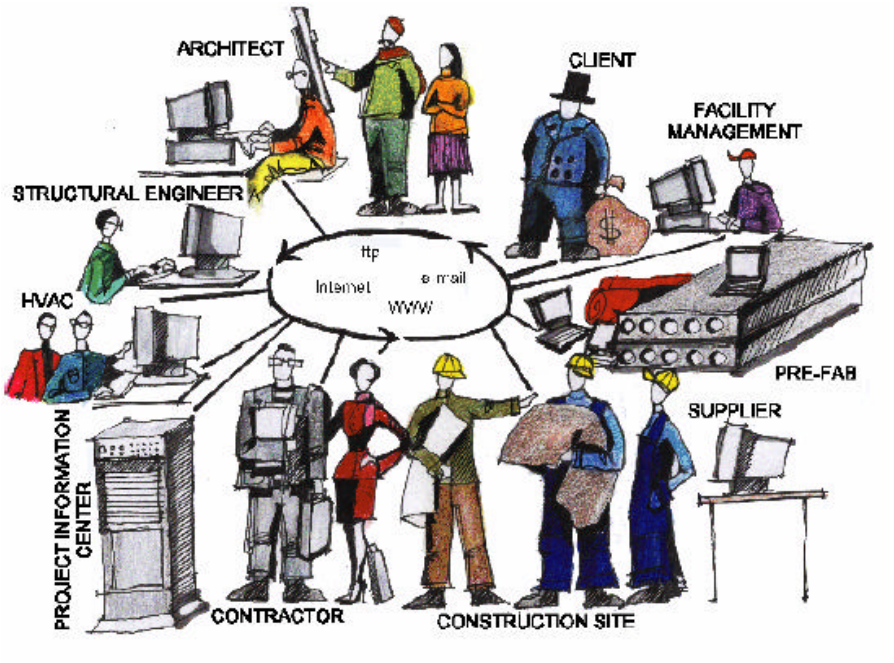

Figure 17. Actors involved in a Construction Project. Figure by Minna Sunikka (Lakka & Sulankivi, 1998)

Following, different classifications of actors from most current models, norms and researchers are analyzed.

7.4.1. Building Act 38/1999

Since our objective is to create a generic mapping taking into account Spanish regulations, we studied the **Building Act 38/1999** (LOE 1999), whose primary end is to regulate the building process by updating and completing the legal concept of the actors involved in the process, stating their obligations in order to determine their responsibilities and cover the guarantees to users on the ground of a definition of the basic requirements to be met by buildings.

This Act applies to building processes, understood as the actions and results of constructing a permanent public or private building.

All individuals or legal entities intervening in the building process are considered building actors. Their obligations shall be determined by the provisions of this Act, all other applicable provisions and the clauses of the contract governing their intervention.

- The **Client** is any individual or corporation, whether public or private, which individually or collectively decides, promotes, plans and finances the building, with its own resources or those of third parties, for itself or for its subsequent disposal, delivery, or transfer to third parties under any heading.

- The **Designer** is the agent who is hired by the developer to design the building in conformity with all applicable technical urban development requirements. Partial projects or supplementary parts of project may be drawn up by other professionals in co-ordination with the designer. In this case each designer shall be the owner of his project.

- The **Contractor** is the agent who enters into a contractual agreement with the developer, wherein he undertakes to use his own human and material resources or those of third parties to execute the works or any part thereof according to the project and the contractual terms.

- The **Project Manager** is the agent who, as part of the professional project management team, directs the development of the works in all technical, aesthetic, urban planning and environmental aspects according to the project, the building license and the contractual conditions in order to ensure its suitability for its intended purpose.

- The **Director of the Execution of the Works** is the agent who, as part of the professional project management team, undertakes the technical functions of directing the material execution of the works and controlling the building and the quality of the works from a quantitative and qualitative perspective.

- **Quality Control Laboratories and Entities** are those qualified to provide technical assistance in verifying the quality of the design, the materials, and the execution of the works and its services, pursuant to the project and to all applicable legislation.

- **Product Suppliers** are the manufacturers, wholesalers, importers and vendors of construction materials. Product supplies are understood as those which are made for the purpose of being permanently incorporated into the construction works, and include all materials, semi-finished elements, components and works or any parts of, both finished and in progress.

- **Owners and Users** are those obliged to keep the building in good condition through proper use and maintenance, and to receive, preserve and transmit the Documentation on the completed works and the insurance and guarantees covering said works. The users, whether owners or not, are obliged to use the building and any parts thereof properly, that is, in accordance with the instructions for use and maintenance contained in the Documentation on the completed works.

7.4.2. Generic Design and Construction Process Protocol

Instead of talking about actors of a construction project, the Process Protocol defines the so called **Activity Zones,** i.e. structured sets of sub-processes involving tasks which guide and support work towards a common objective.

A single person or firm can carry out an activity zone in small-scale projects. In contrast, in a large-scale project, an activity zone may consist of a complex network of people within, and between, relevant functions and/or organizations.

