Graduate Research Seminar
Fall 2002
COA 8903 ES L 87777

Strategies for IT Adoption in the Building Industry
Prof. Charles Eastman
Dr. Rafael Sacks
College of Architecture, PhD Program
Student: Eduardo Lyon
Introduction

Along last decade development, we could perceive the increasing impact of information technology and communications in our daily life; almost every aspect of our lives has been affected by it. Easy access to more and more ways to receive and manipulate information has been influencing in the different profession developments. Architecture, affected by this phenomenon, has had questioning in all its own aspects. Some of those have been favored by a progress without any doubt, especially on those related to the information exchange gathering into a project generation process, and later on the construction of it. In another way, digital media possibilities, not only in the speed of data manipulation but also in the amount of it, affect in the qualitative factor optimization. At the same time it postpone our concern about quality aspect of the project process, and leave us ignoring the modifications which could be operating in the architectural design process. Now a day, as a result of the massive use of computer aided design and drafting software a clear modification in the traditional architectural working process is noticed, it consequences could not be clearly perceived.

The architectural project brings up a certain amount of topics trough of it could be analyzed and build; those topics establish the architectural language. Trough a sequence of iterations during the different stages of the process, architecture manipulates an space capable of include multiple dimensions, including movements, acts and events, able to be dismount in heterogeneous parts trough resultant operations of different conditions (technical, economical, functional, visual, geographical, etc.) This negotiation it is characterized by highly abstraction grade. The parameters needed to guarantee the architectural process coherence are multiples and is possible to check in the architectural practice how the conception mechanisms stay all the time implicit on it. How is possible to develop a project elaboration process, which improves its definition space with other variant, and invariant?

Every process means to establish relations between objects and heterogeneous events. The organization and components of every architectural conception are inference and deduction agents from which a requirements structure manifestation allows to define spatial configurations to give answer to it, and to give place to the potential conditions inside it. This process reveal trough successive scale changes, oriented to control the provisional solution and to improve the original requirements dimensions. The successive adaptations describe the complex of operations which are register from the first contact between the client and the architect, until the end of the project, inscribing the data collection in a process which establish Transformative relations between the different dimensions which are included (individual, object and context). The realization of superior condition projects, in relation to how it complexity include the parameters complexity and diversity involved, demands at the same time the treatment and management of bigger complexity fields.
If architecture has the capacity of propose it own artifacts, this complexity not only has to find its origins at the contemporary reality complexity but also has to find the equivalent complexity on its thought.

Then if the architectural project take form as a continuous research, a process of successive approximations in which the architect achieves numerous departures and returns between the different stages. The computer, as productive tool, with it ever increasing calculation and memory capacities, transform itself in an essential tool in order to achieve economy of time, not only in the design phase but also in the corrections, improvement and execution of different versions and stages outlines.

Therefore, in an immediate perspective the computer is a media that clearly increase and rationalize the production. The development of different technical elements of computer-aided design (CAD) has been traduced on the computerization of a maximum of the possible duties of graphic design. In architecture, the different parts of the architectural project have been incorporated to CAD routines, mainly through the creation and modification of a data structure, which represents a model of the designed object. This model offers a graphic interaction and possibilities the use of new design tools and design routines. Later this data modeling and its manipulation enrich the process, and finally its graphic visualization improves the interaction with the architect.

Generally is possible to state that cad software's process data according to numeric variables, then through different mathematics algorithm make possible to be added, composed and decomposed it, and to be transformed into graphic or numerical data capable to accept high quality visualization, animation and physic prototyping.

With this systems assistance the graphic object (Stable geometric entities) manipulation allows us to easily geometric transformations, sections, additions, displacements, changes, deletion and calculations, in order to evaluate specific characteristics from different space or object components.

At the same time it modifies the way in which information related to an specific project stage could be reversible, its mean you can constantly go and come back through the involved concept development process.

