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XPDL project: Improving the project documentation quality in the Spanish architectural, engineering and construction sector

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ABSTRACT

In this paper we discuss the results of a research project called eXtensible Project Documentation Reporting Language (XPDL). The main objective of this project is to improve the quality of the core project documentation that serves for supporting the construction works in Spain and to facilitate an efficient exchange of information between the stakeholders in the Spanish Architectural Engineering and Construction sector, in particular their relationship with the Professional Associations and Spanish control public bodies. Starting from the premise that high quality project documentation is the basic precondition for a good quality in all the phases of the whole buildings and facilities life cycle, the project is based on Internet, XBRL (eXtensible Business Reporting Language) and the new Spanish standards about the quality in the project documentation (UNE 157000 series). As a result, a new set of XBRL taxonomies has been developed to support the processes of elaboration, verification, sending to the Professional Association, digital stamping, delivery, control, compulsory registration and storage of the construction project core documentation by the public authorities. Our proposal can be extended to other countries, particularly in Europe, since regulations are becoming similar in all EU countries. The potential for spin-off technology utilization is also significant in the areas of insurance, inspection chamber, digital reporting and project management.

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1. Introduction

The Architectural, Engineering and Construction sector (AEC sector) is becoming more and more important in the world economy and its relevance will continue in the future. In all countries, the impact of this sector on the welfare of the citizens is very strong due to its outputs, as buildings, water or energy supplies, sewer systems, constructions, urban developments, industrial facilities, infrastructure works, transport networks etc. support all other economic and social activities, public and private. According to the last annual statistical report from the European Construction Industry Federation (FIEC) in the European Union (EU27) in 2006, the estimated construction investment was 1196 billion euros, which represents up to 10.4% of the EU Gross Domestic Product (GDP) and 50.5% of EU Gross fixed Capital Formation (GFCF). 15.2 million people work in this sector, representing 7.2% of Europe's total employment. This key role of this sector can be better understood by considering that 26 million of EU27 workers depend, directly or indirectly, on this sector. The sector is the biggest industrial employer in Europe (30.4% of total industrial

employment) [1,2]. In addition, construction activities consume large quantities of raw materials, "typically six tonnes per capita annually and its correspondingly large quantity of wastes. Buildings account for around 45% of Europe's energy consumption, with a further 5–10% being used in the processing and transport of construction materials" [3,4].

Today more than in the past, the increase in the standard of living and the economic progress is causing the growing of the society's demands about quality requirements for buildings, infrastructures, facilities and other construction projects, both in private and in public sectors. And this is especially important in Europe where to improve the quality of life is the core objective of the social and economic policies. As a consequence, regional and national public authorities concerned by the AEC sector activities are demanding more and more professional liabilities and core project documentation for the construction projects. In all European countries, the public national bodies in charge of supervision, monitoring, inspection, control and administrative authorization of the construction projects have to elaborate an increasing number of new legal dispositions and regulations to be applicable in the construction works (standards for environment care, security and health, prevention of fires, urbanism and so on). As those new regulations and standards, sometimes compulsories, are passed, the public national bodies require from engineers and architect firms to

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prepare an enormous quantity of documents to justify the compliance of the project with the requirements of laws and statutory regulations for client and authorities.

Therefore, specifications, planning permission, building regulations, legal authorisation and permitting are becoming more and more essential phases of the design and construction processes. This in turn increases project complexity and the amount of documentation supporting the projects, which generates bureaucracy and costs.

The solution to this problem is not simple as in this fragmented sector [5] there are many stakeholders (local and central public authorities, raw material providers, contractors, architects, engineers, consultants, quality control bodies,...), and many quality aspects involved in all of the stages of the whole buildings and facilities life cycle, ranging from the feasibility studies, design, planning and core documentation elaboration; to the construction, facilities management, refurbishing, demolition and final replacement. Clearly, to achieve total quality in the AEC sector activities, the improvement of the project documentation quality is not enough, as other important quality requirements have to be considered, such as raw materials quality control, quality management systems, like ISO 9000 series (specially ISO 10006 standard), regulations requirements, test quality in laboratories and so on. Nevertheless, high quality of the core project documentation is the basic precondition for a good quality in all the phases and processes of the whole buildings and facilities life cycle [6,7].

To face up this problem, the construction industry needs to improve the communication among stakeholders and to increase the efficiency along AEC workflow in the project-construction process, while reducing the costs associated with operations of the project documentation elaboration, distribution, utilization and storage. There are several trends to achieve these goals. On the one hand, more and more companies are choosing to move from a paper-based documentation to an electronic-based system, such as the web-based electronic document management systems (WEDMS) employed by the biggest companies [8,9]. In this manner, Information and Communications Technologies (ICTs) are profoundly changing the way in which companies carry out their activities in all sectors. This is also taking place in the AEC sector, where construction projects typically have long-life, paper-based cycles, and there are multiple parties involved in different activities within the project. However, unlike other industry sectors, construction has not developed a culture of continuous improvement through systematic analysis of performance in use of its outputs, because of the high fragmentation and the short-term relationships between stakeholders [3].

In this context, we are convinced that one of the more important research challenges consists in designing, developing, and implementing efficient systems for the exchange of data, documents, and the rest of required information among the players and stakeholders through all phases within an AEC building project.

Based on the Lisbon competitiveness and growth Agenda set out by the European Commission in February 2005, an E-CORE strategy for the Construction RTD in Europe was defined. This strategy identifies the changes required in the sector and establishes the main avenues in which RTD can support those changes [4]. To do so, the European Construction Technology Platform (ECTP) was born as an initiative to mobilise the whole construction sector – contractors, authorities, architects and other designers, purchasing bodies, and the full range of suppliers, clients and users – to change through Research, Development and Innovation, in order to satisfy the needs of society. The ECTP will act as an umbrella for research initiatives [10].

Analogously in Spain, the so called Spanish Technological Platform for Construction (*Plataforma Tecnológica Española de la Construcción*) has been promoted by the main Spanish construction firms (Dragados, OHL, NECSO,...), with the inclusion of Professional Associations, national bodies, such as the Ministry of Industry, Tourism and

Commerce as representative of the EUREKA High Level Group (HLG), other ministries, SMEs, universities and research bodies, in order to carry out research projects to improve the sector [11].

From our approach, one of the key points to be able to improve the quality in the AEC sector resides in the elaboration of a very good documentation that serves as a solid support for the execution of the construction projects. Furthermore, the lack of attention received by the quality of the documentation of a project as compared to other aspects in the project such as the quality of the materials, constructive systems, etc.) is surprising.

On the other hand, the eXtensive Markup Language (XML) and derivatives are currently the most important approach for data management and data exchange in our web-oriented world. XML-based standards are available for many applications and many industries. XML is the backbone of e-commerce, e-government and all other e-businesses.

This paper presents the results of a research project, called “XPDR”, jointly sponsored by the Spanish Industry, Tourism and Commerce Ministry and by the Spanish Superior Council of Official Institutes of Industrial Engineers, devoted to improve the quality of the project documentation that serves for supporting the construction works in Spain and to facilitate an efficient exchange of information between the stakeholders in the AEC sector, especially the compulsory relationships among designers, professional Spanish Institutes of engineers and architects and the government agencies.