Activity zones generally overlap and are interactive. For example, Design Management often has important input in the Production Management and Facilities Management activity zones, amongst others, and vice-versa. The activity zones defined in the GDCPP are:

- **Development Management** is responsible for creating and maintaining business focus throughout the project, which satisfies both relevant organizational and stakeholder objectives and constraints. The Development Management activity zone is likely to include the following parties: Senior client representation, Suppliers of finance to the client or Professional advisors.

- **Project Management** is responsible for effectively and efficiently implementing the project to agreed performance measures, in close collaboration with Process Management. Project Management is an agent of the Development Management activity zone and is ultimately

responsible for preparing the project execution plan and ensuring that all relevant inputs from other activity zones are guided and integrated towards the successful implementation of the project. The Project Management activity zone is likely to consist of project management professionals.

- **Resource Management** is responsible for the planning, co-ordination, procurement and monitoring of all financial, human and material resources. The Resources Management activity zone is likely to include the following parties: Quantity surveying which will define plant and material needs and monitor their cost; Buying which will procure plant and materials defined by the Quantity Surveying; Project management which will define human resources requirements; and Human resources which will procure human resources defined by Project Management.

- **Design Management** is responsible for the design process which translates the business case and project brief into an appropriate product definition. It guides and integrates all design input from other activity zones. The Design Management activity zone is likely to include the following parties: Design professionals; Suppliers of materials / components; Main contractor and subcontractors; and representatives from: Production, Facilities, Development, Project Management activity zones and Health & Safety, Statutory and Legal Management.

- **Production Management** is responsible for ensuring the optimal solution for the buildability of the design, the construction logistics, and organization for the product delivery. The Production Management activity zone is likely to include the following parties: Suppliers ; Main contractor and subcontractors; and representatives from: Design and Project Management activity zones and Health & Safety, Statutory and Legal Management.

- **Facilities Management** is responsible for ensuring the cost efficient management of assets and the creation of an environment that strongly supports the primary objectives of the building owner and/or user. The Facilities Management activity zone is likely to include the following parties: Facilities management professionals; Building maintenance professionals; Building services professionals; and representatives from: Design Management activity zone.

- **Health and Safety, Statutory and Legal Management** is responsible for the identification, consideration and management of all regulatory, statutory and environmental aspects of the project. The Health & Safety, Statutory and Legal Management activity zone is likely to include the following parties: Development Management activity zone; Design Management activity zone; Production Management activity zone; Facilities Management activity zone; Project Management activity zone; Change Management activity zone; Main contractor and subcontractors; Suppliers; and Resources Management activity zone.

- **Process Management** develops and operationalises the Process Protocol and is responsible for planning and monitoring each phase. Process Management is an agent of the Development Management activity zone. The Process Management activity zone should consist of construction professionals who are independent of the project.

- **Change Management** is responsible for effectively communicating project changes to all relevant activity zones, and for the development and operation of the legacy archive. The responsibilities of the Change Management include: Receiving and structuring change information; Distributing appropriate change information to relevant activity zones in an accurate and timely fashion; Retrieve and distribute appropriate legacy archive information to relevant activity zones; Review and, where appropriate, modify or update the legacy archive.

7.4.3. Industry Foundation Classes

As mentioned above, Industry Foundation Classes created entities to define attributes or pieces of information of construction projects. Referring to the actors and/or roles of a construction project, IFC created the entity ***IfcActor Role*** to define specific metadata and relations among different actors (IAI, 2004). An *IfcActorRole* defines a role which is performed by an actor, either a person, an organization or a person related to an organization.

The 'Role' attribute of *IfcActorRole* is used to assert the actors that are engaged in the communication process. The *UserDefinedRole* attribute is a textual description relating the nature of the role played by an actor and can be used to extend the roles beyond those provided by the current enumerated set within the IFC model.

The 'Escription' attribute of *IfcActorRole* can be used to determine if the role is acting as a sender or receiver of information for that process.

IFC also defines the Roles which may be played by an actor, such as: Supplier, Manufacturer, Contractor, Subcontractor, Architect, Structural Engineer, Services Engineer, Cost Engineer, Client, Building Owner, Building Operator, User Defined and Not Defined. From IFC's point of view, the list of roles and the enumeration values of the Role attribute can never be complete.

7.4.4. Web based Project Management Systems

Many existing construction management platforms allow as many actors as the client wants, but normally in most of the projects actors are classified into: client, contractor, designers (architect, civil engineer, other engineers, etc.), subcontractors, government and suppliers.

Web based Project Management Systems don't care about the actors but only about the accesses and restrictions of these actors (Collaboration Model). This means that the important point is about the information that an actor will be able to view, edit, delete, etc., and not about the type of job the actor is going to develop inside the project.

In Figure 18 there is a possible visualization of actors involved in a WPMS, but notice that these tools don't give restrictions on the quantity of actors nor on the type of role they are developing.