The exploitation of computer concepts and associated technology in relation to its use in research and architectural practice states two related areas:

1. The use and development of computer tools oriented to architectural design.
2. The application and development conceptual and formal ideas make it possible by computers technology.
The information technology has stimulated design and formulation of a big number of CAD software. Its elaboration suppose a new conceptualization of our discipline knowledge, in a body of laws and rules which commands the elaboration of any architectural project. This conceptualization precedes the elaboration of the project, therefore it articulates as preliminary stage for its comprehension, and thereby its field is theoretical. Software writings demand a description of information and the storage in databases of it, in addition to its capacity of build new set of parameters to determine relations between data. Despite of the continuous increment of power in computers and software capacities and the creative space of freedom defined by them acting as generic elements. Every software contain its own limits, which foreshadow the objects capable to be produced according to the complex of functions capable to be produced in each modeling interface and the graphics spaces that determine. The object and architectural space modeling in to a data structure provide a powerful analysis media of those entities. Therefore allow to analyze a certain number of elements and select the appropriate criteria, including a complex of analytical methods to comprehend the architectural project process operations, it mean the object generation which permits to advance through the different elaboration stages, in a process with permanent feedback from previous stages.

Real objects are every time more complex, modeling make evident its parameters in order to be recognizable, with its own attributes, besides it make possible to assign other attributes series managing its own modifications and followings manipulations. This modeling is an unavoidable architectural project conceptualization form. In a CAD environment this is not only just a simple informative media but also is a filter to perceive a possible world, which condition the conception and perception of it. This condition convey from the particular connection which CAD environment pose in between the image and it information, it implies that when you imagine this instrumental space unavoidably condition the way to consider the object.
1. Overview of the architectural services Sector:

1.1 Work structure:

There are many references about how to organize and architectural firm, sub sequentially, in the professional field there are several different practice models organized according to different work orientations and specifics social roles. Nevertheless the architect role in the building construction process is to provide drawings and technical specifications to describe what to construct. In addition to it the architect must assist the client in order to obtain project approvals from local authorities or government officials and to represent or/and assist the client during the construction process with the aim of comply with the architectural project. Sequentially, and in order to obtain a more clear idea of the work organization at an architecture firm, I will look at some general organizational aspects of architect work that are independent of the technologies to perform it.

Nevertheless the enormous advance in management techniques architects tend to ignore it. probably the complexity of this techniques, commonly oriented to large offices or big corporation, scare them and avoid it use by architects. Furthermore large architecture corporations are recently appear and still had no size comparison to what we understand as a business corporation. Anyway the principles governing the management strategies are applicable on any scale, probably a management expert or project manager with management skills should be part of any project team and this is not a common position in an architecture firm. Nevertheless sooner or later according to size increase any architectural firm needs to plan and control the activities that are performed inside it.

According to it internal and also to it external relations with clients, contractors, subcontractors, consultants, local government and other authorities an architectural firm is a complex legal organization, this complex organization is regulated by a series of contracts and other documents that avoid future conflicts between parts, but unavoidable, conflicts still could appear, because of decisions are not recorded or tracked in a correct way.

In a equivalent way Internal relations in a architectural practice needs to be regulated, in order to do this the first step is to set some financial managements structure and again this means the inclusion of a financial manager in the team dedicated not only to perform adequate office accounting and payrolls control but also to structure financially each project entering in to the firm.

In addition to the financial flow control, an architecture office must be understand as a flow of information, in this way somebody must control the flux and distribution of the information inside the production process. This information is characterized by a extreme diversity in origin, format and media delivery: From plans, letters, phone calls, faxes, e-mail, different sizes packages and samples to different types of meetings an architectural firm must deal with a highly complex variety of tasks. A communication manager must be included, or a communications strategy performed in order to concentrate the
firm on to the design process or production activity. The design process conveys from very abstract ideas to a set of descriptions that made possible to built something, this process is similar to other object design process but has enormous variations according to object complexity and the variety of people that take part in it, is in that way that building construction process is on the highest level of complexity. Anyway for architects the design process main product is the architectural project, which consist as mentioned before, in a set of descriptions traduced in plans, Written documents and on site instructions, is in this way that the architectural project process is the most important activity in an architectural firm, for that reason, I will analyze it in a closer view as main subject of this report in a following chapter. Besides in some degree all the above-mentioned activities are external to what we understand as the architect work, but many architectural firm failures had strong relation to miss attention to this aspect of architect work. Finally as any production process there are some residuals, physical and organizational remains that needs to be evacuated or storage for future use, a services area and a file storage and retrieving strategy must provide and an adequate space for disposal and storage of them too.

Administration, production, services and storage are the main activities in an architectural services firm that are inscribed in a more complex set of activities, the building construction process.4.

