Applying IT Strategies in the AEC/FM Industry

Results of a world-wide study with leading organization about current states, problems, and visions in applying Information Technology

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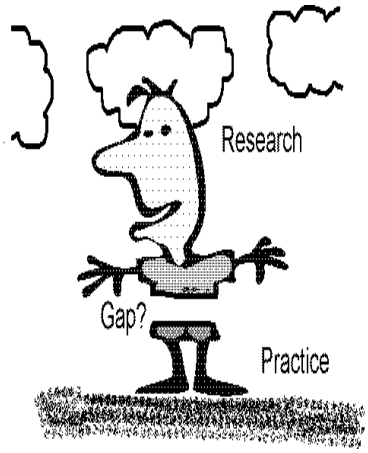
1 Introduction

As more technology becomes available to the AEC/FM industry, we expect more and better use to be made of it. We anticipate that it will have an impact on business processes and that it may even change them. For those people involved with the development of information technology (IT), this is the vision. But is the vision being turned into reality?

In particular, there is a lot of development in the area of object oriented technology. Nearly all of the major CAD systems now claim to be object oriented; most other classes of application software can expect to acquire an 'object oriented' label very soon. But is the industry ready for objects? Does it understand what they are and how they can be used?

These are just some of the questions which prompted the authors of this study to take a close look at how industry views and uses IT and what they expect to be doing with it in the near future (near future being broadly defined as being within the next three years). As people whose work is more normally in the areas of development of some of the most advanced IT concepts for the industry, they felt the need to discover more about how such concepts are being accepted and applied by industry. The results of the study came as a surprise.



The surprise was not so much in terms of acceptance and use of technology, but in terms of other factors that have an impact. In many cases, getting new technologies to be used in industry proves to be more about surrounding factors than about the technology itself. These factors are not normally taken into account by the IT development community. To discover the strategies being used by the AEC/FM industry in applying information technology, a study was carried out on organizations that have a proven record of innovation in this area. In order to give the study a global context, leading organizations in several countries took part. This also enabled similarities and differences in approach between different parts of the world to be assessed and for cultural differences to be considered.

The approach taken was to carry out interviews with relevant staff members of the organizations concerned. In each case, the person interviewed was at a middle or upper management level and was a participant in determining or applying IT strategy.

The interviews were based on a framework of questions that were designed to understand both technological and non-technological issues. However, this was not a conventional survey with an intention to analyze quantifiable data. The intention was to get a qualitative view based on the experience of the interviewees. Because of this, interviews usually took the form of discussions and frequently moved into areas that the framework had never anticipated. The result was that much more information became available and it was possible to modify and improve the framework as more interviews were conducted.

The study was undertaken by interviewing leading organizations within the AEC/FM industry. The organizations are amongst the major business players within their home markets. The geographic coverage is world-wide with selected countries in Europe, North America and Asia.

1.1 Basic Objectives

The basic objectives of the study can be simply stated as discovering:

- What is the current state of applying IT solutions within the organization
- What are the problems encountered in the current use of IT solutions
- What are the management and cultural issues impacting on the best use of IT solutions
- What are the contractual and legal issues impacting on the best use of IT solutions
- What is the vision of future directions for IT solutions and the expected benefit
- What difficulties are seen in achieving the vision

1.2 Interview Strategy

Virtually all interviews were conducted at the premises of the organization concerned. Interviews were guided, but not controlled by the 'framework of questions'. Interviewees were free to move the focus of discussion to those topics that were most relevant to their organization.

The framework includes the following topics:

- General Questions
- General Information Management
- Computer Aided Design
- Electronic Data Management
- Networking / Internet / Project Server
- Process Management
- Cultural Issues
- Contractual Issues
- Legal Issues
- Training

1.3 Types of Organization Interviewed

The study set out to gain a broad picture on IT use and strategy across the spectrum of organization types and professional disciplines within the AEC/FM industry. The types of organization participating in the study include:

- Building Owners / Clients
- Consultants
  - Architecture
  - Building Services Engineering
  - Civil and Structural Engineering
  - Construction Management
- Contractors
  - Building
  - Engineering

1.4 Geographic Distribution

Countries in which participants in the study are primarily located are:

- Denmark
- Germany
- Japan
- Singapore
- South Korea
- United Kingdom
- United States of America

1.5 Limitations of the Study

This is not a survey in the conventional sense. No questionnaires were prepared or distributed. Although interviews were conducted with organizations based on a framework of questions within the areas considered, the questions were used only as a guide during interviews. Interviewees were allowed to develop ideas in the manner of a conversation. From this, it was possible to identify the key strategic interests and areas of concern for individual organizations.

Because of the approach taken, there are known limitations to the study:

1. It is not possible to analyze the results of the study with the objective of identifying quantifiable data. Any quantified benefits that are mentioned in the report are opinions of particular persons interviewed.
2. The number of organizations interviewed is not sufficiently large for results to be treated as having statistical significance.

2 Conclusions

The new generation of IT helps to achieve the following major objectives:

- Better security in planning and construction by reducing the chances for mistakes in planning, particularly in design co-ordination
- Higher effectiveness in planning by applying more sophisticated software tools
- Reducing the re-keying of data through better interoperability of tools
- Higher quality in planning by "information of higher quality", i.e. consistent, re-usable data that can be evaluated in multiple ways

Meeting these objectives is facilitated by:

- Continuous use of the same project information base by establishing a project model that grows with the project through all phases of the lifecycle
- Enabling high consistency of all project information by using new data exchange and sharing technologies and by deriving plan information from the project model as far as possible
- Co-ordinating design by providing a project model that incorporates all the different disciplines and their views and supports that co-ordination through information management functions, such as delta highlights, check-in, check-out, clash detection, etc.
- Achieving information of higher quality through using new object-oriented technology that captures all information about a building object and provides for evaluation processes, such as cost estimation, cost benchmarking, energy performance, structural analysis, etc. Better information can then be provided to the facilities management process, and operational costs can be considered as well.

The most important issue that is addressed by all the potential improvements coming from the new generation of Information Technology is *Risk Management*.

- Less re-keying reduces risk
- Better quality reduces risk
- Partnering reduces risk
- Structure reduces risk
- Better training reduces risk
- Strategy reduces risk
- Vision reduces risk

2.1 Summary of conclusions by area of the study

For each of the technologies and issues studied, the following can be seen as the key results. Bullets in each list relate as follows:

- As-Is
- ➢ Gap
- ✓ Vision

CAD

- A CAD platform strategy is normally applied. Usually central, it may be devolved to departments.
- Specialized 'add-in' software is used to get real benefit.
- Organization standards are usually applied for layers, symbols, external reference file use. These need to be developed and applied on a wider industry basis.
- The great majority of CAD use is for 2D drawings (over 90% of production). 3D models are used for specialized purposes such as design co-ordination and clash checking.
- ➢ Data exchange mostly uses DXF or DWG, but this is limited for exchange of non-geometric information, and both formats are proprietary.

- ➢ Current CAD technology does not effectively support team working. Control is currently at the file level but needs to be more flexible.
- ✓ The vision of CAD is a move towards object oriented technology that enables more generic definition of information from which relevant views may be extracted. This is seen as being supported by a 'project server' database to which information can be sent and from which it can be obtained on demand.
- ✓ Organizations are looking for more effective data exchange technologies and have high expectations of IFC based technology.
- ✓ This vision may not be fully supported in the short term. However, it is expected that priority areas will be addressed including:
  - Integration of data between CAD and other applications (linkage between CAD and HVAC data is seen as the main priority)
  - Better version control between revision of files
  - Access from CAD to external data sources via Internet.