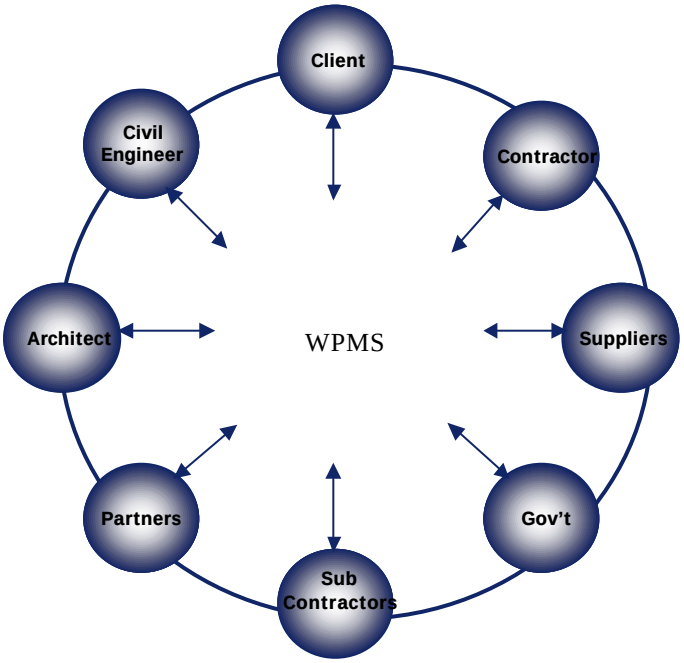

Figure 18. Participants of a Construction Project in a WPMS

7.4.5. ISO 12006-2 Building construction - Organization of information about construction works

In relation to the actors that take part in a construction project, *ISO 120006-2* Building construction - Organization of information about construction works Part 2: Framework for classification of information, defines a *Construction agent* as a Human participant in a construction process. The table concerning to this topic is:

- Clients
- Architects
- Structural engineers
- Civil engineers
- Service engineers
- Project managers
- Main contractors

7.4.5.1. Overall Construction Classification System and Construction Industry Project Information Committee

OCCS and *CIPIC* not only define the process phase but also the process participants which are defined as the actors carrying out the processes and procedures occurring in relation to the life cycle of a construction entity.

From *OCCS* standpoint, the participants of a project are:

- Facility Conception: Planner, Programmer, Space Programmer and Designer Selector.
- Facility Design: Architect, Consultants and Engineer.
- Surveyors
- Project Management: Estimators, Schedulers and Contract Administration.
- Construction: Project Manager, Superintendent, Subcontractor, Safety Officer, Construction Labour, Operating Engineer, Carpenter and Labourer.
- Planners
- Other disciplines: Lawyers, Accountants, Insurance, Bonds

- Owner Representatives: Project Managers, Superintendents, Corporate Managers, Quality Mangers, Facility Managers

- Facility Managers: Leasing Manager, Facility Management, Operations Management, Maintenance Manager

7.4.6. Conclusions

Bearing in mind the different theories and working methods, a summary of the classification of actors/roles in a construction project is shown in the following table. Notice that the grey column gives the final selection of roles that will be used in the system.

Table 12. Summary of the classification of Roles in a Construction Project

Building Act	Process Protocol	IFC	WPMS	PM theories	ISO 12006-2		
Client	Senior client representation	Client	Client		Client	**Client**	
Owners and Users		Building Owner		Building Owner		**Owners**	
Designer	Design professionals		Design team	Design and technology manager		**Design team**	
			Interior Designer				
			Town Planner	Planning manager			
		Architect	Architect		Architect	**Architect**	
			Architectural assistant				
			Landscape architect				
	Professional advisors		specialists consultant	Technical assistance		**Professional advisors**	*Includes: Market research, topographic, feasibility environmental and impact studies.*
Contractor	Main contractor	Contractor	Building contractor	Contractor	Main contractor	**Main contractor**	

Project Manager	Project management		Project Manager	Project manager	Project Manager	**Project Manager**	
Product Suppliers	Suppliers of materials / components	Supplier		Supply manager		**Supplier**	*Includes: equipment, tools, materials*
Director of Execution of the Works	Quantity surveying		Construction Manager			**Construction Manager**	
			Site Manager	Site manager		*included in construction manager*	
Quality Control Labs. and Entities			Quality Control Building control officer Building inspector			**Quality Control Labs. and Entities**	
			Civil engineer		Civil engineer	**Civil Engineer**	
		Structural Engineer	Structural Engineer		Structural Engineer	**Structural Engineer**	*Includes: foundations, structural*
		Services Engineer	Building services engineer		Services Engineer	**Services Engineer**	*Includes: fire, air conditioning, electrical, gas, water, draining systems, mechanical, chemical, renovable energies, telecommunications*
						Services Suppliers	*Includes: electrical, gas, water, draining system, telecommunications*
						Assurance company	
	Suppliers of finance to the client					**Suppliers of finance to the client**	
	Building maintenance	Building Operator				**Maintenance Manager**	

	professionals				
	Facilities management professionals		Facilities Manager		*included in maintenance manager*
			Health & Safety officer		**H&S Man Rep.**
					Quality Man Rep.
					Env. Man Rep.
	Subcontract.	Subcontract.		Other services subcontractor	**Subcontractors**
				Mechanical services subcontractor	*included in subcontractors*
				Fire services subcontractor	*included in subcontractors*
			Transportation planner	Transportation subcontractor	*included in subcontractors*
				Electrical services subcontractor	*included in subcontractors*
	Building services professionals				*included in subcontractors*
		Manufacturer			*not necessary*
		Cost Engineer			*not necessary*
					Marketing representative

