3. Information Technologies applications for Construction

3.1. Introduction

Computing and communication technology, also commonly known as Information Technology (IT) have been radically transforming the way we live, learn, work and play (Capron 2000).

Many companies in the construction industry do not generally appear to have appreciated the positive changes and advantages that the new technology was providing to companies in other sectors of the economy.

During the 1980s PCs were only used in few construction companies. Throughout the 1980s, although most building firms were using computer technology for many of their core functions such as accounting, wages, and salaries, very few of them evolved formal policies or strategies concerning the use of information technology.

By the latter part of the 1980s, about eight years after the introduction of reliable PC equipment, some companies had reached a situation in which their staffs on many of their larger projects were experiencing the advantages of the new technology through the use of planning, drawing, spreadsheet and word-processing software packages.

Today, a large number of software packages are available to all the disciplines of the construction team at every stage of the construction process. They provide support for a broad range of activities such as computer aided design and drafting, building visualization, design appraisal, project management, information storage and retrieval, cost estimation, structural analysis, on-site management, facilities management, etc.

In this Chapter all the specific software applications for different purposes along the life cycle of a project will be exposed, with the consequent necessity to organize and manage all the information arising from these tools.

3.2. The development of Information and Communication Technology in Construction

The use of Information and Communication Technologies (ICTs) in the construction industry is generating new opportunities for collaboration, coordination and information exchange among organizations that work on a construction project.

Complex technical systems do not evolve fully formed, but rather as localized developments. In the development of automated systems for the transfer and transformation of materials, this unbalanced evolution leads to the problem of 'islands of automation', where highly automated materials flows are mixed in with completely manual ones. The same problem exists in the development of computerized information systems. The development of computing technology has meant that tools for analysis involving data manipulation have tended to develop earliest and in isolation. These tools play to the enormous strengths of computers in the rapid analysis of complex data sets –analysis which is frequently impossible if manually attempted. Thus stand-alone applications dependent on numerical analysis, ranging from finite element analysis to critical path analysis, had been developed by the 1960s. Information flows between these types of application continued to use traditional information technologies such as the paper-based engineering drawing.

During the 1970s, a new form of graphical manipulation developed to aid the creation of engineering drawings –computer aided design (CAD). Again, the output from these systems largely relied on traditional technologies for communication between different applications. The construction industry was at the forefront of these developments. By the fourteenth century, scaled technical drawings –probably the most important information technology of the last millennium after the printed book itself- were well established for use on religious and royal building projects.

During the 1970s, large public sector projects –usually relying on extensive standardization and prefabrication- offered the opportunity to develop CAD systems. However, the demise of the large public sector construction programmes which have been essential to the development of ICT applications in every industrial sector meant that this initial momentum was lost (Howard 1998).

The 1980s saw the development of the personal computer (PC) which dramatically reduced the cost of computing power, and enabled a much wider diffusion of computers within the industry, while the processing power of computers continued to grow exponentially. Most importantly, site offices could now be equipped with computers.

The development of communication technologies has taken an independent path. In comparison to computer technologies, developments were earlier and more profound. The telegraph and, more importantly, the telephone, greatly improved communication capabilities. The fax and photocopier are more recent innovations which have had a significant impact. Nonetheless, these communication technologies did not allow any further manipulation of the received data. It was not until the 1970s that they began to be connected to computers to provide integrated systems for the direct communication of information between computer systems. The development of Local and Wide Area Networks (LANs and WANs) proceeded steadily, but interconnectivity between computers was transformed by the breathless diffusion of the internet during the 1990s.

It is this rapid development of the interconnection between communication and information technologies over the last 20 years that has both opened up tremendous new opportunities and posed new technical challenges.