(Fig.1 the building construction process)
1.2 The impact of Information technology on architectural services sector:

The emergence of information technologies in the architectural practice has considerably modified the methods used to conceive, analyze and communicates architecture objects, moreover, information technologies, in a wider perspective and in a similar way than other professions, has modified not only the way in which projects are developed and managed but also the internal organization of an architecture firm. In this way some experts affirm that a major consequence of information technology emergence is the increase of professionalization in architecture firms. As a consequence of this phenomena architecture firms must look into production organization and management methods from other production sectors. A look to ten or twenty years ago work organization, and a comparison with actual information technologies influence in architecture firms situation, leads us to establish some of the consequences of technology implementation:

a) Increase in productivity associated to a costs decrease:

A technologically implemented architectural firm can develop a complex project with a third of people needed in the past with no computer use. This is a dangerous assumption in the way that project also are increasing his complexity in the way that technology is incorporated.

b) Redistribution and decrease of time dedicated to specific repetitive tasks:

Some specific task from old practices had disappeared or minimize, ink delineation, error hand erasing or ink pen hatching are disappeared and also you do not need to draw sanitary using plastic tools, but this does not means that repetitive task had disappeared, because new task have appear, like software install and remove or layering drawing organization. In a general appreciation mechanical and heavy task has been reduced and moreover has been redistributed in an original way inside the process.

c) An increase in the amount of available information for each project:

One of the fundamental changes is the increase in the amount of available information for each project, this phenomena is inside the logic of computerization and it will be more notorious in the followings years, in the way that it will increase the availability of internal and external databases. Computerization had increased enormously the chance to build a project composing from the different kind of information which can be integrated in to the architectural project and this is valid not only for the external information but also for the internally generated information. At the same time this increase the amount of information able to be used in the future and promote it organization.
d) The necessity of a systematic approach to organize the different tasks:

A computer is an artifact that organizes more than seems to, not only organize the files and folders following the user instructions but also obligates the user to be organized. Sooner or later projects organized inside computers will demand organization protocols that specify how to perform specific operations and tasks.

e) Horizontal integration tendency:

In general terms, there are two work organization modes; a vertical flux of information organization characterized by a general and important decision taking on top and detail development of it on the base and is structured in a hierarchical organization with several clearly differentiated positions. A variation of this is a teamwork-based organization with a project manager on top of a smaller but similar hierarchically organized structure. The second type of organization adopt a horizontally organized structure, inside it each specialist develops different project aspects, or specialty teams in highly coordinated organization take charge of specific tasks, moreover this organization demands highly coordination in decision taking, specially decisions concerning project objects elements in use and the relations between them. Nevertheless is difficult to find a strict application of this organization modes, commonly a mixed structure which combined both is noticed.

f) A tendency towards a project development based on existing and available objects:

Computerization allows the open possibility to manage easily and fast prefabricated objects and in the way that architect familiarity and availability of database increase, the prefabricated object direct incorporation to project is favored. This tendency if promote by the increasing technology incorporation on construction industry as we can see on steel industry and soon in the pre cast concrete sector, this tendency is introducing a complete set of prefabricated building and direct part manufacturing.

g) New applications potentiality:

New applications appearance has a positive effect on the emergence of new work methods as we can see in areas such are the facilities management and building visualization and artificial lighting analysis or building energy consumption analysis.
1.3 The architectural project process:
There are different approaches to divide the architectural project. According to AIA Document B141, Basic Architectural services are divided in five phases and each Phase has a specific product or report. This division deliberated exclude pre design phase to consider it as additional services, meanwhile using the AIA information and some other sources like the IAI. I will include all the stages together in order to have a more complete perspective of the architectural project. According to IAI one can recognize three major phases in the process; Pre design, Design and Construction each phase is also divided in other stages. In each phase have a specific product or a set of documents is produced, those documents can be described as reports of the project advance, and it function is to maintain the whole process with a constant flow of information, but none of this reports represent or describe the complete building, following a description of each stage and the product of it:

1.3.1. Pre Design:

1.3.1.1. Identification of needs:
This stage is focused on the determination of specific client and project needs, building type, building size, infrastructure needs, site size and any other client or project specific technical, legal, organizational or spatial requirement. The most common documents at this time are written documents, organizational diagram, spreadsheets and forms.

1.3.1.2. Feasibility studies
According to a client requirements, project needs, and potential site or sites selection and it specific conditions, this stage consist in the definition of an architectural concept provided by a conceptual design process which includes sketches, general schedule and general estimate. To develop this stage the architect use sketches, flow diagrams, spreadsheets and written documents formats.