Includes: concrete and metallic structures, foundations, masonry, carpentry, previous works, paintings, plaster, glass, cleaning, safety

From this table it can be drawn that if we choose the classification by actors we reach imprecision. For example, the designer can have different Roles as architect, quality control consultant, civil engineer, electrical engineer, etc. But on the other hand and depending on the type of project or the type of contract, different roles can be developed by only one actor. For example, the client can assume the role of a contractor or can only assume the role of the client.

Moreover, if we choose the classification by roles, there are many different fields or tasks to be carried out by the same actor. A single person or firm can carry out a specific task in small-scale

projects. In contrast, in a large-scale project, many tasks may consist of a complex network of people within, and between, relevant functions and/or organizations.

Depending upon the contractual arrangement, each actor will have different roles. The contractual arrangement depends also on the type of construction, so all this information can affect the final organization and management of the project and, more specifically, that of the documentation.

Because of this, the fittest way to organize the tasks to be carried out by different stakeholders will be joining all of them into three categories: Client, Designer and Contractor.

- The **Client** represents any individual or corporation, whether public or private, which individually or collectively decides, promotes, plans, and finances the building with its own resources or those of third parties, for itself or for its subsequent disposal, delivery or transfer to third parties under any heading.

- The **Designer,** also known as the design professional, is the party or firm that designs the project in conformity with all applicable technical urban development requirements. The designer can occupy a variety of positions with respect to the owner for whom the design is undertaken, and can be formed by different companies such as the architect, civil engineer, HVAC engineer, etc.

- The **Contractor** is the agent who enters into a contractual agreement with the developer, wherein he undertakes to use his own human and material resources or those of third parties to execute the works or any part thereof, according to the project and the contractual terms.

So then, to create a generic system, whatever actor partaking in a construction project might be included in any of these three categories. Normally, we will have different companies or stakeholders developing different activities, but all of them grouped in just one; for example, the architect and the engineer might be working for different organizations but both of them are working as Designers.

7.5. Document metadata

Document metadata is a set of document properties which are relevant to document management and render business and organizational information explicit, in a way which promotes reuse, user-driven extensibility, and interoperability with heterogeneous systems (Koch N. et al, 2004). In this section,

"**Document metadata** refers to the set of properties which describes and identifies the document, such as the name, the description, the date, etc".

After analyzing different ways of document coding from different construction companies in Spain, the following type of coding will be used in this *Concept Model for Information Flow*.

7.5.1. Document name

"**Document name** is the identifying characters by which a document is known".

The name of the document might give useful and practical information about the content of the document. Many different ways to define the document name can be used.

Each Document name consists of 2letters+3numbers+4letters+4numbers. The first two letters concern the name of the project. The first three numbers are the consecutive relation of Documents with the same characteristics. The following two letters concern the initials of the type of the Document and are written in capital letters. The last two letters concern the initials of the attribute of Document and should be in small letters. The last four numbers are the latest publication date. The first two numbers are the year and the others are the month.

7.5.2. Description

"The **Description** of a document is a set of information of special importance to its understanding".

This field depends on the author necessities and it's not compulsory. The 'Description' of a document can be notes for a better understanding of the Document, a global description of the Document, etc.

7.5.3. Late submittal date (phase)

"The **Late submittal date** is the Phase and Stage where the Document must be submitted for the right functioning of the project".

This field is necessary for the actor responsible to deliver or upload a document, and also for the actor or actors who should use certain type of information/documents to develop their work and to submit other type of information based on the first one. Depending on the type of contract, the same document might need to be delivered in different phases and stages.

7.5.4. Responsibility

> "**Responsibility** is the document-related role that is being performed by an actor. The responsibilities can be *Create* or *Receive*".

Different actors of a project have different responsibilities when referring to a document: author, reviewer, modifier, reader, user, etc. The author is the person who creates the document and can view, upload, create and delete it. The reviewer is the person who is entitled to review the document and can view and upload it. A modifier is a person who can modify a document as well as view and upload it. A reader is a person who has access to the document and can view it. The users are those who will need this document for the completion of the project.

In this Concept Model, where the actors are summarized into client, designer and constructor, the responsibilities of these actors are reduced to **create** and **receive**. Once these responsibilities are defined and the different roles of these actors are described, the other responsibilities such as author, reviewer, modifier, reader, user, etc., can be defined. Each WPMS provides this functionality (to assign different levels of access to a document, depending on the role actors are playing in each project) and it's not the aim of this thesis.

Therefore, according to the contractual arrangement, the different actors will have different responsibilities. As an example, if we choose the Report Document located in the Conceptual definition Stage from the Conception phase, and the Documentation Subactivity of the Project activity, it can be seen that for different contractual arrangements, the client, designer and contractor, have different responsibilities (create - receive).