The main result has been the creation and development of an open new standard to support all the processes of creation, elaboration, preparation, verification, transmission, sending, delivery, digital or by hand stamping, storage, aggregation, compulsory registration, approval, registration, administrative authorization and analysis of the project documentation, available for all the actors involved in the life cycle of the project-construction, based on Internet, XBRL (the eXtensible Business Reporting Language) and the Spanish standards about the quality in the documentation of projects (the UNE 157000 series).

The paper is structured as follows. In Section 2, previous research related to the project and to interoperability in AEC sector is briefly reviewed. Section 3 summarises some differences among construction regulations and control regimes by the governments in EU countries for the AEC sector and discuss the initiatives to create new standards for the quality in the construction project documentation, promoted by the Spanish body for standardization and certification (AENOR) and the AEC sector stakeholders involved. Section 4 shows the objectives of the XPDR project objectives and the methodology employed and it compares the AEC paper-based workflow with digital workflow. Finally, the last section is devoted to present the conclusions and future research.

2. Previous related research

The first generation of the web was essentially focused on the creation and publication of content with humans as the main consumers. The subsequent development of Internet related technologies provided AEC firms with low cost tools for improving project communications. This was a relevant advance, but the arrival of the second generation of the WWW which will be based on the addition of “meaning” to data and information, by the development of new semantic oriented tools and resources, opens enormous possibilities.

All researchers in the AEC area agree to point out to integration and interoperability, as stated by the NIST interoperability study [12], throughout all phases of the whole design–build project life cycle as one of the key points for improving AEC sector competitiveness. Interoperability allows collaborating firms to share electronic data between software applications, so that information flows from one computer application to the next throughout the life cycle of a project.

In this section a detailed review of the work done up to date by the main researchers in this area is presented.

Over the last two decades, a substantial body of research to improve interoperability and more integrated use of Information and Communication Technology (ICT) to support collaborative working in the design, construction, and life cycle applications in the construction industry have been developed [5,13–23]. Despite of many research projects and several standardization efforts, the progress was strongly slow during the 1980s and 1990s, however the speed of transfer from theory to practice is increasing rapidly since 2000 [24]. Although universal interoperability between applications will not be the near-term solution, data standards are being developed to guide the creation of more widely interoperable software applications.

Project Management discipline is defined by PMI as the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements and Project Communications Management is the knowledge area that employs the processes required to ensure timely and appropriate generation, collection, distribution, storage, retrieval, and ultimate disposition of project information [25]. All the players involved in construction projects (engineers, architects, contractors, suppliers, specialties, managers, manufacturers, software vendors, project managers, project team members, standards bodies, government agencies, customers and sponsor) should be aware and understand the importance of the communications and how they affect the project as a whole.

Currently, the standard project management approach in the AEC firms goes from email notification with attached, modified documents to a series of total web-based project management system [WPMS] solutions which have been shown to have tremendous potential for adding value not only to the internal performance of an organization but also to the whole supply chain [9].

From our point of view, effective communication and comprehensive core project documentation are two key components for a successful construction project. Currently, a high percentage of project information is paper-based (mainly construction documents, but also contracts, change orders, field reports, requests for information, and meeting minutes), so the project team generates a myriad of documents to effectively communicate and document the construction progress [26]. The impact on overall construction costs of out-of-date, missing or contradictory information, causing delays, mistakes and expensive re-building, is well known both to practitioners and researchers [5,27]. Due to these problems, it is urgent to improve the processes of communication and documentation on construction projects.

A great deal of previous research for document analysis and classification of text-based, web-based, and image based construction data on has been done in the areas of document management systems and document recognition (e.g., page decomposition and optical character recognition) [26,28–32]. Also, various data analysis tools were also applied on text data to create thesauri, extract hierarchical concepts, and group similar files for reusing past design information and construction knowledge [33,34]. Ei-Diraby et al. [35] developed, as part of the e-Congos project, a process-centred domain taxonomy that allows existing classification systems to be used. Caldas et al., develop a prototype system, called Unstructured Data Integration System (UDIS), developed to classify, retrieve, rank, and associate documents according to their relevance to project model objects [36].

However, in spite of advances for managing the processes, products, documentation and communication, the AEC sector is still highly fragmented. Although there are commercial solutions integrating CAD, ERP scheduling and management tools, ICT-supported construction project management (CPM) processes are mainly defined in terms of the used applications, and not on the basis of generalised industry requirements. The truth is that the application of ICT to the AEC sector has obtained poorer results than in other industries [37–39].

While construction documents have not undergone major changes since the middle of the 20th century and they look much the same as decades earlier [5,40], the technologies for producing, managing, duplicating and distributing such documents have greatly evolved from the introduction of photocopying in the 60s, through fax and the generation of documents facilitated by word-processing and spreadsheet software with personal computers and the introduction of CAD in the late 80s. Nevertheless, the transfer of the information was still done as paper copies in the mail or using couriers although diskettes could reuse the information in digital form. However, the major change took place with Internet in the 90s, which has radically enhanced the possibilities for data transfer and the use of document management systems for project documentation in the construction industry [41,42].

As a result of this evolution, one of the most important ICT-applications in construction nowadays includes the use of Electronic Document Management Systems (EDMS). The application of the principles of Project Management theories has led to the development of Web-based Project Management Systems [WPMS] for construction projects. However the implementation effectiveness is not yet as high as initially expected, since there are many factors that can greatly impact system performance. Several empirical studies are being carried out to capture these important factors and their cause-effect relationships with system performance. [8,21,41]

Of particular interest in our research is a recent survey carried out in Spain where Forcada et al. [42] present the situation of the construction companies in Spain with respect to their use of ICT, particularly DMSs and WPMSs. The results show that nearly all companies in the survey centralise their documentation in a server and use document templates, but the organization of the documentation remains a problem due to the different types of documentation needed for each project. A conclusion of the survey is that traditional procedures need to be redesigned in order to ease the exchange of data and to take advantage of the new opportunities offered by the web [42]. In addition, our practical experience in the AEC sector shows that in the Spanish AEC sector it is needed more usage and investment in ICTs to improve EDMS and WPMS applications, particularly among SMEs and individual engineers and architectures practitioners.

Practitioners involved in AEC computing sector have always complained of the lack of interoperability, classically phrased as the “islands of automation problem”. Commercially available software products typically address part of the constructed facilities product or process, but there is no provision for systematic interaction and integration of the isolated individual implementations. This lack of a “common language” has proved a persistent barrier to realizing in practice the possible benefits of more advanced computing approaches [24,41,43–47].

Although practitioners recognize that very much time and money could be saved by ICT application to AEC sector, the distance between theory and practice is still very big. As Hjelt and Björk say “the effective management of the vast amount of information needed to design, construct and maintain buildings is a formidable challenge” [5]. A recent research sponsored by nine US industry associations to assess the interoperability of software applications and platforms serving the building community and based on responses from a representative sample of 295 architects, engineers, contractors and owners, shows that about 3.1% (on average) of project costs are related to non-interoperability of software. Particularly, manually re-entering data from application to application ranks the highest at 69% with 75% of engineers reporting it as a primary cost [48]. In this vein, another research from the Norwegian buildingSMART program found that the same data is entered into a computer program at least seven times during a building project and that as much as 30% of typical costs are related to non-building activities [49].