EDM

- Approximately half of the organizations participating use EDM to track drawing files and text based documents.
- Naming conventions are normally applied to documents to assist their identification within an EDM system.
- Most organizations use simple databases for EDM. Only the larger organizations use specialist EDM systems. This is because specialist systems are not seen as being sufficiently flexible to meet the needs of the AEC/FM industry.
- ➢ Document management is mostly carried out at the department level and thus suffers from isolationism.
- ➢ Archiving of files remains a problem because of file formats supported by applications. It is normal to archive the application with the information to ensure that the information can be retrieved when needed.
- ➢ EDM offers limited support for nested documents (e.g. external reference files within CAD).
- ✓ The vision of EDM is the use of a lightweight, simple to use, web based system that is supported by a distributed database. A number of organizations identified developments in this area that they considered encouraging.

Networks

- Most organizations now use networks to connect IT equipment. Larger organizations usually have their offices connected together by wide area networks.
- Use of email and the World Wide Web is becoming general although some organizations still restrict access, particularly to the Web.
- Many organizations now have Intranets and are making increased use of these for information delivery to their staff. Increasingly, both Intranet and Internet services are relying on the use of Active Server technology supported by databases to make content management more dynamic.
- A number of organizations have experimented with the use of project Extranets and expect this technology to become normal in the future.
- ➢ A high investment is needed for network maintenance within the organization and for content management for Intranet/Internet services.
- ➢ There is still a problem with speed and dependency of the Internet, particularly when transferring large volumes of data.
- ✓ The network vision is that corporate standards, policies and other documents will be delivered via Intranet and not on paper and that product data will be retrieved via the Internet rather than by access to paper based catalogues, guides and standards. This will accelerate, as XML technology becomes prevalent as the preferred information delivery mechanism.

Process Issues

- Awareness of processes within the industry is largely implicit. It needs to be understood and made explicit to support the development of integrated working and business process improvement across the whole AEC/FM industry.
- IT is seen as a commodity purchase in many organizations and not as part of core business decision-making. This means that corporate management procedures are lacking in IT purchase and use.
- Rekeying of the same information many times is a key problem driving the need for data exchange. It applies to many types of information other than that which is CAD related.

Cultural Issues

- There will be resistance to the introduction of new methods of working. For the introduction of 3D modeling, this is expected to be at the same level as that for the introduction of 2D CAD.
- ➢ Technology is not the problem. It will continue to develop to meet perceived needs. The real problem that needs to be addressed is the attitudes of the people using the technology and in its management.
- ✓ Techniques of managing IT resources that were well known with centralized computing need to be reconsidered and introduced into distributed working.
- ✓ There is a need for an IT Champion operating at the executive level of an organization to promote the interests of best practice in the use and development of IT.

Contractual Issues

- Turnkey systems specified by a client can impose additional costs where the system is not that normally used by a project participant.
- IT standards used on one project may differ from those used on another. This can impose additional costs on project participants.
- ➢ Contracts are currently written to recognize paper-based communication and not electronic communication. This is closely related to legal issues.
- ➢ Integrated working requires extra work during the early stages of a project. However, the benefits of such work are not seen until later. Payment structures do not reflect this.
- ✓ There is a need to develop generic standards that can be used across projects.

Legal Issues

- Where integration takes place at present, it is usually one organization that takes responsibility. Although there are benefits in doing this, the lack of standards and frameworks for data integration means that there is a risk.
- ➢ There is a need to establish a framework for information ownership and liability in an electronic world. This is closely associated with the need for development of satisfactory procedures for acceptance of electronic signatures.

Training Issues

- Most training currently deals with the functionality of individual software applications and not on their use within the context of a project. This is closely related to issues of how information should be delivered for projects.
- Presently, many organizations have to use multiple software applications to satisfy the needs of clients and this imposes extra training costs.
- ✓ Training needs to be continuous as new software is introduced and as project needs become more demanding.

3 Computer Aided Design

The effective use of Computer Aided Design (CAD) systems is a key task for managing the design and engineering activities within AEC/FM organizations.

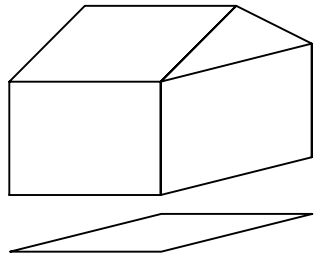
3.1 The As-Is situation

All organizations participating in the study apply a platform strategy in the purchase of CAD software. In some cases, this is enforced centrally at the level of the organization, in others the decision is delegated to the department level. Platform strategy refers to the decision to use a particular software product (AutoCAD in the majority of cases with Microstation as the second most popular solution) and to allow different teams to purchase (or develop in-house) specific solutions as add-on programs.

- One organization directly invested in its own basic CAD development. This was not successful. The result was that they decided to stop basic CAD development. They now only develop specific add-ons for specialized CAD purposes.
- Two other organizations have successfully developed standard software in special market segments, in one case road design and in the other case structural design.

To summarize, all organizations use either in-house or third-party customizations of the chosen CAD platform. In-house CAD system development has only proven successful in special market segments.

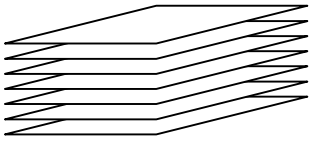
3.1.1 Use of 2D versus 3D approach



A major question is the use of the 2D capabilities of CAD versus the use of 3D capabilities. Currently, CAD usage is predominately 2D, and virtually all organizations use only 2D for construction drawings. This accounts for the major part of the work done in design and engineering departments. 3D modelling is seen mostly as being for visualization purposes only. In several cases, this work is outsourced to sub-contractors, and is also often done using different CAD packages (i.e. different to the platform strategy). Since the tasks for which 3D modelling is used are separate to the main business (design and production drawings), consistency between 2D and 3D models is not keenly sought.

- However, several organizations have started to consider the future potential benefit of using proper 3D models. The advantage is seen in having more information available (e.g. for extraction of quantities) and for better design co-ordination (e.g., 3D clash detection).
- One organization uses 3D for core design (particularly massing studies) during early design and then transforms the 3D model into several 2D drawings for production drawings.
- Three organizations have started to use a 3D approach for real life projects (one for steel structures, one for concrete structures and the third for road and railway projects). In one case this includes co-ordination between trades based on 3D models and layering conventions.
- Another organization currently plans to carry out a subsidized project based fully on a 3D approach. This is to assess the potential benefit of, and to learn how to implement, such a process into the current business process and how to train and motivate the employees.

3.1.2 CAD Practice and Layer manuals



All organizations use in-house or national standard layering conventions. There is no use at present of the International Standard for layer definition (ISO 13567). In the absence of a generally accepted layering convention, the convention used has to be negotiated for each new project. Often the main contractor or client decides on the convention to be used.

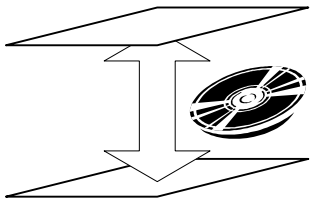
Complex projects, where many disciplines or trades are involved, can use high numbers of layers; in one case, up to 9000 standardized layer names were noted in a project using the organization layer convention. Such large numbers of layers requires special software to handle the complexity. In two

organizations, internally developed layer checking software is used to support the process and form part of the quality assurance system. In a few cases the chosen CAD package determines the use of a particular layering convention.