Table 13. Example of different responsibilities for a document depending on the contract arrangements

Phases	Stage	Activity	Subactivity	Document	Contract	Create	Receive
Execution	Construction	Quality	Communication	Information requests	Prof. CM arrangement	Client	Designer
					Turnkey arrangement	Contractor	Contractor
					Traditional arrangement	Client	Contractor

7.5.5. Role

"The **Role** is the function that an actor is performing in a project".

The previously defined actors (Designer-Client-Contractor) can develop different roles (Table 14) in accordance with the contractual arrangements. The different roles we have defined are:

Table 14. Roles of the different actors

Id	Role	Id	Role
arq	Architect	esb	Owner
asg	Assurance company	esm	Professional advisors
icv	Civil Engineer	dip	Project Manager
clt	Client	lab	Quality Control Laboratories
die	Construction Manager	qmr	Quality Management representative
eds	Design team	css	Safety and Health Management representative
emr	Environmental Management representative	icl	Services Engineer
dsi	Interior Design	ist	Structural Engineer
imb	Main contractor	mcl	Subcontractors
itc	Maintenance manager	mtc	Supplier
mcn	Marketing representative	ctc	Suppliers of finance to the clients

7.5.6. Attribute

"The **Attribute** is the format of the document".

The metadata 'Attribute' gives the format such as a Word Document, an Excel Document, an AutoCAD Document, etc. The different 'Attributes' are: word, excel, access, power point, winproject, CAD, image, web, e-mail, etc.

Table 15. Attributes of documents

Id	Attribute
dc	word Document .DoC
xl	eXceL Document .XLs
pp	Power Point Document .PPt
md	access Document .MDb
wp	Win Project Document
dw	DraWing Document .DWg
im	IMage drawing .gif, .tiff, .jpg, bmp
hm	web Document .HtMl, .HtM

7.5.7. Type of document

"The **Type of document** is the document-related metadata concerning the stored information".

Each Document can be classified depending on the stored information:

Table 16. Types of documents

Id	Document	Id	Document
tad	Administrative procedures	inv	Invoice
ann	Annexes	cts	Letters
rps	Answers	lcp	Licences
afd	Approvals	man	Manual
dac	Awarding	med	Measurements
oes	By-laws	reu	Meetings
pre	Budget	mem	Memory
cit	Catalogues	act	Minutes
crt	Certifications	ncf	Non-conformities
cmb	Change orders	org	Organization chart
idc	Communication reports	pgs	Payments
cnt	Contract	plf	Planning
pcc	Control Plan	prc	Procedures
ldd	Defects List	prg	Programming
pls	Drawings	rec	Receipt
fmt	Forms	ins	Reports
dgc	Generic documents	pdo	Request of tender
inc	Incidences	ldo	Site Book
sif	Information requests	snt	Site Note
pdi	Inspection Points	spc	Specifications
int	Instruction	orb	Tenders
seg	Insurance	fct	Turnover

As an example, below there is a description of some Types of documents:

- **Letters:** This category includes project announcements, letters of intent, letters of award, notices to proceed and bidding bonds. These legal documents are important in the tendering and bidding and can be easily handled in conventional ways or through electronic transmission.

- **Specifications:** This category includes general and special conditions, proposal forms, and technical specifications. Most specifications are expressed in text format.

- **Drawings:** Being prepared for presenting engineers' or designers' detailed ideas, plans, and engineering drawings, are always the thickest part of a project documents.

7.5.8. Related Documents

"**Related Documents** are those extra documents which are necessary for the entire understanding of the document".

Some documents might be self understandable so they must not need extra information; others might not. For example, a related Document of a Request for Information might be the drawing that we are asking for. The related Document of: FO005RIdc0302 might be: FO024PAdw0211.

In Figure 19 the definition of a document using metadata is summarized.

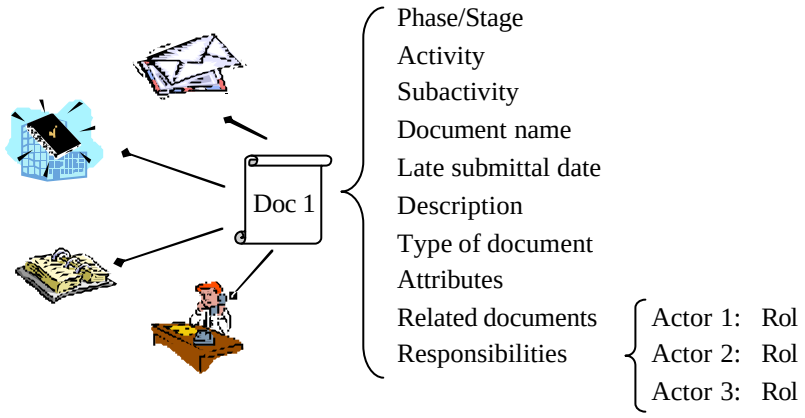

Figure 19. Metadata assigned to each Document

7.5.9. Relations to IFC standard and other organizational methods

As aforesaid, Industry Foundation Classes have created several entities in IFC model (IAI 2004), so that process models and, subsequently, project schedules, can be derived.