There are too many barriers to achieve seamless interoperability within the AEC industries. According to the McGraw Hill report

mentioned above, software incompatibility is the largest obstacle to interoperability together with high costs and expenditures coming from training and time spent on translation when switching to programs allowing interoperability [48]. Other reasons for not interoperability are the fragmented nature of the industry, psychological resistance to change [8,9] and that software developers do not invest money on new set of standards because these companies do not see the monetary benefits. Finally, we agree with Rezgui et al. [50] that one of the most important obstacles is the lack of consensus among the main international organizations that are developing those standards. Perhaps for us this lack of process **standardization** hinders their use.

To face these problems of integration and interoperability, a huge amount of research has been done in the last two decades in order to define new methodologies and tools for documenting the information requirements for the design, construction and facility management processes. As a result, advances in object-oriented programming, database systems and product data modelling technologies, have provided a strong framework for advancing in this integration. Special consideration in regard with this paper is given to the efforts to standardize the data and the interfaces needed for automatic exchange of information between the information systems of construction project participants.

We shall review two different approaches, the first one is the XML-based schemas [20,45] and the second is the framework based on object-oriented databases, such as those based on Industry Foundation Classes [IFC] developed by the International Alliance for Interoperability [IAI] [51,52], and the ISO 10303 [53]. The emerging initiatives that specifically address interoperability for the AEC industry are based on the eXtensible Markup Language (XML) as the common language, which is used to describe semantic content of information generated in the domain of building design, construction, and operation. The following initiatives should be mentioned:

- 1) bcXML. The acronym “bcXML” derives from “Building Construction Extensible Markup Language” [bcXML]. The creation of this XML-based standard was funded by the European Commission and included a ‘pan-European group of construction-related organizations’ through “The eConstruct project” to develop a new Communication Technology specifically tailored to the needs of the EU industry. It supports electronic business between clients, architects and engineers, suppliers [of components, systems and services], contractors and subcontractors; is integrated with e-commerce and design/engineering applications, and it supports virtual construction enterprises over the borders of the individual European member states. Moreover, bcXML has been adopted as the format to import taxonomies into the construction-oriented ontology that was developed in the IST e-COGNOS project, which implements a Knowledge Management infrastructure tailored to the needs of the construction industry. The e-COGNOS ontology was developed taking into account the IFC model, the bcXML MetaSchema/Taxonomy, the BS6100 Classification, the SUMO ontology, and the DAML + OIL language. [43–45]
- 2) aecXML. Although initially promoted by Bentley Systems in 1999, aecXML is now a standard recommended by the IAI [International Alliance for Interoperability] and a XML-based language for representing information within a business to business communication in the AEC industry. The name “aecXML” groups “Architectural, Engineering and Construction”, and XML [54].
- 3) ifcXML, an XML representation of the IFC EXPRESS model developed by the IAI [55].
- 4) BCIS for Cost Analyses in XML format so that they can then be imported straight into compatible estimating systems [56].
- 5) ifc-mBomb, an XML Schema for sharing project information modelled in CAD applications, defined by IAI as an IFC **Model-Based Operations and Maintenance** project [57].

- 6) agcXML is a suite of XML schemas for exchanging construction project information between software applications used by facility owners and AEC firms [58].
- 7) CityGML, an open data model and XML-based format for storing and exchanging virtual 3D city models [59].
- 8) ebXML (electronic business using eXtensible Markup Language) is a modular suite of specifications that enables enterprises to conduct business over the Internet, it has been promoted as a joint initiative of the United Nations Body for Trade Facilitation and Electronic Business (UN/CEFACT) and the Organization for the Advancement of Structured Information Standards (OASIS) [60].
- 9) gbXML (green building XML), an XML schema developed by Green Building Studio, Inc. to facilitate the transfer of building information stored in CAD building information models, enabling integrated interoperability between building design models and a wide variety of energy analysis tools [61].
- 10) LandXML to facilitate the exchange of data during land planning, land survey and civil-engineering processes [62].
- 11) Finally, the eXtensible Business Reporting Language (XBRL) used in our project, was born in 1998 with the objective to simplify and automate the exchange of **financial** and business information. XBRL has been adopted by a large number of enterprises and central banks in many countries [63].

Among the object-oriented databases we must first cite those based on Industry Foundation Classes (IFC) born in the 90s and developed by the IAI [51,52], and the ISO 10303 [53] series Standard for the Exchange of Product Data (STEP). IFCs are a high-level, object-oriented data models for the AEC/FM industry, where data elements represent parts of buildings or elements of the process and contain the relevant information about those parts. IFCs are used by computer applications to assemble a computer readable model of the facility that contains all the information of the parts and their relationships to be shared among project participants. These models are continuously improving and maturing towards a true standard for cooperative model-based working processes in AEC/FM [64].

STEP was the origin of the development of current AEC EDI standards, intended to be an open set of standards for data exchange and sharing to help engineering coordination. The international adoption of the standard began in 1994 through the International Standards Organization as ISO-10303. The standard is now known as ‘Industrial Automation Systems and Integration: Product Data Representation and Exchange’ [65] and consists of a number of Parts, Resources, and Application Protocols [APs]. APs are a set of exchange standards governed by a product model in the EXPRESS language. Examples of APs include: AP230 “Building Structural Frame: Steelwork” and AP228 “Heating, Ventilation and Air Conditioning” protocol. Parts can be considered specifications for STEP. Part 21 governs the format of the STEP File Structure. A STEP data exchange file is divided into two sections: Header and Data. The Header contains exchange structure data, such as file conformance and file name. The Data contains the information to be transferred, including physical project data. The project data, such as member type, attributes, and locations, is represented using EXPRESS. Part 11 specifies the EXPRESS modelling language [66].

From the first efforts at integration motivated by the increasing use of CAD in design offices in the mid 80s and the necessity of transferring CAD data from one system to another which resulted in de facto standards that persist to this day (such as the Drawing [or Data] Exchange Format – DXF [67] or the Initial Graphics Exchange Specification – IGES – and its successor the Product Data Exchange Specification [PDES] of the American National Standards Institute [ANSI]) until the more coordinated efforts of the STEP application protocols for construction which resulted in ISO 10303, part of the International Standard for the Exchange of Product Model Data, a lot of work has been done.

A sub-domain well developed has been in the steel industry with the CIMSteel project [68], also known as the EUREKA Project EU 130. This project began in Europe with the collaboration of nine countries and 70 organizations. The objectives of the project were to reduce design and construction times, and produce more economic steel structures. A result of the project is the CIMSteel Integration Standards [CIS], which allow the exchange of information throughout the steel design and construction process. In 1999, the American Institute of Steel Construction launched a second release, CIS/2 as the interoperability interface of choice for the AISC EDI initiative [69]. The CIS/2 includes the logical product model and electronic data exchange format for structural steel project information. It has been adopted by the American Institute of Steel Construction as their format for electronic data interchange. CIS/2 has been implemented by many steel design, analysis, engineering, fabrication, and construction software packages to create a seamless and integrated flow of information among all parties of the steel supply chain involved in the construction of steel framed structures. NIST is helping software vendors implement the standard; helping steel designers, detailers, and producers use the standard; and is part of the CIS/2 International Technical Committee which oversees the standard and has released of second edition of CIS/2. NIST has developed a translator from CIS/2 to IFC to assist software developers in implementing IFC entities related to structural steel and to help end-users move CIS/2 information into IFC importing applications. CIS defines its supply chain as information contained within the design, detailing, scheduling, tendering, ordering, purchasing, and payment of structural steel buildings. CIS is similar to AP230 in that it relates information about the steelwork in structural frame buildings. However, it is a less formal version of the STEP protocol. This reduces the time necessary to establish the AP and made CIS more practical. CIS uses the STEP Part 21 exchange format as its file format.