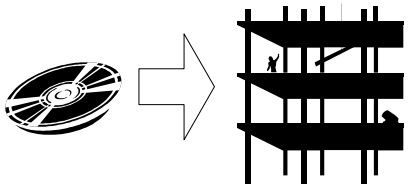
- All organizations have developed and use CAD Practice Manuals for internal CAD operations. The content of such Practice Manuals includes naming conventions for layers, use and naming of external reference files, styles for linework and annotation (text, hatching and dimensioning) and file use and naming. Often the use of output facilities such as paper space is also regulated. However, to be used successfully, the guidance given with the CAD Practice Manual needs to be seen as part of the organizations normal operating and quality procedures. This is often not the case.
- One organization is making extensive use of external reference file technology to reuse standard solutions and for semantic interpretation of design objects. The required nesting of external reference files reaches up to six levels, which means that use of this technology is stretched to its limits. Elsewhere, it is noted that there are recommendations to limit nesting of external reference files to no more than three levels.
- In some countries national standards or industry-wide conventions exist for layering conventions. These are increasingly being accepted by AEC/FM organizations in those countries. Standards developed or in preparation include:
  - the American Institute of Architects (AIA) layer convention in North America,
  - BS 1192 part 5 in the UK,
  - the IT user group layer convention for the building industry in Denmark,
  - VDI 3805 part 1 (a layer guide for HVAC design) has recently been published in Germany.
  - national layer guides are in preparation in Japan and Singapore.

3.1.3 Data exchange

Data exchange of CAD drawings within the AEC/FM industry is currently restricted either to the DXF format or to the file format of the chosen platform (DWG for AutoCAD or DGN for Microstation being the most prevalent). Frequently, the use of native file formats is preferred to the use of DXF to ensure that there is no data loss in the exchange. IGES, which is widely used for graphics data exchange in the automotive and aerospace industries, is almost unknown in the AEC/FM industry.



3.1.4 Data extraction



In general, organizations make very different use of the ability to extract other data from CAD models or drawings. Some do not extract data at all. However, there are many that do try to reuse data based on the current technology available. The extent to which this is done varies according to the technical capabilities within the organization.

- Some organizations extract area measures from CAD drawings, e.g. for space programs (or the “space book” – a particular deliverable in Germany).
- Two organizations extract Bill of Quantity information from CAD drawings for a limited subset of quantities (in this case, for concrete work and for road design).
- One organization extracts some data from CAD as input into structural analysis (but not detailing)
- One organization extracts data from CAD for formwork design. This is done by extensive use of a layer convention.

3.2 Current Problems and Gaps encountered

A major drawback of current CAD technology is seen as the inability to provide the means for design co-ordination. Many organizations still rely on paper drawings for this purpose.

3.2.1 Use of 2D versus 3D approach

The following reasons have been identified with regard to why current CAD use remains predominantly limited to 2D working:

- 3D modeling has not yet achieved a break-through. Software that works in 3D is still too complicated and too slow whilst the training requirements for its use are too high.
- There is a general consensus that 2D working is economic but that this is not the case with 3D working.
- Employees are often not sufficiently motivated to take on the challenge of new technology, nor is enough time given to them to learn how to use it effectively. Draftsmen have (typically) been trained using older education techniques and are often unwilling to change their working style. Even architects and engineers are not usually trained to take on the challenge of 3D working.

3.2.2 CAD Practice and Layer manuals

Layer conventions were first introduced by organizations who became aware of the benefits of structuring their data. Working in isolation, each major organization developed its own layer convention. Later efforts to harmonize layer conventions within formal standards have not yet had real impact even though organizations recognize their benefit. Organizations and, more significantly, their employees are reluctant to change.

Problems existing within the current situation can be seen as:

- Different philosophies exist for naming layers. This makes conversion between two layer conventions difficult.
- In some cases, due to different professional views, there are even different Practice Manuals and layering conventions used within different departments of the same organization.
- There is an understanding that the existence of CAD Practice Manuals is not enough. Their use has to be controlled and needs to be part of the quality assurance process.
- The shortcomings of layers to structure AEC/FM information are well understood. However, layering is the best technology that is currently available.
- Layering technology mixes two concepts, the structure of information and the presentation or visibility of geometry (line style, thickness, colour).
- There are some examples of harmonization of layering at a national level and to enforce their use through procurement requirements. However, these are still in the process of development or dissemination, e.g., the Japanese C-CADEC (Construction CAD Data Exchange Consortium) layering guide and the Singapore layering standard. These layering guides are not seen as a universally applicable layering convention (as organizations already have their own established conventions and are hesitant to change). They are seen as a conversion mechanism between layering conventions particularly to allow the development of co-ordination drawings. This is a similar philosophy to that adopted by the ISO Layering Standard ISO-13567 which allows for ‘conceptual compliance’ of standards whose naming approach can be readily converted to ISO format.
- No intermediate solution can be seen from current layering techniques until there is a standard that defines how to exchange information between the new generation of object-oriented software applications. The work of International Alliance for Interoperability (IAI) in developing specifications for Industry Foundation Classes (IFC) is seen by many large organizations as the best solution for the next generation of data exchange. End-user access to IFC based application interfaces is time critical, otherwise different in-house or vendor specific solutions will appear.

3.2.3 Data exchange

Data exchange formats that are widely used at present (DXF, DWG, DGN) do not remain stable for long periods of time. They undergo change as the owning company brings out new releases of software and the change usually reflects capabilities of the new software rather than the requirements of industry. This imposes problems for medium-term data storage.

3.2.4 Data extraction

In general, there is still minimal integration of CAD with other engineering software for e.g., area or quantity takeoff.

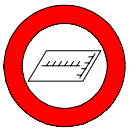
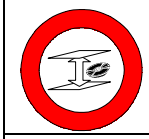
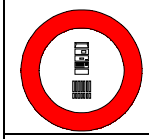
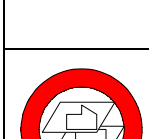
- Quantity take-off from CAD is not often used in practice (and then only for limited subsets). 2D data is of limited use for full quantity take-off
- Area calculation can be partially achieved within CAD but national building codes and standards often impose measure rules that cannot easily be dealt with by current CAD software.
- Integration with other engineering software is achieved primarily through manual data re-entry.

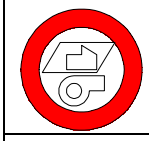
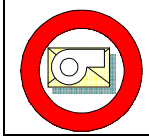
3.2.5 Other Subjects

Effective teamwork is hampered by the fact that there are no real solutions available for multi-user access to data. Current locking mechanisms work at the file level. This is too coarse to work effectively as a file usually represents a large block of data such as a whole building storey.

In one case problems were identified with the theoretical exactness (or precise meaning) of CAD drawings, since exact dimensions are not usually required in architectural design drawings within the current culture. This further diminishes the use of CAD drawings.

3.3 Future Vision

	Object technology will provide the breakthrough to model based working. The object-based approach will deliver the means to structure design/ production/ maintenance information and to allow seamless and continuous use of this information during the life cycle.
	For one organization at least, getting unambiguous and precise 2D drawing data remains the vision for the near future.
	Information sharing will accomplish the link between design, management and schedule data, including such data as is used or generated on the building site.
	A project server and data pool from which all applications can get and send their data is envisioned as being used from the beginning to the end of the project. Further the use of design data as input into the facilities management process is expected.
	The means to allow collaborative work through appropriate multi-user access techniques will be developed.
	For object-oriented data exchange, organizations involved in IAI have the vision that with IFC, there is a great chance to have a standard supported by commercial software at the same time that a new generation of software is introduced. They believe that this chance is there only once. If IFC fails, the same situation that prevails with layering technology will also happen with object technology.
	Major productivity gains are anticipated from automatic comparison between design and production drawing versions, such as highlighting changes made during last session(s), or differences between two versions during data exchange.

	Major productivity gains are anticipated from establishment of bi-directional links between CAD systems and other applications to reflect the consequences of design changes. In particular, better co-ordination between CAD and HVAC is considered to be the first priority
	Major productivity gains are anticipated from access to and use of external library data such as part libraries, manufacturers data, etc in conjunction with the new generation of object oriented software.

4 Electronic Document Management

Electronic Document Management (EDM) offers the ability to track documents both internally and as they are shared with others. The organizations participating in the study utilized varying techniques for deploying EDM, ranging from simple approaches developed in-house to commercial off-the-shelf products designed specifically for this task.