IFCs are a high-level, object-oriented data model for the AEC industry that have the potential to allow full interoperability between systems. *IFCs* deal with data that are fully structured according to a common standard.

For this reason, the following comparison and the relationships between the proposed system and the IFC is considered very important.

The comparison will be focused on the *Stages* of the system, on *IfcTasks, Responsibilities* of the system, on *IfcActorRole,* on *Document metadata* and *IfcDocumentSpecifications*:

7.5.9.1. Stages - Tasks

In the *Concept Model* we define *Phases* and *Stages* to locate each document thorough the life cycle of the project, and *Activities* and *Subactivities* to define the specific area of the project where a document belongs.

At the same level, *IFC* created the *IfcTask* entity and other attributes, both directly associated with the task and acquired through inheritance.

The attribute *'Name,'* that can apply to any object through inheritance from the core *IfcRoot* class, is asserted to define the process name.

The attribute '*Description*', similarly inherited from *IfcRoot*, is asserted to define the process description.

The IfcTask attribute '*Identity*' is used to assert the identity of the process in the matrix.

The IfcTask attribute '*WBSCode*' allows for the assignment of work breakdown structure; the IFC model allows for several such codes to be given to a task. In this case, the work breakdown structure can be used to assert the Phase where the document is used. Project phase/stage within the database is used to constrain the range of selectable documents/processes and not to define process sequencing.

The *'ObjectType'* attribute is inherited from *IfcObject* and can be used to determine whether the process in an action (cannot be further decomposed) or an activity (that can and should be further decomposed).

The following figure shows the relationship between some attributes of *IfcTask* entity and the location of a document in the proposed Concept Model. Notice that *IfcTask* provides information about *Phase*, *Activity* and *Subactivity* of a document, and, for instance, *IfcTask* gives a specific attribute to define the *Description* defined in our Concept Model as additional metadata.

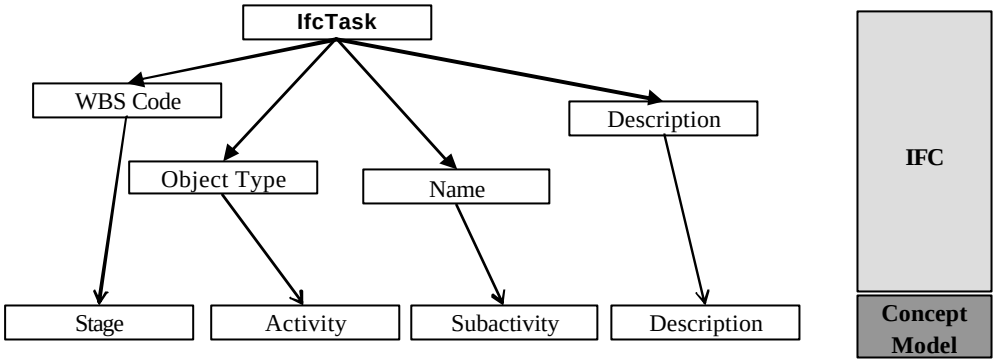

Figure 20. Comparison between IFC attributes of Ifc Task and the Concept Model

7.5.9.2. Responsibilities - Actor Role

The *Role* attribute of *IfcActorRole* is used to assert the actors that are engaged in the process communication. The *'UserDefinedRole'* attribute can be used to extend the roles beyond those provided by the current enumerated set within the IFC model. This Ifc attribute is similar to the metadata *Role* defined in the proposed system. And the *'User Defined Role'* gives extra information that can be compared to information stored in Stages, Roles, or Metadata packages of information of our database.

The *'Description'* attribute of *IfcActorRole* can be used to determine if the role is acting as a sender or receiver of information. This attribute reflects the same as the first level of metadata responsibilities, where sender is called create and receiver is called receive.

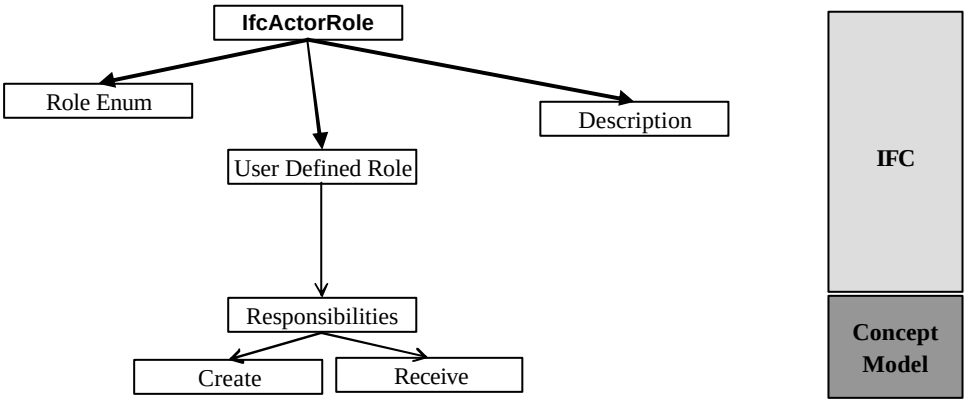

Figure 21. Comparison between IFC attributes of Actor Role entity and the Concept Model

7.5.9.3. Document metadata - Documents specification

The entity *IfcDocumentReference* is an objectified model reference to a project document and defines extra information of a document.