Other initiatives from academic research are the RATAS model [69], ATLAS [70], the COMBINE Integrated Data Model [71], OPIS [72], and the AEC Building Systems Model [73]. One of the last projects has been the IFC Model Server from VTT of Finland [74] designed to host entire building models described in the IAI IFC format.

The last applications, termed as building information modelling [BIM] applications, adopt advances from ATLAS and COMBINE, whilst still relying on data exchange standards or API level customisation for interoperability/integration. Recently, the American National Institute of Building Sciences has created a committee to look into creating a standard for lifecycle data modelling under the BIM banner [75]. The idea here is to have a standard that identifies data requirements at different lifecycle stages in order to allow a more intelligent exchange of data between BIM enabled applications. Another interesting initiative is BuildingSMART, also promoted by the IAI to accelerate achieving the dynamic and seamless exchange of accurate, useful information on the built environment among all members of the building community throughout the lifecycle of a facility. There are also efforts on roadmaps for the adoption of BIM modelling as FIATECH from the European Commission, the Associated General Contractors of America, the U.S. General Services Administration [GSA], U.S. Coast Guard, U.S. Army Corps of Engineers, as well as in Denmark, Finland, Norway and Singapore.

The National BIM Standard [NBIMS] states that a Building Information Modelling [BIM] is the electronic model for the main features of any industrial plant. For the BIM functioning, a certain level of collaboration between the different parts involved is needed. This process of collaboration will take place during the whole facility life cycle.

Other research projects and programs that can be highlighted are:

- 1) FIATECH project, before mentioned, is developing XML specifications to automate information exchange among software systems that support capital facility equipment engineering, procure-

ment, construction, and operations and maintenance work processes [76].

- 2) BUILD NOVA – Building innovation in the European Construction Sector [77].
- 3) COSPACES – Innovative Collaborative Work Environments for Engineering [78].
- 4) COVES – Collaborative Virtual Engineering for SMEs [79].
- 5) e-NVISION – A New Vision for the participation of European SMEs in the future e-Business [80].
- 6) ERABUILD – Sustainable development in the construction and operation of buildings ERA and EUREKABUILD – Umbrella project for launching research projects under the EUREKA program, [81].
- 7) KNOWLEDGE is a research project focusing on the analysis, exploration and improvement of training systems dedicated to specialists who deal with building inspection in the European countries [82].
- 8) SARA – Towards value networking in construction in Finland [83].
- 9) STAND-INN – Integration of performance based building standards into business processes [84].
- 10) SWOP – Semantic Web-based Open engineering Platform [85].

Very similar to our proposal, although later in time, it was the start-up from USA of the AGCxml standard in 2006, promoted by the Associated General Contractors of America [AGC] and the National Institute of Building Sciences [NIBS]. AGCxml consists of a set of standard industry schemas for exchanging electronic data among AEC business process software applications in order to increase efficiency and collaboration among facility owners and design and construction professionals [38]. Analogously, the Centre for e-Business in Construction is developing the project CITE [Construction Industry Trading Electronically] to define an XML Tendering Standard. The CITE XML Tendering Standard will allow all types of tendering information to be exchanged, not just bills of quantities but also information about the contract conditions, the specification and drawings. Similarly, the storing and sending of post-contract information between the design team, contractors, subcontractors and suppliers will benefit from the adoption of agreed XML formats. Information will become more readily accessible and retrievable with less human intervention [86].

All these proposals represent the first steps in creating the ability to streamline information flow through each business process while at the same time maintaining and improving the ability to share information between business processes. In this sense, Boddy et al. [67] propose a re-focussing of computer integrated construction [CIC] research on the relatively under-represented area of semantically described and coordinated process oriented systems to better support the kind of short-term virtual organization that typifies the working environment in the construction sector.

3. The construction regulations and control regimes for the EU AEC sector

AEC sector regulations and control regimes differ between EU member states and there are not two member states having the same system. For most buildings, some form of building permit is required (after checking the construction documentation for compliance with planning criteria and for compliance with building regulations). This is followed by a system of site inspection, and ends with issuance of a completion certificate, fire certificate or other approvals of the finished building. There are varying exemptions for small buildings, un-occupied buildings, extensions, or civic/military buildings. However, the situation is not the same in all countries. The more regulated countries in EU are France, Germany, Portugal and Spain, and there are less mandatory requirements in Nordic countries and the British Isles [87].

A standard is a voluntarily applied document that contains technical specifications based on the results of experience and technological development. Standards are the result of consensus among all the parties that are interested and involved in the relevant activity. They must also be approved by a recognised **standardization** body. In Spain, the Spanish Association for **Standardization** and Certification (AENOR) is the responsible body for developing Spanish standards termed UNE Standards. Also it is a full member and Spanish representative of the International, European, and regional **standardization** bodies (ISO, IEC, CEN, CENELEC, ETSI, COPANT), As other EU **Standardization** Bodies, in the AENOR structure, there are technical bodies, known as **standardization** technical committees that study and present the needs of each sector, and develop and approve standard drafts which are later published as UNE standards. Each committee has an approved number, title, composition, and scope [88]. As stated in Section 2, one of the first steps to improve the quality of construction projects is to pay attention to the beginning of the life cycle project-construction, which is to improve the quality of the documentation supporting the project. In Spain, this task is being carried out by the AEN/CTN 157 Committee of AENOR [88].

4. XPDRL project research objectives and methodology

If we think about paper documents, no sector generates more paper per hour than governmental agencies and control bodies making permits, licenses, certificates and so on. Although the situation is changing, governments run on paper and much of it needs to be signed. Electronic signature helps administration to greatly reduce the cost of using and moving paper. Therefore, nowadays, there is a very important trend to use e-Government services for the relationships between citizens and the public governmental agencies. This is happening in all economic industries and the AEC sector is not an exception.

In many industrialized countries, specifications, planning permission, building regulations, legal authorisation and standard forms, are an essential part of the design and the construction processes. The amount of paper used, carried around, signed and stored by the professionals of the AEC sector, becomes incalculable. Also, many system management tasks, such as service verification and re-configuration due to changes in the law, are often performed manually. This is error-prone and requires an enormous amount of time.

In this paper we focus onto the Spanish case, although we believe that many of the procedures and problems are common to all countries.

The AEC workflow is based on a series of coordinated and interconnected events between all the stakeholders: industries, professionals, clients and users, public authorities and so on. Usually, a project starts with an idea from the owner. Then, a designer (architect or engineer) elaborates a working document that may require multiple iterations until the generation of the final version that constitutes the documentation to support the project. Usually, these **project-construction** documents include two-dimensional (2D) drawings and budgets, and most of them contain written text.

Project documentation is generated using a set of tools, such as Microsoft Office (Word, Excel, PowerPoint, and Visio), Microsoft Project for the Project Plan or some EDMS-ERP toolset for document management control, issue management, status reporting, project calendar, etc. All of these documents (including the drawings generated by some CAD tool) are converted to the PDF format, whose use is widespread given its advantages in front of alternative products [89]. Regardless of the procedure, high quality documentation is vital to a successful construction and project management.