The promise of EDM is one in which the status of any document can be easily assessed and charted throughout the lifecycle of the project. However, all participants identified that the approach currently used within their organization must evolve to a higher level of usefulness and dependability.

4.1 The As-Is situation

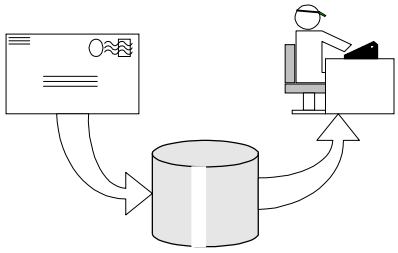
The most common application of EDM found applies to documents related to the deliverables provided to customers. These documents typically include CAD drawing files and text documents such as specifications, reports and correspondence with the members of the project team.

About half the participating organizations utilize EDM for the incremental activities within the organization that occur between milestones (e.g., tracking revisions to engineering calculations, equipment product selections, etc.).

Only a few organizations currently apply EDM to all aspects of the business in which they are involved, including corporate management, marketing, human resources and accounting.

4.1.1 Simplified Approach to EDM

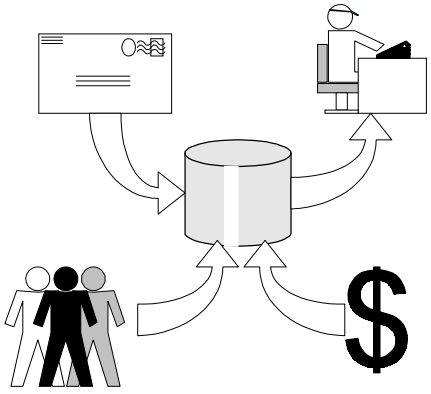
The most common approach to EDM involved logging information into a database as documents are delivered to or received from project team members. This is typically done manually by the project manager. The EDM procedures tend to be less formalized, and typically it is the responsibility of the project manager or group leader to ensure that procedures are enforced.



Documents are most frequently stored in a set of common project directories on a server with access restricted by department. For example, the CAD staff has access to the CAD drawings, but not necessarily to the engineering documents. In many cases, organizations chose to separate EDM procedures for CAD drawings from EDM procedures for other documents. This resulted in a more formalized set of procedures for CAD drawings than for other documents.

A predefined file naming system is normally employed so that project participants can identify documents without having to view their contents. At milestones, project directories are backed up for archiving purposes. However, it should be noted that nearly all the organizations that utilize this approach perform all these tasks manually, rather than relying on an integrated EDM product to automate the process.

4.1.2 More complex Approaches to EDM



Few of the organizations in the study utilize an EDM product designed specifically for this purpose. These products provide all of the capabilities defined above plus those required for documents related to project management, human resources, accounting, etc. However, the EDM products that are currently available are not necessarily specific to the AEC/FM industry, and were usually tailored to meet specific needs.

Organizations using this approach tended to be larger with more formalized procedures for adherence to EDM policy across the entire organization.

It should be noted that several organizations that have investigated solutions to a more complex approach to EDM rejected current commercial off-the-shelf products. The reasons for these rejections include:

- The desire to keep things simple and not introduce a formal EDM layer into the organization
- The currently available EDM solutions are not flexible enough for handling the various AEC/FM industry workflow processes
- Normal practice in AEC/FM projects requires flexibility in workflow processes, often even breaking own rules for making immediate decisions. The more rigid EDM systems that come with workflow management capabilities are not yet suitable to cope with this requirement.
- The cost to properly configure and deploy a full EDM strategy was prohibitive

However, those organizations that had evaluated available commercial off-the-shelf EDM products intend to re-evaluate products every six to nine months to stay abreast of product capabilities, particularly with regard to web-based solutions.

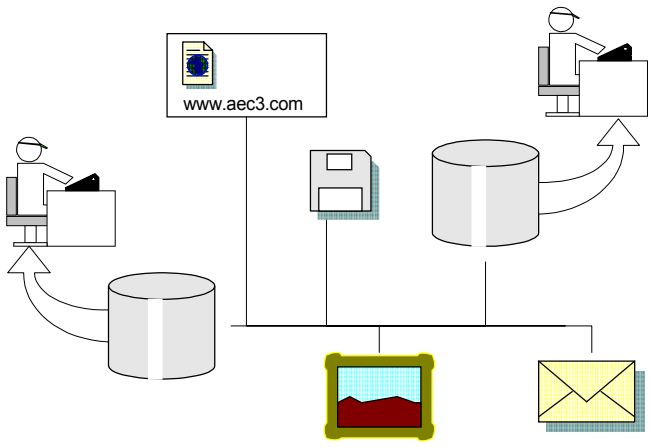
4.2 Current Problems and Gaps encountered

The typical EDM related problems and gaps that were encountered concern the isolation of groups within an organization. It was very common for each department to have control over its own documents. This prohibits the use of a project-related EDM strategy spanning multiple groups within the organization.

Another key problem surrounding EDM is related to the archiving of data. Few organizations have found a solution to archiving data independently of the applications used to create them. For example, CAD systems used today may or may not be able to read CAD drawings twenty years from now. Consequently, the 'brute force' solution is to archive the applications that are used to create the documents simultaneously with the documents. However, few organizations in the study have made this a standard practice.

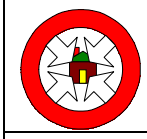
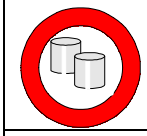
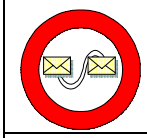
A related problem concerns documents that are referenced within documents (e.g., CAD files that are background or external reference files within the current document). EDM strategies offer limited support for archiving these referenced documents.

4.3 Future Vision



Organizations participating in the study have the vision that a lightweight, web-based EDM product will provide the capabilities to meet their requirements. Although some are experimenting with such products, few have identified this as a strategic business objective.

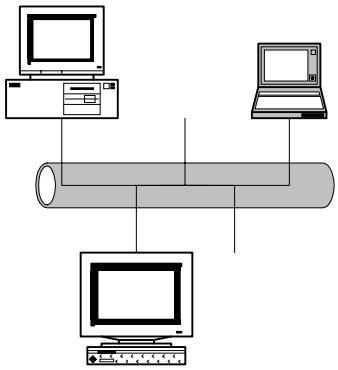
The vision of the attributes that are required for an EDM product that would satisfy the needs of the AEC/FM industry includes:

	EDM will operate on Extranets that enable a project-centric approach. This will focus attention on information that exists for the project and will unite team members across corporate boundaries.
	Provision of EDM on Extranets will enable the use of a repository for the project into which project information can be placed and from which information can be taken by others as needed..
	Provision of active content that can be accessed by the EDM system will facilitate the development of a distributed database that can be shared across Extranets, Intranets and the Internet for project team members.
	EDM will work in conjunction with process developments to enable flexible and easily configurable systems for handling varying workflow processes.
	EDM systems will enable identification of project participants and the types of information that they need and will integrate with corporate email systems and Extranet, Intranet and Internet technology to deliver only relevant information.
	Problems surrounding the inclusion of reference files or documents and difficulties of long term access to files stored using proprietary file structures will be resolved to enable free access to archived data.

5 Networks, Project Servers and Inter/Intranets

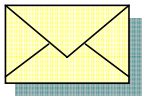
All organizations involved in the study utilize network technology to provide internal connectivity and electronic mail and web browsing. Most also provide servers dedicated to specific projects as well as Intranets that are used for intercommunication amongst both organization employees and project collaborators. Nonetheless, all expect to significantly invest further and redefine these services as information technology evolves.

5.1 The As-Is situation

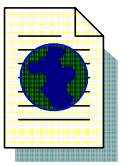


Without exception, all organizations in the study provide fundamental networked services to their employees. The most common configuration was Intel-based computers with Windows NT servers and Windows 95/98/NT clients. However, nearly all participants had other operating systems and/or architectures that were in use, including Novell and Linux servers, IBM mainframes and iMac clients. These network services provide file services (e.g., storage, personal directories, project directories, etc.) and peripheral sharing (e.g., printers, plotters, modems, etc.).