3.3. Current Information Technologies for the Construction Sector

Information technologies or Software applications are available to support most aspects of a construction project. They have been designed largely as solutions to specific problems. These applications can be grouped into the following categories (Sun & Howard 2004):

- Computer Aided Design and Visualization
- Building Engineering Applications
- Computer Aided Cost Estimation
- Planning, Scheduling, Site Management
- Computer Aided Facilities Management
- Integration
- Business and Information Management

Figure 7 is a roadmap showing where and when these applications are being used along the construction process. The main purpose of the diagram is to indicate the main application areas for the existing discrete software packages in the construction supply chain.

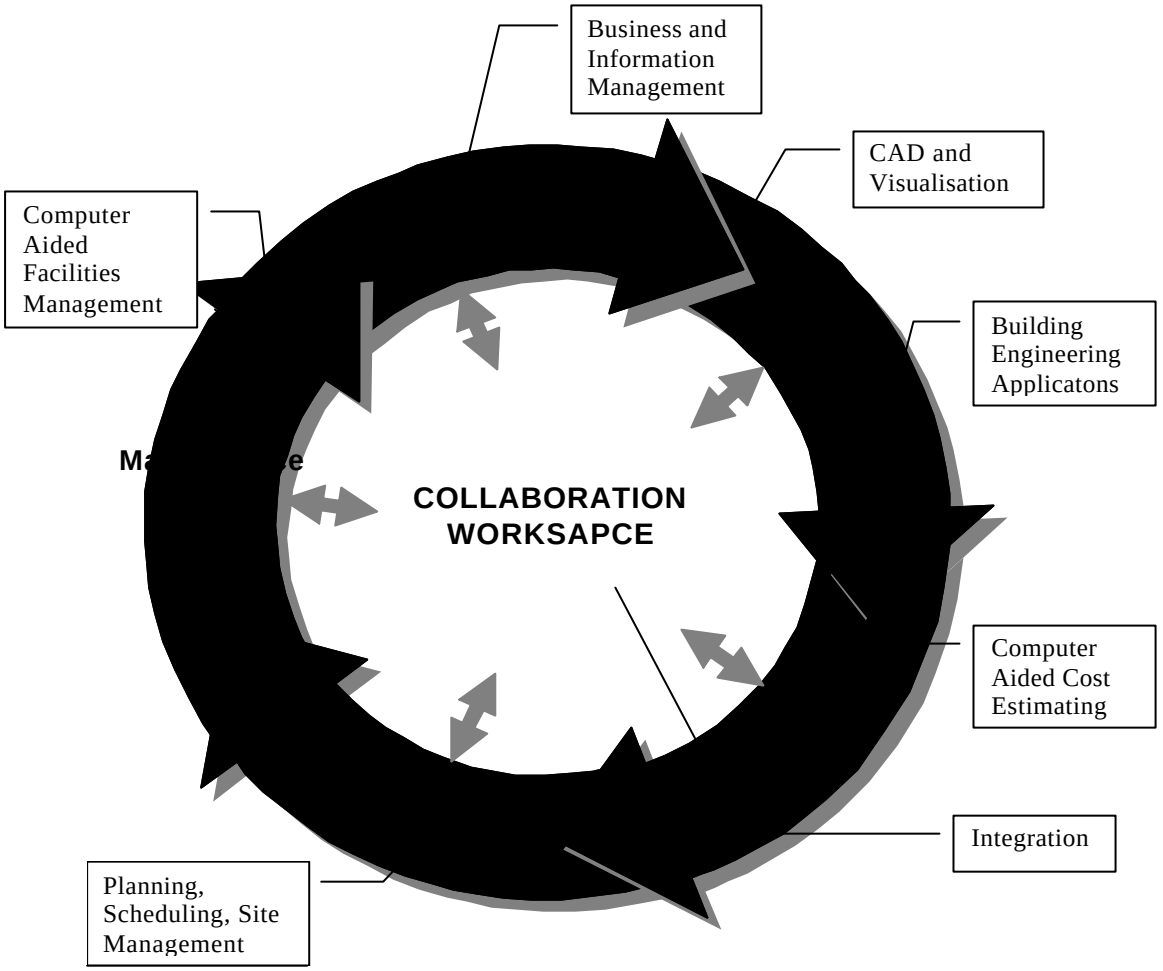

Figure 7. Construction Process and IT application

3.3.1. Computer Aided Design and Visualization

Computer Aided Design (CAD) software is widely used by design professionals, and AutoCAD has the largest share of the CAD market (Howard 1998). Other popular CAD software include Microstation, ArchiCAD, MiniCAD, FastCAD, etc. These CAD programs have largely replaced the traditional drawing board at the production information stage.