In Spain, starting-up a building or an industrial facility needs the requisite authorization of the corresponding administrative body. Aside, there exists an administrative system to supervise the compliance of all relevant regulations by all stakeholders taking part in the design, construction and maintenance of industrial facilities.

More recently, a Building Technical Code was passed in order to set the basic quality requirements, which may be fulfilled during the project development phase and during the building construction and maintenance. As the competencies are distributed among the state, the regional governments and the municipal authorities, many times, it is costly and difficult to determine exactly which laws apply to a project, comply with all the laws during the design stage and remedy non-compliance during/post construction. Moreover, costs of not complying with the law can be huge.

Although many professional and organizations are involved in the life cycle of a constructed facility; owner, designers (architect, structural engineer, mechanical engineer, etc.), contractors (general, site work, concrete, mechanical, systems, etc.), regulators, financiers (construction loans and long term finance), occupants, maintainers, refurbishing, etc. It is infeasible for all of them to acquire and use computer hardware and software from the same vendor, or to maintain such hardware and software for the 50 year life typical of a constructed facility. The alternative to automatic exchange of information between dissimilar computer systems is to accept the costs, delays, and mistakes involved in manual transfer of data from one computer's output to another's input [21].

Among all of them, in Spain, the more important role is performed by the Spanish Official Institutes of Engineers and Architects. They are public legal entities of obligatory membership for freelance professionals of architecture and engineering and voluntary membership for those who either do not **practice** or do so under other systems and are therefore not legally obliged to join the Association (civil servants, lecturers...). These Institutes ("Colegios Profesionales") represents all active professionals in the AEC sector in Spain and are the state delegates into them the authority to certify the qualification of the professionals in AEC (engineers and architects).

Furthermore, other types of professional work such as preliminary designs, feasibility studies, etc. require the visa from the corresponding Institute. Therefore, the project visa is compulsory and regulated by law whenever the projects should be presented to the Public Administrations to obtain the corresponding report, concession, or to obtain the legal authorization of the facilities and buildings projects. By means of the visa, the Professional Institute:

- 1) Certifies that the author(s) of the project posses the required professional and legal qualification to carry out the project.
- 2) Certifies the authentication and completeness of the supporting documentation.
- 3) Checks the compliance of the project with the relevant laws, standards, and technical dispositions.

For decades, this process of project visa has been carried out manually according to the following steps:

- 1) First, the authorized designers (engineers/architects) elaborate and sign the construction project core documentation (called in Spain "official documents").
- 2) These "official documents" has to be sent (physically transported) by the designers to the offices of the respective Professional Associations or Institutes because every single page should be stamped by them in order to be valid.
- 3) Finally, the documentation has to be sent to the corresponding bodies for authorization purposes.

From the point of view of the Institutes, the project visa procedure consist on: reception of the Project documentation, checking the qualification of the author, checking the completeness of the documentation, and checking that its content complies with the legal norms and standards.

Therefore, Professional Associations and Institutes all over Spain receive millions of projects and other technical documents which have to be signed and stamped. They validate the signature from the members and sign by hand or automatically millions of documents. In

many occasions, these projects contain an enormous amount of documentation that should be transported using vans, e.g. in the case of refineries, or big industrial facilities. Several copies of the full documentation are required. Moreover, if the project experiences some change, it is required to modify the documentation and to repeat the process of impression, drawing, packaging ... as mentioned before, every single page in the document should be checked and stamped. This long procedure includes queues, long waits and document transportation – sometimes with huge boxes or trucks.

Until recently, all of these procedures were performed manually, although in the latest times these Institutes are offering the possibility to change it by a digital stamping by means of digital signature and electronic document management systems via Internet.

Digital stamping allows members of Professional Associations or Institutes to sign their documents electronically. Electronic signatures are legally valid as handwritten signatures since autumn 1999. Digital stamping speeds up the stamping procedure and saves time, costs, paper, space and efforts. Obviously, electronic signature software and pads for the capture, binding, authentication, and verification of electronic signatures in digital documents is needed. Therefore, digital stamping guarantees the identity, qualification and authorization of the person that signs the core project documentation, providing also authentication, registration and the accuracy of the files according to applicable legislation and without changing the content of the project. For example, members of Associations could have an electronic signature issued by the Association to which they belong to.

Generally, a member of the Association turns his projects into PDF documents using Adobe Acrobat and sign them electronically, usually using PDF standardized format from Adobe in order to add the author's signature, because of the spreading of PDF format among the business world. With the e-certificate, electronic documents and digital signatures replace paperwork and traditional signature in all documents created as a part of a professional's job.

Once the project documentation has been digitally signed by the authors, it is sent to the authorized Professional Association or Institute. There, digital signatures are verified and documents are automatically registered for its approval and certification. The Association receives the PDF documents by email or in a web page already signed by its members. The electronic signature tool, installed in the server, validates the signatures from the members of the Institute. After validating the signatures, the Institute signs and stamps automatically thousands of documents per hour. Later, the system makes the stamped documents available to members and saves a copy for the Institute.

The digital stamping serves to:

- Replace printed jobs in paper, standard forms, specifications, planning, drawings, regulations by electronic documents in PDF format.
- Replace a hand written signature by a secure digital signature compliant with legal authorities.
- Replace delivering documents in person and waste of time in deliveries of documentation by fast and easy electronic mail (email, FTP).
- Replace the traditional and physical storage and filing of folders in shelves by the storage in electronic format (hard disc, CD, DVD, etc.).
- Replace traditional stamp by electronic certificate.
- Replace collecting documents in person once they have been approved and certificated by the according authority, by receiving these approved documents automatically (web, email).
- Replace traditional payment methods by electronic transactions.

All these changes imply very important savings in time and cost for all players involved. The advantages for the professional consists on the simplification and speed up of the visa project process, as all steps can be done via Internet, also avoiding the need to move to the offices of the Institute. Another advantage is the possibility to track the status

of the documents. From the Institute viewpoint, the advantages reside in increasing the quality of service. It also opens the door to directly communicate with the different administration bodies. The storage of the documentation is also greatly simplified.

Every project starts with a definition of scope, a document on which the design is formulated. The design process defines the structure of a project and the contributions made by various specialties and disciplines. Once the Project starts, the main goal of the Project Management Board is to verify that the Project is completed according to the design, with the required quality, within the estimated budget, and in due course. As in any other project, building and construction projects require tight coordination among a large number of different players during all stages of the project in order to reduce costs and risk. Aside, this task is usually carried out under enormous time pressure. A requirement to achieve this is to have a good documentation that serves as a basis for construction works project management.

Following PMBOK [90] the key stakeholders on every project include: Project manager, Customer/user, Performing organization (contractors), Project team members, Project management team, Sponsor (owner), Influencers and Project Management Office (PMO), if it exists. In the AEC projects, these influencers are: Designers, Architects, Engineers, Cities, Regions, and other government agencies, Materials and equipment manufacturers and suppliers, Services Providers, Business and Professional Associations, Financial institutions, Temporary or permanent lobbying organizations, and Civil society-at-large, among others.