The *DocumentType* attribute describes the type of document referenced, providing a description, file extension and list of registered applications that can edit this document type.

The *DocumentName* File attribute gives the name or document name assigned by owner.
The *DocumentDescription* gives a description of the document.
The *Location URL* defines the pathname or physical location of the document.
The *DocumentOwner* attribute gives information about the person and/or organization acknowledged as the 'owner' of this document. In some contexts, the document owner determines who is entitled to access or to edit the document.
The *PreparedBy* attribute gives a list of people who have created this document.
The *CreationDate* attribute shows the date and time when the document was originally created.
The *Editors* attribute gives a list of people who have permission to edit this document.
DateOfRevision shows the date and time stamp when this revision was registered.
DocSectionReference gives optional reference to a section within the document.
DocumentScope gives the cope for this document.
DocumentPurpose gives the purpose for this document.
DocumentIntendedUse shows the intended use for this document.

7.5.9.4. Association to documents

The document association relationship establishes links between a document reference or document and any type of object. It considers that any type of object or property may be associated with a document. The use of the association relationship enables a single document to be associated with many objects. By using several instances of the association, relationship, a single object may also have many documents associated to it, if necessary.

As a full associated document information, the level of information -as normally found within document management systems, such as author, revision, access status, confidentially, document type, summary, etc. - is provided.

As a conclusion, Document reference defines information about the document type, owner, creation date, last modification date, revision, location, etc., basically the same information shown in the metadata category of the organization of documents of our database.

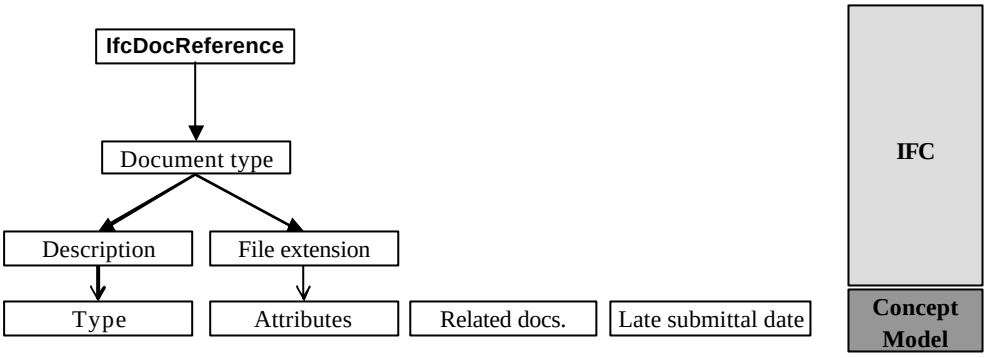

Figure 22. Comparison between IFC attributes of Document Reference entity and the Concept Model

Figure 23 shows Turk's (1994) conceptual schema, proposed to increase interoperability in construction documentation and also the relations to the system proposed in this thesis. The coloured boxes are the ones also set in the system.