1.3.1.3. Site selection:
Consist in a process of site selection according to the architectural concept and the marketing analysis and considering legal aspects, local government or authorities conditions and financial structure. Written reports, site plans, topographic plan, spreadsheet are major product of this stage.
1.3.2. Design:

1.3.1.1-Programing:

Programming stage is about the definition of spatial specific characteristics of the spaces included in the project. From a list of activities and a set of relationships in between them, this stage is focused on the analysis of the spatial conditions inside the project and how they relates to an specific site and an architectural concept. Program diagrams, function diagrams, Schedules in spreadsheet or flow charts.

1.3.1.2. Schematic design:

This stage is focused on the analysis of the client program; site and budget. Once determine a basic program, a site and an estimate budget, the architect produce preliminary design studies using sketch drawings, diagrams, massing studies, study models, perspectives, site analysis drawings, and also plans, sections and elevations in sketches form.

1.3.1.3. Design development

Design development stage consists in a further development of schematic design using measurable drawings and includes the definition of basic project systems and materials. Major decisions in this stage are to define project size, general dimension of it, an architectural project specific expression and an adjusted estimate. More precise plans, sections, elevations, site plan drawings more realistic perspectives and study models are developed in this phase.

1.3.3. Construction:

1.3.3.1. Construction documents:

Consist in the detailed design of the project, including engineer design, selection of materials, construction details, and all the construction documents necessary to obtain construction bids and building permits. Consist in working drawings, specifications, bidding information.

1.3.1.2. Bidding or negotiation

This stage consist in the assistance the client in finding, screening and selecting qualified general contractors to obtain bids or to negotiate the construction contract. During and after the completion of the construction documents the architect assist the client in reviewing bids and awarding contracts. Contractor's bid, construction contract and modified design documents to comply with the final specifications are produced here.
1.3.1.3. Construction Administration:

As representative or assistant the architect assist the client in construction administration, this stage includes design changes, site visits, construction work inspection, payment request, and specification in detail of any part included in the project. The architect perform also as mediator in between client and contractor. Design change documents, Field reports, certification of payments and completion are major activities.

Following a high-level process model of existing information-dependent workflows. 

(Fig 2 Pre Design stage)
1.2 Scale of industry sector:

In the same way as we analyze the architectural project as part of the building construction process, architectural services market must be analyzed as part of the construction industry market. According to 1997 economic census the construction sector comprises establishments primarily engaged in the construction of buildings and other structures. The total value of construction work in this sector in 1997 was US$845 billions, 50% was produced in building construction area, it means around US$381Billions, building construction sector in Georgia state is a US$28 Billions industry, as we can see is a big market, now I will look inside this market to the Architectural, engineering & related services sector.

1.2.1 Architectural, engineering & related services

This sector comprises establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures by applying knowledge of design, construction procedures, zoning regulations, building codes, and building materials. Architectural, engineer and related services represents 15% of total construction market, but architectural services represents only 2% of whole construction market, and includes around 20,000 firms and 146,702 workers, which is a small piece of the market for our interest, but let take a closer view inside, the first problem in this assumption is that according to AIA there are around 80000 firms working in architecture in USA, this means that architects work is not just in the architecture services area, in fact the second largest in 2001 revenues size construction manager firm ranking is an architects firm. Using a more closer analysis, I will look at the annual revenues from the main professional firms involved in the building construction process; there are six main categories: architects firm, architect and engineers firms, engineer and architects firms, engineer firms, contractor firms and Construction manager firms all together obtained US$ 102.6 billion in revenues 2001, if we assume that the three first categories includes architectural services it means Architects firm, architect and engineers firms, engineer and architects firms those all together reported US$6.65 billion in revenues during 2001, if we think that the average percentage of revenues dedicated to Information technology is around 8%, this means that we are talking about US$ 500 million in Information technology investment. The first problem with this assumption is we are putting together people that work in the building construction process but in different areas, for example architects firm and architects/engineer firm main work area are commercial and institutional, and a small portion in industrial. In the opposite side engineers/architect firm and engineer firms are more oriented to industrial and institutional sector. This turns a little bit difficult to engage them in to a common initiative.

The solution to put some of them together is to look at the possible associations that bring them together. The AIA is the biggest architect association in the USA and probably in the world and should be our target to focus our proposals.
there some funds dedicated to practice improving but still are small amounts (US$100,000 annual per project) and in the other hand some earlier internal initiatives from AIA, as the Contract document software, does not had a good evaluation from the users\textsuperscript{24}.