The basic function of CAD tools is allowing the user to build up drawings by manipulating lines, circles, rectangles and texts interactively on the screen. The clear advantage of CAD software is the ability to allow ‘editing’, which means delete, move, copy, rotate, scale mirror, etc.

Furthermore, since the drawing can be saved at any stage, the designers are able to keep various versions of the building layout for later study. Once the geometrical information of the building design is stored in a CAD package, different views of the building can easily be produced.

Visualization and animation systems, like 3D studio, can produce photo-realistic, static, and moving images, so that the clients can view the final appearance of the building at the design stage. The emerging Virtual Reality technology even allows the user to interact with the design model and experience the building in simulated reality settings.

3.3.2. Building Engineering Applications

Nowadays, construction industry clients have ever-higher expectations. They want their buildings to look good, to be safe, to provide comfortable living environments for their occupants, to consume less energy in operation, etc. The ever more complex demands on the building design process have given rise to the need for a new approach to building engineering design based on computer software.

Once a building is constructed, it is very costly to correct any design defects. It is, therefore, important to simulate accurately the building's performance at the design stage so that problems can be identified and solved. Over the years, a variety of methods and algorithms have been developed to predict building performance in thermal, lighting, acoustics, and structural aspects.

Because of the complex and tedious calculations that involve these simulations, it was nearly impossible to carry them out before computers. During the last two decades, a range of building engineering applications have been developed for energy analysis, HVAC design, structural analysis, lighting simulation, etc.

The benefit of these applications is that they allow designers to evaluate alternative design solutions in order to reach optimum design.

Examples of this software are: ATEAN from Carrier, and CARGASW from Climasoft, that offer comprehensive range of software options for climatic energy design; CALCULUX for lighting and building services design, CYPE INGENIEROS S.A. for structural design, COSMOS for finite elements analysis, DUCTSIZE from Elite Software for electricity and water nets design.

3.3.3. Computer Aided Cost Estimation

Controlling costs is one of the most important requirements during a construction project. To achieve this, contractors and subcontractors must first make accurate cost estimation. Rigorous project accounting must then be used to control the spending. Today, there are sophisticated computer software packages, such as Esti-Mate, Manifest, FBS-Estimator, and PRESTO from Soft, GO from Star, ITEC and ARQ from AM2, which allow project managers to make estimations and to keep track of project spending.

Other software can help to measure, count, compute and tabulate quantities, lengths, areas, volumes, etc., of objects found in plans and specifications. Furthermore, most cost estimating programs can be integrated with databases of costs for labour, materials and equipment. The advantage is that cost data do not need to be re-entered, thus improving the celerity in estimating and avoiding errors. Computer based estimation of costs archives and retrieves large volumes of resource, cost and productivity information, makes fast and accurate calculations and presents results in an organized, neat and consistent manner.

3.3.4. Planning, Scheduling and Site Management

Construction works require careful planning and skilful management of human and physical resources. Computer systems can assist on-site managers to plan ahead, evaluate different options and adopt and execute the most efficient construction operation.

Besides the widespread use of planning packages such as Microsoft Project, Primavera, Power Project, etc., to plan and schedule detailed construction activities, some applications like JobMaster, ICON, GEST, and Presto Control, are designed to log and track internal processes during the construction phase.

Site operation simulation programs can emulate what happens in a real construction site by representing workers, machines, and materials, and computing the cycle of each step taking into consideration many uncertain factors (Paulson 1995).