All the study participants with multiple offices provide some form of electronic collaboration among employees at different sites. Most organizations provide wide area networks typically using ISDN or Frame Relay technology to connect to servers in the larger corporate offices. The most common backbone among remote offices was the Internet with firewalls protecting the host Internet connection sites from intrusion.



Nearly all study participants provide electronic mail and World Wide Web access to employees via their networks, and indicated that the use of electronic mail and web access was critical for client communication, research, marketing, etc. About half restrict or monitor access to the web using electronic filtering.



Most organizations have Intranets with which they provide organization information to employees as well as share project information internally. About half these Intranets are driven using active server pages to ease maintenance associated with underlying database-driven content. The use of Intranets was noted as a critical mechanism for project collaboration particularly among organizations with a distributed workforce.

Nearly all organizations have experimented with sharing project information using project-specific Extranets with external team members, clients, contractors on site, facility operators, etc. However, these services are typically provided on a limited basis due to the cost and maintenance associated with their maintenance. A common expectation was that these types of services will be used predominantly in client driven contract scenarios, such as turn-key projects, design/build or design/build/operate scenarios.

5.2 Current Problems and Gaps encountered

All organizations noted that there was a high investment necessary for maintaining servers, networks, Intranets, etc. Hardware and software must be continuously maintained and upgraded, and the personnel costs are high (e.g., dedicated IT staff, training of non-IT staff, etc.). Security and dependability were also cited as issues that warranted concern.

The speed and dependability of Internet connections can be problematic. Organizations that must transfer large quantities of data across the Internet typically encounter problems associated with synchronisation of content across remote sites.

Organizations where employees can access files on a twenty-four hour basis have encountered problems ensuring adequate backups can be performed, since open files are locked during the backup process.

5.3 Future Vision

All organizations expect to continue to evolve and enhance their networks, servers, and Intra/Intranet services. These services are critical to business operations and must remain current with industry trends for their organizations to remain competitive.

The following are some views of short-term expectations for the organizations that participated in the study:

	There is an expectation that web technologies will become even more critical for project co-ordination both internally and externally.
	There will be less dependency on paper as all corporate standards, policy, etc. are published on the corporate intranet.
	There will be expanded use of project servers and Extranets for sharing project information. The receiver will place information on the project server / Extranet for downloading on request. Notification of placement will be issued rather than issuing the information directly as at present.
	There will be more widespread use of active services for real-time update of content on Internet / Intranet / Extranet and this will enable more dynamic maintenance of information.
	There will be a fast migration of XML into the workplace as the technology becomes built into mainstream office applications and web browsers. For instance, it is noted that Internet Explorer 5 and Netscape 4.5 are already XML capable.
	There will be continued experimentation with alternative platforms and services (e.g., handheld computers, Linux, etc.) and these will make project sites into an integral part of the project information network.

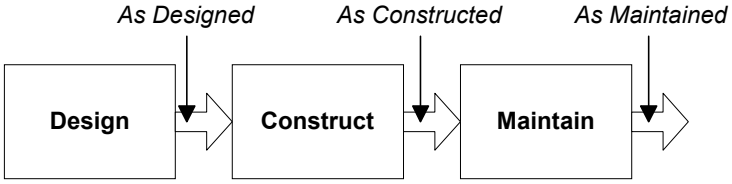
6 Process Issues

Process issues arise from the need to know what IT systems are to be used at which stages in the development of a project and, more importantly, what they are intended to produce. They also have an impact on quality management since an understanding of process enables the 'process model' to be used as a checklist to ensure that all work that is required has been carried out.

6.1 The As-Is situation

6.1.1 Process Definition

For designers, plans of work published by professional institutions provide a degree of process definition but they exist only at a high level. However, these are relatively crude as process models and are designed to identify only the major stages of a project for information turnover and points at which payments are relevant. There is little evidence to indicate that organizations set out to define processes in terms of their information and communication requirements. The operation of the design process therefore is implicit in the mind of the designer and this means that the designer must identify what needs to be done and when from experience.



For constructors, the process requirements of specific projects are usually made explicit via the schedule of work. However, the schedule tends to be unique for every project; there is little evidence of constructors trying to define detailed, generic processes explicitly.

A few notable exceptions to the above analysis were noted during the study. For Client organizations that are motivated to take a 'hands-on' approach to AEC/FM undertaken on their behalf, there is evidence of interest in process. For instance, BAA plc. regard process definition as a key development and they are currently documenting all of the processes within their organization (not only those concerned with AEC/FM). However, even within BAA, some problems were identified due to the fact that different parts of the organization are using different techniques to define their processes.

The notable exception to the lack of process definition occurs within accounts departments. Usually, the accounts department knows exactly the process it is following, has it defined explicitly and follows it precisely.

6.1.2 Quality Assurance

QA

An explicit definition of process is required for quality assurance and quality management according to International Standards. However, quality assurance is usually seen as something that ensures work has been done according to set down documentation standards after it has been completed rather than defining how the work should be done in the first place.

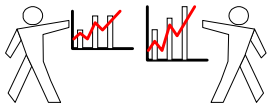
Not everyone includes IT within their quality assurance processes. Whilst most AEC/FM organizations in Singapore are ISO 9001 certified for design and construction purposes, it was noted that many organizations did not include their IT processes within the certification. This was also found to be true of organizations in Japan. However, in Germany, it was found to be normal that they were documented in the organizations quality assurance manual.

One organization in the UK is beginning to make use of product model based data exchange according to the CIMsteel Integration Standards. They noted that one of the benefits of the approach is that it built quality into their IT processes and that this resulted in better engineered products, less communication problems, clear understanding of requirements and better value engineering.

6.1.3 IT In Core Business

A major problem identified by many organizations in the study is that the use of IT on projects is not perceived as a core business activity. Usually, IT is used to automate manual processes and increase the speed of production of information. The important aspect of this is that the process adopted with the IT system is exactly the same as that adopted for the manual system and the information output is exactly the same as it would be with the manual system.

6.1.4 Business Process Change



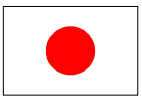
It was noted that many organizations participating in the study were undergoing corporate restructuring or had recently done so. However, there were no examples of opportunities being taken to restructure the design, construction or facilities management processes at the same time.

However, not every organization felt that there was a need to change business structures or business processes to obtain better application of IT. This tended to be more the case for organizations based in Asia than for those based in Europe or the United States.

6.1.5 National Initiatives

However, even those organizations that do not see the need for business process change expect that national initiatives that will complete development over the next few years will have an impact on business process.

In Singapore, developments in integrated submission systems and model based working (rather than drawing based) are expected to cause change.



In Japan, the CALS project undertaken for the Ministry of Construction will require electronic submission of prices and will set standards for the development and delivery of CAD information; both requirements that can be expected to impact on business process.

6.2 Current Problems and Gaps encountered

6.2.1 Process Definition

Although AEC/FM is a process, there are very few organizations that have set out to define their working processes and how they relate to each other.

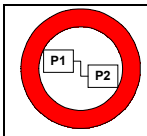
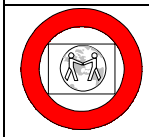
6.2.2 Re-entering Information

A key factor in the potential for business process change is that the number of times that the same information has to be re-entered to the computer can be reduced. Studies in the UK by Laing have identified that, for certain information, this can occur 5 to 6 times during the project lifecycle. Clearly, each time that information is entered, having been entered before for a different purpose, there is a cost and time implication. If information could be 'Key Once, Read Many times', there is a clear business benefit. In the process industry, studies by Shell have identified that 16-17% of IT usage time could be eliminated if re-entering data could be eliminated.