The communication among those stakeholders is done mainly through text-based documents and it includes construction documents, specifications, quality assurance documents, progress reports, procedures and maintenance manuals. AEC is an industry in which documentation is the basis for the delivery of products and services. Certainly, for engineers and architects the only tangible commodity they deal is documents.

Sharing and archiving documents requires a safe, small and smart format, a role for which Adobe's Portable Document Format (PDF) is suited. PDF has become the *de facto* standard for submission and distribution of these documents in government and regulatory agencies, world-wide [89]. This is a partial solution to the problem, as it happens that information has to be duplicated in order to address different audiences or accommodates minor changes and many costs are associated with document management such as printing, copying, distribution, filing and storage. Also, users will need access to complete copies and incremental updates. On the other hand, accessibility of information within a document is dependent on the size of the document, the richness of the index and the proximity of logically related information. Whilst having an entirely electronic information system ensures that relevant documents can be transported electronically, the access to information within these documents may still prove difficult [91]. As a consequence, it is necessary to favour the communication between all of the different stakeholders in the design-construction life cycle: manufacturers of construction materials, products and equipment; designers; consultants; contractors; owners and operators of buildings, plants, infrastructure and facilities; standardization agencies and technical approval bodies; local and national governments [3].

As we have shown, the public national bodies demand to the engineers and architects firms that elaborate an enormous quantity of documents so every time more, specifications, planning permission, building regulations, legal authorisation and permitting are becoming more essential phases within the buildings, constructions, and facilities life cycle.

At the same time, the development of Internet related technologies with the arrival of the second generation of the WWW which will be based on the addition of "meaning" to data and information, by the development of new semantic oriented tools and resources, will

enable to the players of the AEC sector improving their project communications. In fact, the development of the electronic project visa, opened the door to apply ICT to check the Project documentation automatically. As a result, by the end of 2005 the authors in this paper began a research jointly sponsored by the Spanish Industry, Tourism and Commerce Ministry and by the Spanish Superior Council of Institutes of Industrial Engineers, whose aim was to develop an open digital standard to improve the quality of the AEC projects and to increase the efficiency and effectiveness of all stakeholders taking place in the AEC sector. To achieve this goal, the following objectives were set:

- 1) To develop a standard named XPDRL (eXtensible Project Documentation Reporting Language) able to specify the minimal set of content in project documentation. XPDRL is to be based on XBRL and on the national standards UNE 157001:2002 ‘General criteria to develop projects’.
- 2) To apply the XPDRL taxonomy to the automation of the project visa in the Professional Institutes.
- 3) To evaluate the implications and consequences of the adoption of the aforementioned taxonomy by the different stakeholders from a technical, economic, and social perspective, regarding five specific processes:
 - The procedure of obtaining the project visa,
 - The storage, maintenance, dissemination and consultation of the data and information of projects in Spain, making it available for all stakeholders while guaranteeing the intellectual and property rights of the authors or owners of the project,
 - The automation of the internal control procedures carried out by the Institutes as well as the external control procedures carried out by the corresponding Administration bodies,
 - Development of auditing systems and statistical analysis to the aforementioned processes,
 - To analyse the internationalisation of the XPDRL proposal.

The XPDRL project development was organized in three phases: The first phase consisted in the development of XPDRL taxonomies for the AEC sector in Spain. The second phase consisted on the use and adoption of these XPDRL taxonomies by the Institutes for the project visa process. The third phase consisted in the maintenance, use, enhancement, analysis and evaluation of these taxonomies by the rest of the stakeholders in an AEC project life cycle. The project is currently in the third phase. During the first phase, up to eight modules of the taxonomy based on the UNE standards [88]. These standards describe the set of metadata to be included, the format and the structure of the different data as well as their relationship among them. From a technical perspective, these modules are XML schemas that comply with the standards established by the XBRL specification. Among these modules, one is common to any type of project while the rest are for project-specific (see Table 1).

The modules of the taxonomy also include the different ‘linkbase’ of the core taxonomy. The linkbase are part of the XPDRL specification and their goal is to give information on the different elements defined by the taxonomy. For each UNE standard within the 157,000 series, four files were created with the following names: pd157nnn.xsd, pd157nnn-label.xml, pd157nnn-presentation.xml, and pd157nnn-report.xml. Table 1 summarizes the number of items for each of the eight modules in the taxonomy.

The core module of the taxonomy (pd_157001) consists of 437 elements, from each 66 are abstract and 371 are boolean (Table 2). The modular design facilitates the development of new taxonomies in order to add values to the list defined for the XPDRL taxonomy. In order to develop these items, we have adopted the L3C (Label Camel Case) convention. Under this approach, the names, identifiers and labels have been constructed in English.

In the second phase of the project, we have developed specific software to convert the project documentation according to the

Table 1 Types of projects covered by XPDRL taxonomy. t.1.1

UNE 157001	General criteria in the project design (core standard).	t.1.2
UNE 157601	General criteria for the project of general activities.	t.1.4
UNE 157701	General criteria for the design of projects intended for low voltage electrical installations.	t.1.5
UNE 157751	General criteria for the design of projects intended to centers of transformation and analogous facilities of receipt, maneuver and measure in high voltage, over to 1 kV and up to 66 kV included.	t.1.6
UNE 157921	General criteria for the preparation of studies of environmental impact.	t.1.7
UNE 157922	General criteria for the production of environmental impact studies for railroad and roads projects.	t.1.8
UNE 157923	General criteria for the products of environmental impact studies of projects for irrigation.	t.1.9
UNE 157924	General criteria for the products of environmental impact studies of projects for dams.	t.1.10

XPDRL taxonomy (Fig. 1). Currently, pilot testing is being carried out in the Official Institute members of the project. The tests consist on the automatic generation of a number of documents required for the authorisation process. Besides, a web portal has been created, where the different taxonomies have been published, making them available to the rest of the stakeholders (available at the intranet of <http://www.ingenierosindustriales.es>).

Regarding the technology employed, XBRL (eXtensible Business Reporting Language) was originated in 1998 by Charles Hoffman, expert accountant and auditor with the objective of simplifying the automation of financial information exchange by means of XML. Currently, XBRL is administered by an international consortium (XBRL International Incorporated) constituted by up to 500 organizations, including government agencies, consulting companies, and software developers. XBRL International is structured in national jurisdictions, which are institutions that promote the use of XBRL at a national level and develop the XBRL taxonomies to define the requirements of the financial information for a specific domain. The taxonomies are a set of metadata that describe the data to include, their format and structure, and the relationships among them. Technically, these taxonomies are XML schemas that must enforce the XBRL standards. On the other hand, the data to be reported are represented by XBRL instances. Fig. 2 offers an overview of the XBRL standard.

Unlike HTML, which utilizes meta-labelling to specify the visual format intended for the information transmitted, XML provides additional information (meta-information) on the precise nature of the datum in question. XML is the de facto standard [92] in telematic transmission and in the storage of information. However, many XML initiatives have been put into operation for vertical or horizontal B2B transmission, such as ebXML, RosettaNet, HL7, and cXML. The diversity of XML formats causes difficulty in facilitating exchanges of XML-based data. For this reason, a new language based on XML has been created specifically for use in the area of project management and AEC sector.