Other possible approach is to focus in one larger or several medium size firms to see how much they invest in information technology and what we can propose in relation to this money. Thompson Ventulett, Steinback & associated, is a Atlanta based Architectural firm with 268 employees and reported revenues in 2001 about US 40.3 Million\textsuperscript{25} and if we projected an annual information technology budget around 5% of revenues\textsuperscript{26}, it is mean about US 2 million and we are talking about one firm. Anyway there are several possible financial sources in the sector, what also is important is what the architects and especially firm principal think about IT incorporation.

2. Available and suitable information technologies:
Recent surveys show a full cad technology implementation in architects firms in addition to it also e-mail, web sites and database and accounting software is also noticed\textsuperscript{27}. Architects firm are fully computerized but still troubled with information technologies, the cost of purchasing and implementation, the software decision in a overload market and the new operation condition inside each technology are the main issues today in relation to information technologies at architectural firms. In Most architects firms is widely acceptation of information technologies importance's to business operation, but still there is a resistance. According to PSMJ's A/E Automation &Information Technology Survey, few firms are resisting automation, but the industry is still hesitant to get out in front and try unproven automation approaches. However, the “leading edge” group is getting substantial business benefits and is more satisfied with technology results than other respondents\textsuperscript{28}. To understand the actual use of technology in architects firm is necessary to make a division\textsuperscript{29} in between them:

Base technologies: Are the basic technologies that allow you to be competitive in your specific area. Other than phones, cellular, PDA’s, voice mail and fax machines, base technologies to architects office are Personal and portable computers, printer and plotter, scanner and digital cameras, networking abilities and file server. Software also are part of base technology, the most used packages includes: Spreadsheet Packages, Database software, project manager/scheduling software, financial managing or accounting software.

Nevertheless the most important package is CAD (computer aided design) software that at least includes a two dimensional drafting software and a basic three dimensional modeling software.

Key Technologies: These are technologies that provide you competitive advantage. Visualization software including rendering and animation capabilities, virtual reality with immersion capabilities software and hardware, video conferencing systems, web sites including intranets, gis applications, extranet or database access.
Advanced technologies: These could become tomorrow’s key technologies, object oriented or parametric 3D cad, 3D building product model, building analyses and simulation software, design collaboration techniques, rapid prototyping and direct manufacturing.

To be more specific about task, applications and software’s I will show it in the following table:

<table>
<thead>
<tr>
<th>Task</th>
<th>Application</th>
<th>Software (2002)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two dimensional sketches</td>
<td>CAD 2D</td>
<td>Architectural Studio, Autocad, Microsation, Archicad, Arris, Vectorworkk, Allplan.</td>
</tr>
<tr>
<td></td>
<td>Image</td>
<td>Photoshop, Illustrator, Frehand.</td>
</tr>
<tr>
<td>Three dimensional</td>
<td>CAD 3D</td>
<td>Architectural Studio, Viz, Maya, Rhinos, Lighwave, FormZ, Autocad, Microsation, Archicad, Arris, Vectorworkk, Allplan.</td>
</tr>
<tr>
<td>sketches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two dimensional plans</td>
<td>CAD 2D</td>
<td>Architectural Desktop, Microsation, Archicad, Arris, Vectorworkk, Allplan.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three dimensional</td>
<td>CAD 3D</td>
<td>Revit, Solid works, Architectural Desktop, Viz, Maya, Rhinos, Lighwave, FormZ, Autocad, Microsation, Archicad, Arris, Vectorworkk, Allplan, and Accurender.</td>
</tr>
<tr>
<td>models</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visualization</td>
<td>Rendering</td>
<td>Architectural Studio, Viz, FormZ, Maya, Universe, Artlantis, Softimage, Microsation, Archicad, Renderworks.</td>
</tr>
<tr>
<td></td>
<td>Animation</td>
<td>Softimage, Viz, Max, Maya, Cinema 4D, Lighwave, FormZ, Universe, Artlantis.</td>
</tr>
<tr>
<td></td>
<td>Multimedia</td>
<td>Director, Quick Time, Quick Time VR, Ipix, DVD studio</td>
</tr>
<tr>
<td>Organization</td>
<td>Operating systems</td>
<td>Windows 2000, XP, MacOS, MacOSX.</td>
</tr>
<tr>
<td></td>
<td>Networking</td>
<td>Windows 2000P, MacOSX.</td>
</tr>
<tr>
<td>Communications</td>
<td>Collaborative web</td>
<td>Buzzsaw</td>
</tr>
<tr>
<td></td>
<td>E-Mail</td>
<td>Eudora, Outlook, Entourage</td>
</tr>
<tr>
<td></td>
<td>Web browsing</td>
<td>Explorer, Netscape, Opera</td>
</tr>
<tr>
<td></td>
<td>File transfer</td>
<td>Fetch, Cute ftp, Anarchie</td>
</tr>
<tr>
<td>Management</td>
<td>Project Management</td>
<td>Deltek, Quickbooks, Quicken, Primavera</td>
</tr>
<tr>
<td></td>
<td>Schedulers</td>
<td>Fast Track, Visio, MSproject</td>
</tr>
<tr>
<td></td>
<td>Database management</td>
<td>Acces, Filemaker, SQL</td>
</tr>
<tr>
<td></td>
<td>Accounting/Financial</td>
<td>Deltek, Quickbooks, Quicken, Excel, Primavera, Timberline</td>
</tr>
<tr>
<td>Administrative</td>
<td>Text Editors</td>
<td>Word, Word perfect</td>
</tr>
<tr>
<td></td>
<td>Spreadsheet</td>
<td>Excel</td>
</tr>
<tr>
<td></td>
<td>Contract editor</td>
<td>AIA EF</td>
</tr>
<tr>
<td>Task</td>
<td>Application</td>
<td>Software (2002)</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>Specifications</td>
<td>Word processors</td>
<td>Word, Word perfect</td>
</tr>
<tr>
<td></td>
<td>Specification software</td>
<td>Spec link, e-SPECS, Master spec</td>
</tr>
<tr>
<td>Estimate and material cost</td>
<td>Cost estimating</td>
<td>CD Estimator, Timberline, Costimator, Excel, RS Means, Cost Works</td>
</tr>
<tr>
<td>Design presentation or proposal layout</td>
<td>Page layout</td>
<td>Quark press, Page Maker, In Design</td>
</tr>
<tr>
<td></td>
<td>Digital Video</td>
<td>Premiere, Avid, After Effects, Sound Edit, Quick Time Pro</td>
</tr>
<tr>
<td></td>
<td>Slide show</td>
<td>Power Point, Architectural Studio</td>
</tr>
<tr>
<td>Text capture</td>
<td>Optical character recognition</td>
<td>Omni page</td>
</tr>
<tr>
<td>Drawing capture</td>
<td>Drawing recognition</td>
<td>Streamline, Corel Trace</td>
</tr>
<tr>
<td>Image capture</td>
<td>Scan</td>
<td>Hardware provided</td>
</tr>
<tr>
<td>Data capture</td>
<td>CD-ROM Product Data</td>
<td>Sweets, Pella, Anderson, Hickman, NFPA, Graphic Standards, Thomas</td>
</tr>
</tbody>
</table>

As we can see from the available technologies chart, is hard to find another profession working with such variety of applications and software’s, it takes sense if we relate this diversity with our flowchart and with the variety of tasks performed by architects during the architectural project, if those applications suppose to reduce time effort relations, why architects are not seeing those tools as effective as it was some years ago? one big frustration cause is the time effort necessary to deal with that applications and software variety, the second one and more important is the excessive variety of formats that those applications and software put in place, some times you need to be an advanced user in several software’s and also an expert acrobat in some more complicates abilities like interoperability issues; to migrate from one to other choosing the correct extension or adequate format. But what it is in the back rather that technical problem are factor like learning curves that some times in some applications are too steep, and overall is the difficulty to digest the crucial understanding that digital technologies implies new production process and organizational methods, architects firm are still using technologies in the same way that previous techniques, in that way a CAD workstation is just an electronic drafting table, and a digital model is a digital maquette, a web site is a digital firm brochure, an e-mail is a digital letter and a digital presentation is a slide show, the real change is not perceived and it will not perceived until architect realize about the real implication in the use of information technologies and the great potentiality inside it.
### Appendix 1