6.2.3 Links Between IT Functions

Re-organization of the design, construction or facilities management activities within organizations is hindered by the fact that there are few links between corporate IT functions and project related IT functions.

6.3 Future Vision

	There is a requirement for one or more process models that define good practice for working within the industry and that allow the identification of use of IT.
	Definition of these models at a generic level will allow individual organizations to map their methods of working to established industry best practice.
	IT processes will form part of quality assurance and quality management initiatives within an organization and they will be an integrated part of ISO 9000 series certification.
	National and international initiatives for information submission in support of particular processes will identify key points in generic process models.
	The understanding of process will enable the definition of information supporting particular processes. This understanding will be translated to information exchange and sharing (databases) technology that will remove the need to re-enter information multiple times.

7 Cultural issues

The introduction of new technology into an organization inevitably leads to changes in the structure and culture of that organization. This is particularly the case as organizations move from personal working to collaborative, distributed working across networks. The potential for massive change is apparent. The possibilities of global working are becoming evident and we must expect this to impact the AEC/FM industry as much as it is doing with other industries.

However, cultural issues are not restricted to the macro scale; they also impact within the organization in a number of ways and in the relations between the organization and other project members. Many of these issues relate to the reaction of people to the introduction of new technology solutions. It is clear from interviews that people within organizations are considered to be inherently conservative. Sometimes there may be good reasons for this conservatism.

7.1 The As-Is situation

7.1.1 Philosophy of IT Use

A major cultural issue identified within the study is that there is no consistent philosophy of IT use either within large organizations or between different disciplines.

Between disciplines, philosophical differences are substantial. They relate to the way in which different disciplines practice and how they develop and use information. For instance, although it is normal for architects and engineers to use CAD to develop designs, these have to be printed onto paper for submission to the cost consultant.

Philosophical differences can also be seen in the way in which classification systems are used as a means of identifying information type. Elemental approaches are used in architecture and structural engineering whilst work section based approaches are more normal in services engineering. Cost consultants will often classify bill items differently again.

There are a number of efforts occurring to resolve the classification difficulty but it must be anticipated that it will be many years before there is a general solution in widespread use.

7.1.2 Decision Making

A cultural issue closely related to the philosophy of IT use is that of decision making on IT systems to be used. Because IT at the project level is not regarded as core business, the equipment and systems are largely considered as commodity purchases within the budget and control of the various divisions of an organization. This can lead to different purchase decisions being made within the same organization.

This issue is then extended to decisions about the operation of the equipment and the standards to be applied to its operation. Again, these can be different. Within organizations participating in the study, there are several instances quoted in which the manner of IT operation differs greatly between different divisions. Elsewhere in this report, the use of different standards for CAD use is identified. As well as being a technical issue, this is also cultural. It stems from decisions by different operating units that they should be independent of the rest of the organization in what they do.

The issue also extends into decisions about the management of IT systems. Again, there are several instances where access to the Internet and the use of Internet/Intranet technology differs between different divisions of the same organization. In some cases, Internet/Intranet use is generally available without restriction and is seen as a positive working tool. In other cases, it is seen as subversive and a technology that undermines management control.

Clearly, the development of integrated ways of working with IT depends upon clear vision of IT use and an implementation policy that is designed to bring about integrated working. There are clear signs that this is being increasingly recognized and that organizations are beginning to take action to bring it about.

7.1.3 IT Champion

It is noticeable that those organizations that are making the most effective use of IT and who are making the strongest moves towards integration are those that have an IT Champion operating at executive level within the organization. The IT Champion may not be someone with a deep technical knowledge of IT but it is someone who has a belief in its effectiveness as a business tool, who takes advice from technologically aware people and who then applies business common sense to that advice.

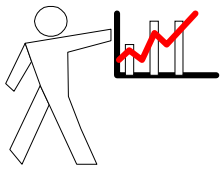
One organization in the United States identified that many of its executive level staff acted as IT Champions and that, as a result, they had been able to develop complementary skills. This had resulted in a policy that the organization always provided 'best technology' solutions to its staff. They felt that they needed to do this in order to remain competitive.

In parts of Asia it was found that IT use was seen as a technician level skill and not as something with which professional level staff became involved. In consequence, the role of IT Champion was not practised at executive level. In such organizations it was noted that, whilst heavy use might be made of IT, the level of development of use of standards and integrated facilities was less than elsewhere.

7.1.4 Marketing Solutions

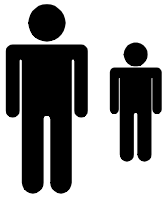
Part of the problem in demonstrating the value of new IT methods is that they are not well marketed to potential users. This may be for various reasons including:

- insufficient allowance being made for trials of the new IT methods,
- insufficient allowance being made for dissemination of information about the results of successful trials,
- inadequate presentation of the results of successful trials either through too much emphasis on technical detail, too little emphasis on business benefit or simply poor presentation.



Innovative organizations have identified the fact that there is a need to test new technologies in practice under controlled circumstances and that this requires investment by the organization (either alone or in collaboration with like minded organizations). Having proven the value of the technologies, it must be professionally marketed with emphasis on the business benefit (higher productivity, higher profitability etc.) rather than on the technical innovation.

7.1.5 Generation Conflict



New generations coming into the industry will have been trained using IT. They have an awareness of what IT can do and an expectation that they will be using it. Although limitations do exist in training (see Training Issues below), organizations can benefit from this awareness.

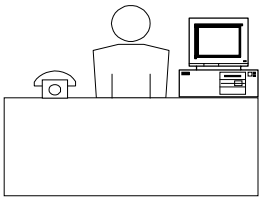
The problem of generation conflict was most evident in discussions with organizations in Japan where it was clearly identified that many current, but older, managers are not familiar with IT and that they are reluctant to change working practices.

Some design organizations interviewed had a noticeably young staff and a culture that encouraged their engagement in decision making on the use of new technology. Generation conflict was not an issue for them. They were also the organizations that were exhibiting the highest growth rates in terms of profitability and staff intake.

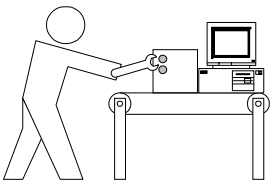
7.1.6 Who is the Operator

Two models of IT use were identified in the study:

1. operation of IT systems is by all staff (professional use model),
2. operation of IT systems is by specialist staff who take instruction from professional levels of the organization (technician use model)



In practice, every organization operates according to a mixture of these models. In particular, the most advanced technologies remain the province of specialist users who have received the necessary detailed training and acquired the appropriate experience in their use. These technologies include such items as complex 3-D modelling and visualisation, analysis using computational fluid dynamics (CFD) and simulation and analysis using other complex mathematical techniques. What differs is the emphasis and mix of these use models.



The technician use model is predominant in Asian countries. It was suggested that this is due to the more traditional cultural approach in Asia which places a greater distance between the professional person and the technician. However, the technician use model is also relevant in Europe and the United States. One of the most innovative United States organizations stated that *'There is a preference to have those with specialized skills in an aspect of IT usage (e.g., CAD) perform these tasks rather than requiring all employees to have expertise in all aspects of IT. Consequently, employees receive only the training in their area of expertise'*.

Probably the most relevant comment made concerning this issue was that it is necessary to understand exactly who are the IT operators, what skills they have or what skills they can be trained to have and what support is to be provided to the chosen model of operation. Without this knowledge, a clear strategy cannot be formulated.

7.1.7 Introduction of Model Based Working

Resistance to change was a constant theme in discussing cultural issues. It was also seen as an important factor in the introduction of 3D and object oriented software.

A leading UK design organization indicated that they currently have difficulty in persuading people to move to the use of 3D modelling even when it is beneficial to a project. A number of reasons were put forward for this reluctance to change but the most significant was that approachability of software tools remains a problem. Current user interfaces are satisfactory for present approaches such as 2D CAD but are probably not the best design for 3D and object based work. The user interface paradigm requires more work before model based working can be truly an 'everyday' working method.