Table 2 Modules in the XPDRL taxonomy. t.2.1

Module	No. of elements in the module		
	Total	Abstract	Boolean
pd-157001	437	66	371
pd-157601	497	61	436
pd-157701	502	74	428
pd-157751	589	72	517
pd-157921	428	57	371
pd-157922	459	61	398
pd-157923	482	61	421
pd-157924	479	60	419
	3873	512	3361

ACCESO REPOSITORIO Consejo General de Colegios Oficiales de Ingenieros Industriales de España

nombre de usuario

contraseña

REGISTRAR

Petición Claves


PROYECTO XPDRL

TITULO ABREVIADO:
 Parametrización y transferencia de un estándar digital para la gestión de información sobre proyectos ingenieriles en España.

TITULO EXTENDIDO:
 Parametrización y transferencia de un estándar digital abierto para la creación, transmisión, visado de la documentación, autorización administrativa, tratamiento y almacenamiento de información sobre proyectos en España, disponible para todos los agentes involucrados en el ciclo de vida del proyecto, basado en XML y en las normas de calidad sobre la documentación de proyectos de la serie 157000.

PROMOTOR
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 MINISTERIO DE INDUSTRIA, TURISMO Y COMERCIO *Cofinanciado por el ministerio de industria, turismo y comercio*

Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica (2004-2007)

PROGRAMA DE FOMENTO DE LA INVESTIGACIÓN TÉCNICA (PROFIT)

RESOLUCIÓN de 20 de abril de 2005, de la Secretaría de Estado de Telecomunicaciones y para la Sociedad de la Información.

(boe 28 abril 2005)

área temática: **tecnologías de la Sociedad de la Información**

programa NACIONAL: **Tecnologías Informáticas**

Fig. 1. XPDRL project web.

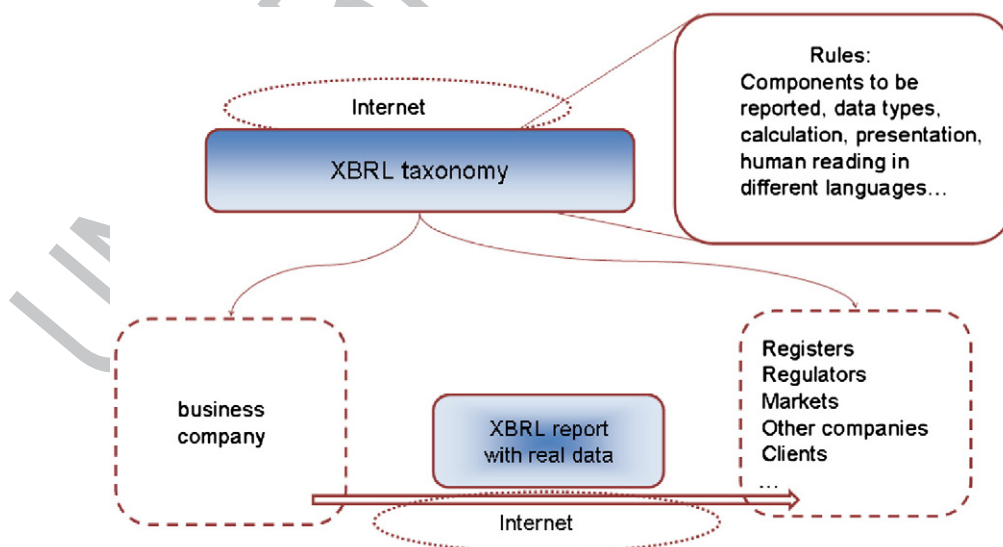


Fig. 2. Overview of XBRL.

XPDR (eXtensible Project Documentation Reporting Language) is one of the digital markup language successors to XML (eXtensible Markup Language) and serves as the nexus between different entities when transmitting project documentation information telematically. XPDR is based on the production of different XPDR Taxonomy modules, which are generated and agreed by consensus in various working groups formed by specialists in computer software, systems and AEC projects and the Official Spanish Association for Standardization (AENOR). The principal mission of these groups is to generate a specific taxonomy; that is, the group analyses the reporting model that XPDR is intended to support and facilitate, and identifies univocally a dictionary of terms for utilizing these labels in the subsequent generation of reports in XPDR containing real data that will be transmitted electronically. Thus the working group generates the taxonomy, which is made available free on the Internet, and this allows users to generate various types of report and validate them correctly; the taxonomy thus represents the best “substratum” for expressing project information of all kinds for utilizing by the numerous applications that companies and other organizations must use to manage this project information. When the XPDR taxonomy is generated, much care is taken to introduce different project rules into it. These rules take material form by way of standards of presentation, labels in different languages, rules of calculation and logical relationships; these are standards and rules with which the real data “hosted” by the digital labels in the various XPDR Reports must comply. A plain text file with the .xml extension supports the transmission of the data expressed in this new language. XPDR Reports are usually very compact in size, which increases the capacity of existing computer systems, in addition to the advantages offered by the syntax that ensures that items of data are conveyed intact and perfectly delimited. By means of this language a scenario is provided in which the issuers and recipients of this type of information find an efficient “substratum” for making use of it digitally and electronically in various ways, and particularly for using the latest high-performance analytical applications, since all the relevant project information is contained or can readily be contained in XPDR Reports (Fig. 3).

There exist various mechanisms for the calculation and logical validation of content of the labels that comprise an XPDR taxonomy. Because these labels, and the real data that these labels “host” when an XPDR report is produced, can be submitted by means of these mechanisms, they become simple but powerful tools. When project information is expressed by XPDR, this represents an additional guarantee of the quality of this information. Furthermore, XPDR

taxonomies can be extended by the user privately; this facility ensures that, on the one hand, companies can make use of their own more detailed reporting models with particular characteristics specific to their own project, for internal use, and on the other, that there is no loss of compatibility with the general model that the company must use to report externally.

When the XPDR taxonomy is generated, much care is taken to introduce different rules into it. These rules take material form by way of standards of presentation, labels in different languages, rules of calculation and logical relationships, for the real data “hosted” by the digital labels in the various XPDR Reports must comply with many different rules of this kind. A plain text file with the .xml extension supports the transmission of the data expressed in this new language.

The technical advantages of XPDR have been well received by organizations that until now have been managing their project information by more rudimentary methods. Among the descriptive terms associated with XPDR are “better, faster and cheaper”.

Regarding the implementation of XPDR, two phases were identified (see Fig. 4). In the first one (the current one implemented nowadays), the core project documentation is constituted by the output of different tools (such as word processors, spreadsheets, CAD systems, etc.) in PDF format, according to the model currently used for digital stamping. Then, the PDF is analysed by a software application developed for the project. The application detects if the project contains all sections required by the UNE 157000 standards. It then generates an XBRL report composed of Boolean elements, one for each of the sections required. If all elements in the XBRL are positive, then the project automatically obtains the corresponding project visa. The taxonomy integrates the information contained in three resources constituted by three different files (see Fig. 5):

- A spreadsheet file containing the mapping between the xml labels in the taxonomy and the text codes required by the UNE 157000 standards.
- A word processor file containing the project core documentation with the codes according to the UNE 157000 standards.
- The corresponding XBRL report file: pd-157xxx-report.xml.