#### Data from 1997 USA census

<table>
<thead>
<tr>
<th>Construction</th>
<th>Value of construction work</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>US$845,543,552,000</td>
</tr>
<tr>
<td>1.1. Building, developing, &amp; general contracting</td>
<td>US$381,641,600,000</td>
</tr>
<tr>
<td>1.2. Special trade contractors (Sub-Contractors)</td>
<td>US$336,060,352,000</td>
</tr>
<tr>
<td>1.3. Heavy construction</td>
<td>US$127,841,600,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GA</th>
<th>Value of construction work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US$28,171,342,000</td>
</tr>
<tr>
<td>1.1. Building, developing, &amp; general contracting</td>
<td>US$15,234,889,000</td>
</tr>
<tr>
<td>1.2. Special trade contractors (Sub-Contractors)</td>
<td>US$3,298,023,000</td>
</tr>
<tr>
<td>1.3. Heavy construction</td>
<td>US$9,638,430,000</td>
</tr>
</tbody>
</table>

#### Value of construction work

1. Architectural, engineering & related services USA...
   - Engineering services..................US$ 74,565,673,000 63.7%
   - Architectural services, except landscape...US$ 14,528,876,000 12.4%
   - Interior design services..............US$628,270,000 0.5%
   - Urban or city planning services........US$306,865,000 0.3%
   - Industrial design services ............US$100,753,000 0.1%
   - Landscape architectural services.......US$ 223,726,000 0.2%

1.2 Architectural services, except landscape USA...
   - Architectural design services
     - for public and institutional projects......US$ 5,003,100 4.3%
     - Architectural design services
       - for commercial projects ................US$ 4,703,691 4.0%
     - Architectural design services
       - for residential projects ..............US$ 1,551,852 1.3%
     - Architectural advisory and predesign services........................ US$ 1,500,756 1.3%
   - Architectural design services
     - for other architectural design projects...US$ 906,404 0.8%
   - Architectural design services
     - for industrial projects............... US$ 863,072 0.7%

1.4 Architectural, engineering & related services GA...
   - Engineering services........................ US$ 2,041,713
   - Architectural services ..................US$ 506,929
   - Testing laboratories.................... US$ 114,532
   - Surveying & mapping services ........ US$ 102,451
   - Drafting services ...................... US$ 15,375
   - Building inspection services ..........US$ 10,973
   - Geophysical surveying & mapping services US$ 1,453

---

Strategies for IT Adoption in the Building Industry
Appendix 2:
Data from Cad for principals Organization. The study found widespread dissatisfaction among principals with the use of CAD tools at their firms. Principals were less likely than others in their firms to use technology and many felt that their CAD tools did not contribute to the primary goals of the firm – delivering high quality designs and responding quickly and effectively to client needs. http://www.cadforprincipals.org/

1) Firm Size

2) Services offered
3) Project Types Representing More Than 10% of Work

4) Management Issues

Strategies for IT Adoption in the Building Industry
5) CAD Impact Evaluation

6) Where's the Pain with Current CAD Products?
7) Software Evaluation Report Summary Results

8) Application Importance or Applications Used: CAD Products.
9) Application Importance or Applications Used: Paint, Imaging, Publishing Products.

10) Application Importance or Applications Used: Cost Estimating Products.
Appendix 3: Data from Personal Interview.

Firm’s name: Lord Aeck Sargent  
City: Atlanta  
State: Georgia  
Multioffice: Yes  
National: Yes  
International: NO  
Staff members:90  
Number of principals:10  
Number of associated:0  
Number of support staff:80  
It Staff:3  
Pc/Mac: Pc  
Number of computers: 110  
Printers networked:10  
Plotters:2 one color and one large format laser  
Year originated:1942  
Technology Infrastructure:  
Web site: Yes(outsourcing)  
Network:100mb and 10/100T Cat.5  
Operating systems  
- Client/Server: Windows 2000 proffessional  
- Cluster: No  
- Workstations: 30  
Servers  
- File: 3  
- Mail: 1  
- Web: 1  
Type of database:  
- Client: Yes/Web acces  
- Project: Yes/Web access  
- Employee: Yes/Web acces  
Software:  
- Database software: Acess  
- CAD software: Microstation  
- Modeling software: FormZ and Microstation Triforma  
- Rendering software: FormZ and Microstation Triforma  
- Accounting software: Axiom  
Training  
- Marketing trainer provided for technical stuff: Yes  
- Computer trainer provided for technical stuff: Yes  
Business:  
- Number of principals involved in business development:10  
- Percentage of time in business development: 30% to 60%  
- Overseas market: No  
- Percentage of revenues from overseas markets: 0  
- Percentage of repeat client:80%  
Additional services: Pre design/ Programing/ Comissioning/Inspecting/Government certification in environmental issues  
Organization by:  
- Studio: Yes  
- Project type: Historic preservation/Education/Science  
- Principal: Yes  
- Case by case
Questionnaire:

1) How is the flow of written and graphic information controlled and decision making documented from initial design sketches to construction drawings and as built plans?
   Using digital technologies like E-mail, scan, Document Camera, Video conference

2) How is the information organized, indexed and filed for future retrieval?
   Each project received a number once the financial manager authorize it and a digital an physical archive are open, both are equal in contents but the physical is the official.