3.3.5. Computer Aided Facilities Management

Facilities Management is a relatively new discipline that emerged in the early 80s. It is based on the operation, maintenance, and impact of the building operations on the life cycle costs.

The available software for Facilities Management is a combination of CAD and database management systems. Special routines enable blocking and stacking studies to be carried out to explore different layouts or to reflect organizational changes. Databases are the most important part of Facilities Management Software. It holds data from people and their services so that when they move, their services can follow them. ITE (Inspección Técnica de Edificios), for example, is a tool that makes possible to create a report of the state of the building.

3.3.6. Business and Information Management

The construction process is an information intensive one during which a huge amount of information in generated and consumed by all the professionals involved. The common type of information includes site survey, cost analysis, design drawings, documents, correspondence, fax, computer files or e-mails. Electronic Document Management Systems can create an environment in which disparate forms of information can be linked together, within the context of a project or organization, to achieve easy access and control.

All the previous tools and software for cost estimating, planning, scheduling, etc., are generated in a specific stage of the project. Sometimes this information is updated, modified, consulted, etc., at any moment of the project. Consequently, **Document Management Systems** are tools that comprise whatever information throughout the life cycle of the project, from the conception of the need to the maintenance.

Electronic Document Management Systems are applications that can be linked to **Web Based Project Management Systems** for to improve communication among partners and between them and the management of the project. In addition, Web Based Project Management Systems have other functionalities like project coordination, scheduling, etc.

3.3.7. Integration

From the first software applications, many different tools were developed. They use their own data formats, which are not compatible with each other. As a result, data cannot be electronically exchanged between them. In recent years, there is an increasing awareness of the need for integrated construction processes and many research projects are investigating related issues.

During the last two decades, advances in object oriented programming, database systems and product data modelling technologies have provided a solid platform for integration. Data standards are being developed first by the International Standards Organizations (STEP), and then by the International Alliance for Interoperability (IFC). At present, these standards are still evolving. An integrated project database covering the whole life cycle of construction projects remains a future prospect.

3.4. Current Communication Technologies for the Construction Sector

Communication technologies are the technologies dealing with the transmission of information. They support the process by which information is exchanged. Figure 8 shows the evolution of some information technologies (mainly, communication technologies) in construction. They are positioned according to their complexity (vertical axis) and construction specifics (horizontal axis). Notice that the most specific services tend to use or rely upon the generic ones, and that the most complex services tend to integrate simpler ones.

The first services were generic and included networked file archives, e-mail communications and text-based group conferencing. The web provided a much friendlier navigation and presentation of the files on remote machines. It was as that time when first construction related content appeared. Out of the first 1000 websites only two were related to construction.

The first construction specific services used the web to publish information such as scientific papers, building codes, product specifications, etc. The next generation services were staring to use the Internet as a collaboration platform for the companies involved in a construction project (Turk & Cerovsek 2003).