7.1.8 Management of Distributed Working

The introduction of the personal computer created a revolution. It enabled tasks to be completed faster. It placed analytical power in the hands of end users and took it away from the centralized Management Services department. This was not a problem when computers were truly personal and carried out dedicated tasks for their users.

However, most organizations now have their computer systems interconnected via a local area network; those with multiple offices are using wide area networks and Internet technology will make interconnection a possibility for virtually everyone. New generations of software are being designed for distributed working.

Large organizations identified a particular cultural issue in that management of distributed resources and working procedures had not kept pace with their introduction. Evidence of this lack of management control was seen in many areas;

- Disjointed decisions concerning purchasing enabling the proliferation of different hardware and software types (resulting in increased support costs and decreased purchasing power),
- Lack of consistent standards and procedures in IT use (resulting in reduced ability to integrate applications across networks),
- Insufficient attention given to analysis of user requirements and their 'best practice' satisfaction.

7.2 Current Problems and Gaps encountered

7.2.1 Definition of Information

There is not yet a single standard that is widely accepted that defines the semantics (meaning) of information in a dictionary form or the classification of information hierarchically within such a dictionary.

7.2.2 Project IT at Executive Level

There are too few organizations that have well informed IT representation at the executive level. This can hinder the development of IT solutions. It also acts to reduce the importance of project related IT issues in relation to corporate IT issues. Both are important.

7.2.3 Role of Project Leaders

A major block to the introduction of new IT methods are project leaders. However, a good case can be made for their reluctance to embrace innovative technology, particularly where this can be seen to have come from research efforts and where it has not yet proved its stability or value.

A project leader is given the task of ensuring that a project runs to time and budget and has the responsibility of ensuring an adequate return (profit) to his or her employer. The pressures placed on the project leader can be high, particularly where completion schedules are tight and where there needs to be close control on costs to achieve adequate profitability. In such circumstances, the use of new, uncertain and often unproven technology is a risk. A significant role of the project leader is to reduce risk and uncertainty and this naturally leads to a conservative view.

Project leaders will accept new technology if and when its value can be clearly demonstrated. However, demonstration of the new technology must include considerations of its security and stability. It must also identify to the project leader that there is support for the technology and assistance in its implementation.

7.2.4 Generation Conflict

Although it is gradually reducing, there is a generation conflict existing that plays a cultural role in the introduction and use of IT within organizations. It is still the case that there are insufficient people at the executive level of organizations who have substantial experience of IT. This is particularly the case for the newer technologies that have the potential for a big impact on the way in which the industry works.

7.2.5 Stability and Support of IT Solutions

Many organizations participating in the study identified the fact that too many IT methods for AEC/FM are promoted without regard to stability or support. This leads to a natural scepticism within the industry and a reluctance to change.

7.2.6 Resistance to Change

It is expected that the introduction of 3D modelling and other object oriented software applications will cause the same resistance to change as did the introduction of 2D drawing based CAD 10 year ago.

7.2.7 IT Management Procedures

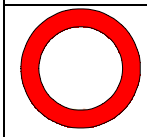
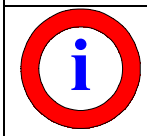
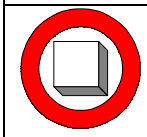
It was considered that there is a need to bring back some of the ideas of mainframe computer use in information management for distributed working. This will enable more effective use of IT resources. But it needs to be done without impacting on application software at its point of use.

7.2.8 Technology Is Not The Problem

One interviewee described attitude as being the biggest cultural problem in the use of IT methods. In his view, technology is not a problem as we move forward; everything in the technology area is a 'can-

do' culture. The major problem is the attitudes of the people using the technology and what they are prepared to do. Too often, this is more of a 'no can do' culture.

7.3 Future Vision

	Professional and trade bodies representing different disciplines within the AEC/FM industry will work together to define common philosophies for information use.
	Organizations will recognize that their future well-being depends on project performance and will give equal emphasis to Project Information Systems as they currently give to Management Information Systems.
	The development and use of Project Information Systems will be represented at executive level within organizations.
	Information about the development and use of new technologies will be presented to industry in appropriate form (marketing and language) that enables them to better identify business benefits and so overcome the reluctance of blockers within the organization to the introduction of such technology.
	Model based working will become more effective with better user interfaces so that it can take a more prominent place in the set of tools used by an organization (along with current drawing technology).
	Tools and techniques for the management of distributed working will become available and useful.

8 Contractual issues

IT is changing the ground rules for contractual arrangements and the conduct of contracts. Traditional ways of defining contractual relationships may not be effective for projects where IT use is extensive.

IT offers great potential for new ways of working with information and the results can be highly beneficial to designers and contractors as well as to Clients. However, effective use of IT may cause changes to the profile of work within a project. Presently, there are few developments in contractual approach that recognize this change in profile and which understand that the shape of the curve of risk and reward has changed as a result.

Changes in the conduct of contracts will continue as yet more new technology emerges and affects how information is exchanged and shared. This section identifies a number of issues of concern.

8.1 The As-Is situation

8.1.1 Integrated Working

Many organizations interviewed are taking steps towards the use of integrated IT working. They believe that there are benefits to be obtained from its use, not only for themselves but also for their clients. However, they do identify that there are risks involved in integrated working and that these risks have both a legal and a financial implication.

Having integrated information available also enables and promotes better co-ordination between the work of the project members. It allows for co-ordinated development at both the design stage and the construction stage whilst good co-ordination will facilitate better project maintenance. However, co-ordination does require effort and it requires effective sharing of information. Many examples were quoted in the study of the use of integrated project information enabling the identification and resolution of co-ordination problems before they arose on site. The effort put into identification and resolution ensured a better project and reduced costs (in comparison with after the event). But again, this is an investment made early in the project which, because it will reduce costs, might actually work against the profitability of the project.

One organization interviewed in the UK identified a historical context with regard to co-ordination. During the 1970's, co-ordination was identified as a specific consultancy service on many public projects and was subject to an additional fee. With changes in fee arrangements, this service is now not normally identified as an additional service.

8.1.2 Turnkey Projects

A turnkey project is one in which the use of IT systems is dictated to project members. Usually, this will be by the Client but it could also be by the lead contractor. For the organization dictating the system to be used, there are significant advantages since the format in which other partners deliver information can be guaranteed to be immediately useful.

However, there can be costs and problems associated with turnkey projects. These costs may be borne by the Client but, more often, they are borne by project members. Several organizations identified the difficulties as:

- The fact that systems specified are not the same as those in use within an organization will cause the need for purchase of additional software (and possibly hardware)
- Lack of familiarity with specified systems means that organizations need to undertake training or buy in experience.

These factors will cause higher costs and lower profits to the organization.

The reason that turnkey projects are specified is often because the available methods of data exchange are not sufficiently reliable. In Germany particularly, problems with use of the DXF specification for drawing exchange have been identified. This is seen as less of a problem in the UK where detailed guidance on the use of this specification is available and where a validation programme

for DXF translators is in place. However, since not everyone uses this guidance and since not every software company submits their DXF translator for validation, difficulties still exist.

In Japan, there appear to be few projects in which turnkey systems are specified. However, many sub-contractors voluntarily use the same system as the lead contractor or Client to "please" them. In this case, although there is no coercion, the decision to use a particular system which is not that normally used can be seen as a marketing decision.

8.1.3 Use of Standards

Apart from the specification of particular IT systems to use, lead organizations on a project might also specify the use of their organization standards for information production and delivery. This might also be done as an alternative to the specification of particular systems.

For other project members, the difficulties and costs that arise from the use of standards that are different from those normally used are exactly the same as those that arise from the use of turnkey software.