3) What type of information is most commonly retrieved and why?
   At design stage are construction details and pictures file at marketing proposal assembly stage. There is not a standard detail library.

4) How are marketing proposal assembled?
   In project archives as Page maker format and later in databases as pdf format.

5) How are old proposals stored for future reference?
   In project archives as Page maker format and later in databases as pdf format.

6) How are owner/architect and architect/consultant contract written, retrieved, edited and signed?
   Using AIA electronic document software, which is buggy but useful. Specific contractual issues are manage using the same software creating templates inside it.

7) How is their status tracked?
   Simple database search.

8) How are fee budget developed and revised during the course of a project?
   There are in house financial and accounting consultants that define budget and constantly tracked project cost, cash flow managed and revenues projected. Monthly spreadsheet report with key financial indicators is reported.

9) How are project cost (labor, consultant fees, and direct and reimbursable expenses) monitored and compared to the project budget?
   There are in house financial and accounting consultants that define budget and constantly tracked project cost.

10) What information do the project manager require and when?
    Project manager usually with one of the principal and financial consultant define fees project budget and set a schedule for control meeting. Monthly spreadsheet report with key financial indicators is reported.

11) How are insurance requirements for consultants monitored?
    Legal consultant outsourcing, insurance representative and one principal.

12) How are photographic material digitized, stored and made accessible?
    Image archive database with web access trough asp (Outsourcing development). Each image has 3 sizes and two back up one physical CD and digital hard drive.
13) How do project teams communicate with consultants and keep them informed about new issues that affect their work?
- By phone, fax and e-mail or using intranet through web site to track project development.
- Net meeting or video conference room.
- Unified Voice, fax and email using PDA’s.

14) How digital information is shared with consultants and how often is shared?
- Mostly digital and tracked through document database. (Outsourcing development).

15) How are the contractor’s shop drawings, request for information, product data, samples, and changes orders logged and tracked during construction?
- Logged and tracked through document database, which also emits site inspection reports, the database has two main sections: Submittal track and potential changes. (Outsourcing development).

16) How is the digital data delivered to the client?
- During the project data from project web site and at the end of the project a complete set with the final project delivered.

17) How does the firm prepare itself to support client specific organizational requirements?
- Including those requirements in contract and specific issues like autocad specific formatting are resolved externally as outsourcing drafting company.

18) How are postoccupancy evaluation conducted?
- Yes but not often, a human resources outsourcing company recently developed an approval mailing form.

19) How are the results communicated to the project team and the rest of the firm?
- Not yet

20) How are project archives organized, stored, and retrieved?
- Each project has two versions: one physical in a storage outsourcing company and 4 digital: 2 cd and 2 tapes. In addition to digital files in file server accessible through project database.

21) In which part of the process are archives created?
- When financial personnel gives a project number

22) Does the firm work with same consultants for every project?
- Yes

23) Which are the most common error during design development?
- Mechanical project HVAC plans inconsistency. To avoid design error they hired a ready check process from an outsourcing company.
References:


2 The image of the architect / Andrew Saint. Yale University Press, 1983.

3 Aplicaciones informaticas en arquitectura Javier Monedero Isorna. Ediciones UPC, 2000


6 Idem 3

7 Idem 5


9 Idem 5


12 Idem 8

13 Idem 8


15 US Census Bureau. 1997 Economic Census

16 Idem 15

17 from: http://www.aia.org

18 Building design & Construction magazine July 2002 (http://wwwbdcmag.com)

19 Idem 18

20 Idem 18

21 Idem 18

22 Architectural record Magazine July 2002

23 Idem 18

24 J. Douglas Glasgow AIA I.T. Manager from Lord, Aeck, Sargent (Personal interview)

25 Idem 18

26 Architectural record Magazine May 2002

27 http://www.cadforprincipals.org/

28 The CAD Software Evaluation Report PSMJ Resources, Inc.


30 Idem 3

31 Based on personal information and sources 3 and 5.

32 Idem 29

33 Idem 27