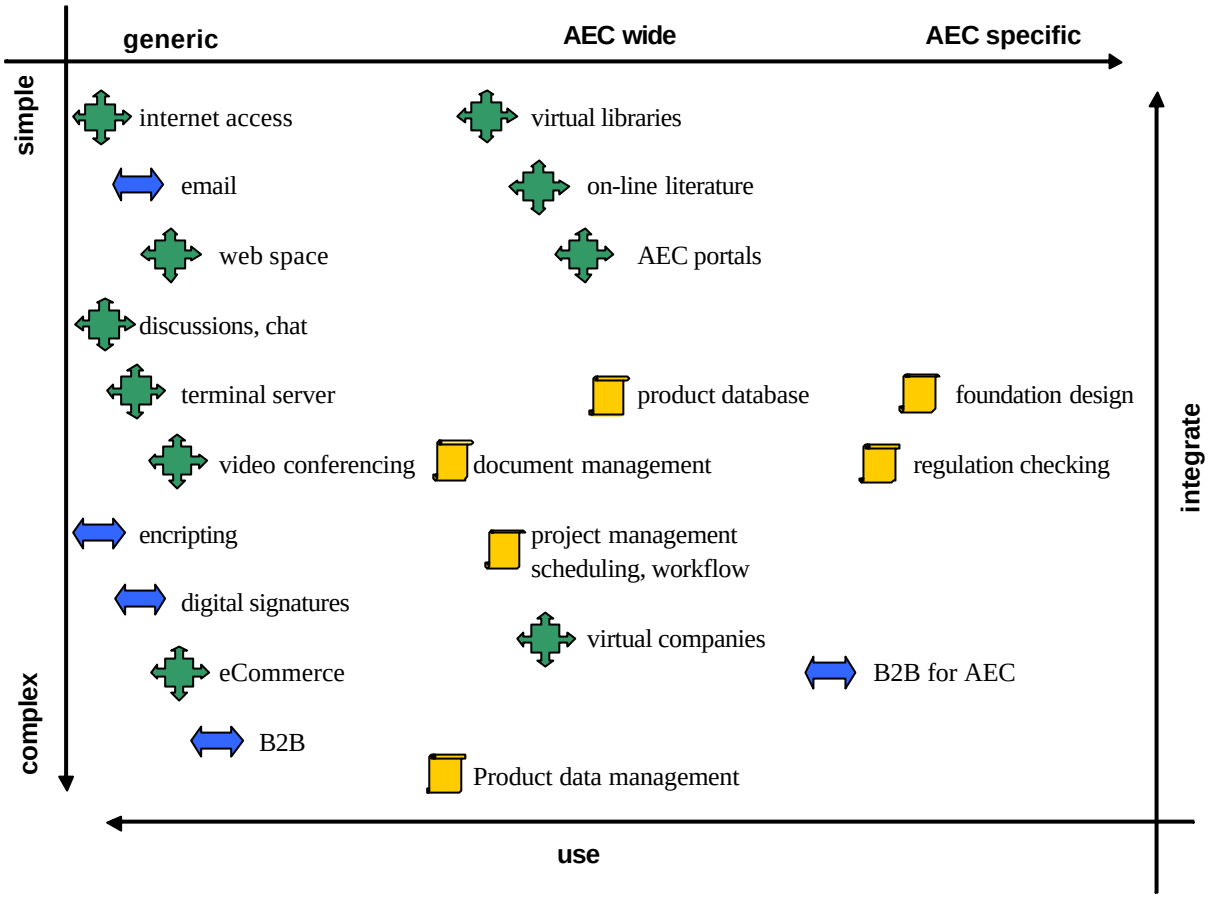

Figure 8. Evolution of Internet related communication technologies

Since 1998, however, construction has been following trends of general service supplied on the Internet. A business model of the providers of various kind of Internet related software (e.g. for managing mailing lists, discussion forums, help desks, photo albums, etc.) has evolved from the sale of software for the users to install on their servers, to the offering of a service on their Website, that offers the same functionality to the end user. In the construction **context there are now dozens of companies providing collaboration tools such as document managing, project coordination and scheduling**.

3.5. Summary

Construction industry has lagged behind other sectors in terms of applying Information Technologies. In the main, the boards of operating construction companies are dominated by engineers and surveyors whose knowledge of computing is very often limited to what systems have been implemented at head office, and whose interaction with computer is limited to occasional meetings with senior computer professionals rather than fellow engineers. Their general view is that the implementation of any new system takes a long time, is expensive and involves 'outsiders', and this is aggravated by with the degree of scepticism in terms that it's generally believed that the end product will in any case not achieve its initial specification.

Nevertheless, many software is currently being used by the construction sector like CAD tools, Spreadsheets, Word Processing and so on. Information is used and should be managed from the conception stage, design, and execution, to the facilities management stage.

With the growth in the use of information technologies by construction companies, the increasing availability of electronic documents, manual classification becomes impractical.

With such amount of information, **Document Management Systems** which are considered as a glue or integration of all the other software for cost estimating, planning, scheduling, etc., generated in a specific stage of the project, are an indispensable tool for the current Project Management activities.