In a second phase, the output from the designers will be according to the XBRL format. In this format (in all XML files) it is possible to embed graphics. Then, the information system from the Professional Associations will be able to read the XBRL file and to determine both content and structure. By this system, it will be possible to perform

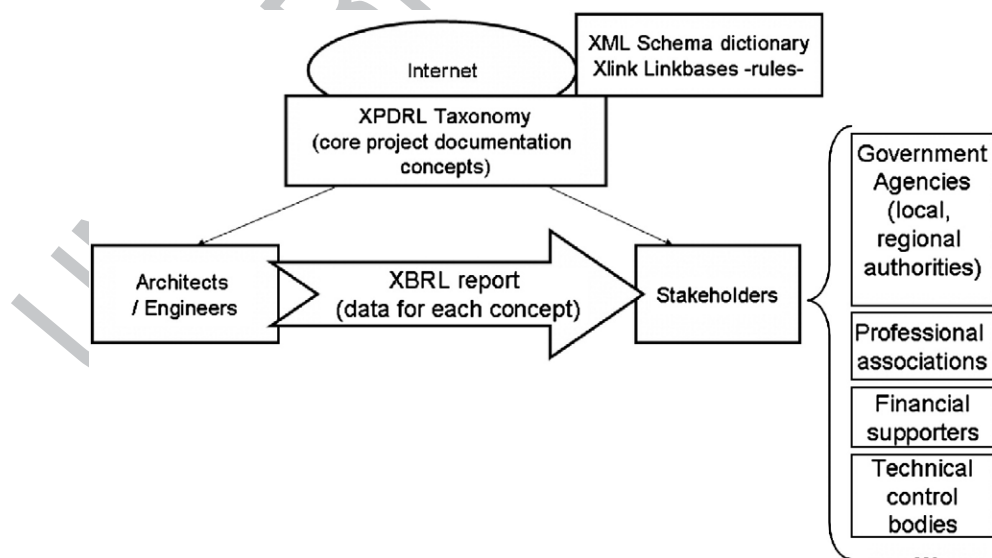
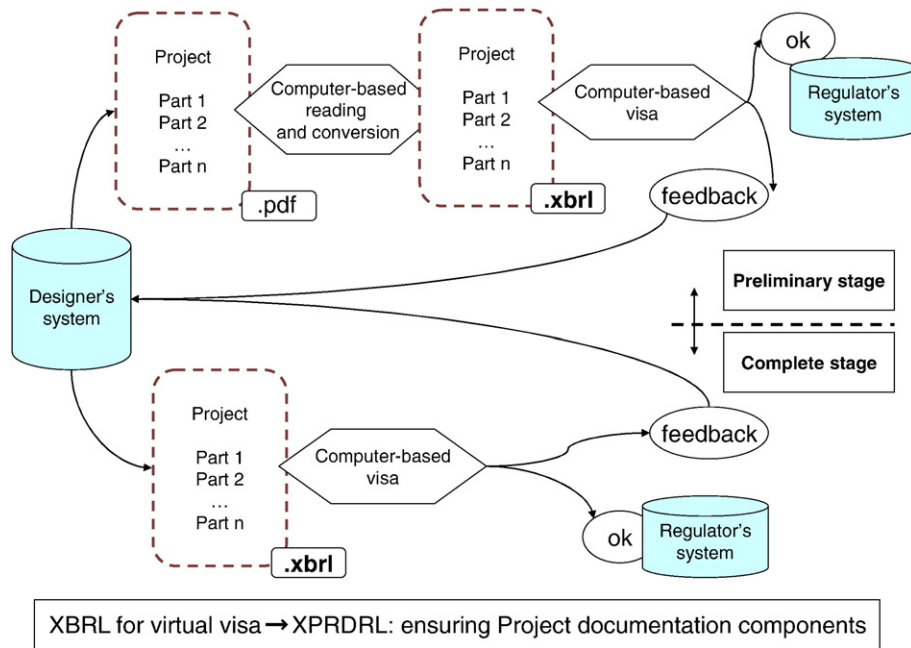


Fig. 3. XPDR in operation.



XBRL for virtual visa → XPRDL: ensuring Project documentation components

Fig. 4. Two phases in the XPRDL project.

1045 digital stamping in which the quality of the project can be determined
1046 with the highest degree of detail.

1047 **5. Conclusions and future research**

1048 In Europe, professionals and enterprises in the AEC sector are
1049 continuously facing growing construction quality requirements and
1050 professional liabilities, from their national public authorities
1051 concerned by the AEC/FM sector activities. The driving force is the
1052 need to conform fully to the complex legal and social requirements in
1053 the fields of Environment, Health, Safety and Quality. As a conse-
1054 quence, both of them have to elaborate more and more core project
1055 documentation where they justify the compliance with the require-
1056 ments of laws and statutory regulations for client and authorities, in
1057 the construction projects. In this context, high quality project

documentation is vital to a successful construction work because of
1058 standardizing the way project information is communicated and
1059 stored results in measurable savings in construction sector costs. In
1060 this paper, an extensive initiative for improving project documenta-
1061 tion quality and make exchanged information easier in the construc-
1062 tion projects in Spain have been summarized.

The main result of this research has been the development of a
1064 new open standard to enable and encourage information sharing and
1065 interoperability throughout all of the phases of the whole building life
1066 cycle. The prototype system developed is based on Internet, XBRL and
1067 the Spanish Project Documentation Quality Standards. UNE 157000.
1068 Also an Internet-based portal that enables AEC professionals to submit
1069 project and related documents to regulatory authorities for approval
1070 has been developed. Our proposal focuses specifically on AEC projects
1071 documentation, which is one of the most important aspects to
1072

Name	Objective for Mapper
PortadaEstudioImpactoAmbiental_Titulo	Estudio de Impacto Ambiental referido al proyecto de...

**Estudio de impacto ambiental referido al proyecto
de.....
(CIP: 2006/.....)**

Cliente/Promotor:
CIF/NIF:

Autor(es): D./D^a:
NIF:

Ingeniería:
CIF/NIF:

```

<pd-157921:PortadaEstudioImpactoAmbiental_Titulo contextRef="prueba" true/>
<pd-157921:PortadaEstudioImpactoAmbiental_Emp plazamiento contextRef="prueba" true/>
<pd-157921:PortadaEstudioImpactoAmbiental_TerminoMunicipal contextRef="prueba" true/>
<pd-157921:PortadaEstudioImpactoAmbiental_Provincia contextRef="prueba" true/>
    
```

Fig. 5. The three files (spreadsheet, word processor, and XBRL report).

increase the quality of AEC projects. The adoption of XPDL offers benefits for all the AEC stakeholders.

Regarding future research, the intention is to develop “intelligent products” in order to improve the communication, delivery time, costs, and the quality throughout the whole building life cycle. To do so, it will be necessary to address issues related to the semantic web, so the content of the web pages will be structured by means of XML labels, so the search of information in the web would be similar to searching in a database. Furthermore, the development of model data standards such as IFC, will make it possible to structure the project information by using objects. We are convinced that the use and future development of the proposal taxonomies will help professional civil, mechanical and electrical engineers; architects and construction managers to better document control, ease of collaboration with clients and permitting agencies through common, completely searchable, document format.

Finally, to highlight that our proposal has a great technology transfer potential and can be extended easily to other countries, especially in Europe, because EU regulations are very similar in all the European countries and because all of them have to comply with the UE Directives. Besides of the potential for spin-off technology utilization it is also significant in the areas of insurance, inspection chamber, digital auditing and reporting, education and information management.

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