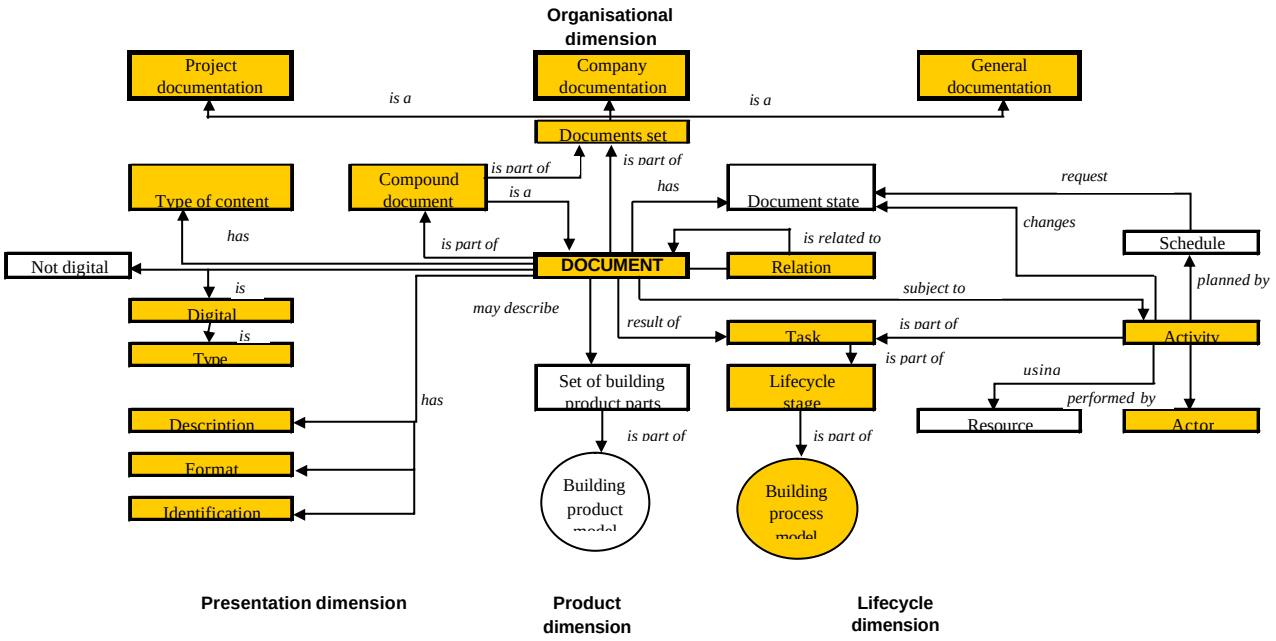

Figure 23. An international standard for construction document meta data could be very helpful to increase interoperability between commercial systems. The figure shows a proposed conceptual schema for such information (Turk 1994)

7.6. Formal presentation of the relations of the Documents

From the Map of the life cycle, actors, metadata, etc., of a construction project, a friendly, easily understandable organization of the contents arises.

The formal manner to present the relations of the documents is achieved by a three dimensional table suitable for database processing, that brings all stored information concerning a reference activity together in a box of a matrix. This approach has been adopted because, as experience shows, industry end users are not particularly familiar with formal modeling notations.

The next figure shows the basic organizational matrix used in the proposed system.

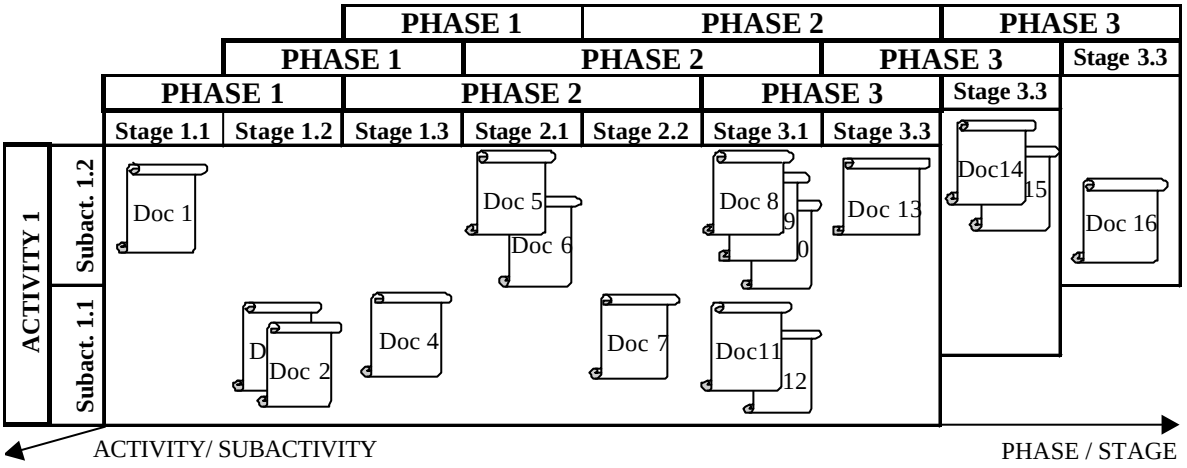

Figure 24. Basic matrix to access the guide information

7.7. Summary

Each project brings together different actors in an association solely for that project. Each actor has his own internal information system which must, in part, mesh with those of other actors. At the same time, each member will be engaging in other associations for other projects, each with a unique information system in whole or in part. The need, then, is for information transmitted and received to be in a common currency, to be in terms that require no translation. Where a group of people working together on an enterprise speak the same language, use the same terms in the same senses, and order communication between themselves or between their group and other groups in common units, there is no 'information problem'.

In this Chapter, rules of indexing and classification of flow and storage of information to standardize the project information are defined. Doing so requires content- and context-related properties of each piece of information.

From the study of different theories we reached to an organizational model for Information Flow based on the life cycle of the project, on the actors involved in it and on extra metadata of the documents, and we generated a friendly, easily understandable organization of the contents.

The formal manner to present the relations of the Documents is achieved by a three dimensional table suitable for database processing, that brings all stored information concerning a reference activity together in a box of a matrix.

On the x axis lays the organization of information by Phases and Stages. On the y axis lays the organization of information by Activities, and on the z axis lays the organization of information by Subactivities. Then, each box of the matrix contains information related to a specific Phase, Stage, Activity and Subactivity.

Each document is also provided with other additional information which makes it easy to search, retrieve, classify, etc. This extra information is called document metadata, and is a set of document properties such as name, description, type, etc., which describes and identifies the document

Another important point is the actors involved in the project and the function each actor is performing in a project, depending on the contractual arrangement.

This indexing and classification system will be used in the following chapters to develop the *Life cycle Document Management System* and the *Guidelines for Document Management through WPMS*.