8.1.4 Collaboration

Information production and delivery in a consistent from for a project is facilitated by collaboration between project members. However, collaboration within AEC/FM is usually focused on a project, there is almost no guarantee that the same team will continue with a new project. This works against the establishment of mutually harmonized organization standards.

8.1.5 Contractual Agreements

Client organizations in many countries are recognising the need to become involved with the processes that deliver and maintain their buildings. Those organizations taking part in the study have realized that conventional forms of contract are not proving effective at supporting the information sharing that they require on projects or at delivering the required buildings on time and budget. They are looking at alternative ways of working.

In the UK, BAA plc have developed a 'Framework Agreement' for work carried out on their behalf. Organizations within the Framework Agreement are pre-qualified according to criteria of technical capability, quality of work and other factors. Designers and contractors then work according to process requirements set down by BAA. Because the Framework Agreement sets down a working protocol and because there is a limited number of organizations within it, it overcomes one of the principal problems in AEC/FM. That is, the virtual organization of a project in which project members are often new to each other and to each others way of working. The Framework Agreement is a form of 'Partnering' in which the partnership rules are made explicit.

Partnering in the broadest sense enables organizations to define means of working together as though they were a single organization. At the information level, it does require that there is a consistent approach to the use and sharing between the partners. A leading firm of structural engineering consultants in the UK sees partnering as an important competitive advantage on major projects and sets out to identify other organizations that share their philosophy and work with them.

8.1.6 Multiple Packages

Many of the organizations interviewed indicated that they maintain several different software packages for the same purpose. This gives them the capability to use the software that is most relevant for a given project (according to the known systems in use by other project members or the specification of turnkey software). They recognize that, in doing this, they have higher costs for purchase and training than would be the case for a single system use and their total efficiency in system use might be reduced.

8.1.7 Electronic Bidding

After drawing based data exchange, the leading candidate for exchange of information electronically is cost information.

Standards exist for this purpose and are already in use in Germany.

In the UK, an EDI message (in UN/EDIFACT format) has been defined by EDICON/CITE for the transmission of Bills of Quantities at various stages.

In Japan, the construction CALS project defined by government will start electronic bidding in 2001 (for parts) and 2004 in full.

8.2 Current Problems and Gaps encountered

8.2.1 Payment Profile

Many organizations identified that, for the additional efforts of generating a structured plan and for creating and maintaining integrated project information, reward is not defined in the current payment scheme. This hinders the break through of CAD use in construction, since CAD can only be efficiently used, if data are well structured. This causes higher investments at the beginning of a project with the payback on the investment being returned at the end. However the actors involved at the beginning of the project (mainly architects and consultants) do not get higher percentage fee on the project costs. Therefore they are discouraged from putting effort into better CAD usage.

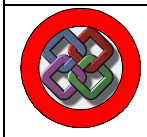
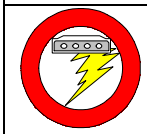
8.2.2 Harmonized Standards

There are few harmonized standards available for IT use and those that are available are not always used. This leads to the situation where lead organization standards may be specified for a project. The lack of harmonized standards increases project costs and hinders the ability to exchange or share information.

8.2.3 Contracts

Current forms of contract are written for the age of communication by paper. By not recognising the potential for electronic communication, they act to limit the potential for IT use and hinder the development and acceptance of new technologies.

8.3 Future Vision

	Rewards for integrated working will be redefined to reflect more closely the distribution of effort that is required to achieve it.
	New or revised contract arrangements will recognize IT use and will be written to encourage it.
	Improved methods of data exchange and sharing will be developed that allow organizations to maximize the investment of their system of choice. This can only come about if the difficulties of information exchange that are now known can be overcome in new and/or improved exchange formats.
	Electronic submission of information will become normal for many information requirements.

9 Legal issues

Closely related to contractual issues are those issues that have legal impact since every contract has a legal framework. Progress in legal developments in relation to IT is notoriously slow. Of itself, this may not be a bad thing since any legal framework must have a sound and proven basis against which to operate. However, there are circumstances in which legal issues may play a part in hindering the development of IT use in AEC/FM. The result of this is that innovative organizations who do press forward with the development of IT solutions may be putting themselves at risk.

9.1 The As-Is situation

9.1.1 Ownership of Integration

The legal implication arises from the current state of development of integrated IT and its use within the AEC/FM industry. Because there is no generic way to integrate applications, it is currently usual for a single organization to integrate information on a project. This involves more work at the beginning of a project and means a higher financial risk and presents a greater risk of error which, in turn, means a higher legal risk.

9.1.2 Information Ownership and Liability

One of the biggest issues facing organizations that wish to exchange and share information is that of information ownership and liability. This is a subject that has no geographical limit; it is consistent for every organization interviewed and in every country in which interviews have taken place.

The major difficulty that arises from this issue is the identification of who is liable if things go wrong. With paper copies, established practice makes the situation very clear. If the information provided is wrong, it is the sender who is liable. If the information is used incorrectly, it is the receiver who is liable. Information exchange adds another dimension to the problem in that current data exchange techniques cannot cope with every situation that a user of the technology might attempt. This is particularly the case with drawing data exchange where lines can be shown differently on received drawings than on the sent version, text font and size can differ, units can be interpreted differently on different systems etc.

Most of these problems can be resolved with a little effort on the part of the sender and the receiver. However, this effort is required at the beginning of the project and may require the sender and receiver of information to modify their IT usage practice.

That this can be done was seen from UK practice where the recommendations of the European CAD Quality Manual were followed. This is the one example noted that provides for a data exchange agreement. This agreement allows liability to be defined.

In both the UK (English and Scottish law) and Singapore, work has been undertaken on the legal and liability implications of data exchange.

Banking Practice

Banks will accept instructions to act on account if they receive a letter through the mail with an original signature. However, they will not normally accept instructions sent through by fax with a copy of the signature.

In a remote action of this nature, the bank acts to reduce its liability risk because it cannot guarantee the facsimile signature.

In Internet banking, an account holder can move money between accounts or issue instructions to the account without the intervention of the bank.

In a remote transaction of this nature, the risk is with the account holder and not with the bank.

9.1.3 Electronic Signature

The issue of information ownership and liability also extends to the provision of electronic signatures so that there is the same indication of responsibility for issuing of a document or drawing electronically as there is for the issuing of it in the form of paper.

Work on electronic signatures has been undertaken in Germany in connection with a European Union funded research project. One interviewee in Germany was also able to identify that a recent project by the German National Railway Company (Deutsche Bahn) had recently undertaken a project in which electronic signatures to documents was used. This required the use of a workflow solution, based on

Lotus Notes EPLASS which allows check-out, check-in, electronic submission of plans and limited change management by providing red-line capabilities (based on bitmaps).

9.1.4 Importance of Paper

Because there is no legal support for the exchange and sharing of information electronically, paper copies of drawings and other documents retain their legal significance as contract documents. For legal protection purposes, organizations must issue paper copies along with electronic copies. This necessarily slows down the communication process and results in a limitation of the impact that information exchange and sharing technology could have. This is particularly the case at contract interfaces where there is a need to freeze information at a particular stage of development and hand it over to others for continued development.

The fact that it is the paper document that has legal significance can act to increase overhead costs associated with information exchange and sharing. This is because the receiver of the information must use time and effort to ensure that the information that they have been given in electronic form is exactly equivalent to the information that they have been given in paper form or that they are at least aware of the differences and can question how these differences can be resolved.

There are signs that this situation may be changing. The Civil Evidence Act passed in the UK Parliament in 1997 allows for information to be stored in digital format providing that it cannot be changed once stored and that the original form of the information on paper can be recovered. This is being used by some leading Client organizations who are scanning their archive drawings and storing them on optical media. This reduces the need to store paper and saves office space that can then be used for other purposes (a significant factor in locations where space rental costs are high). In Asia, the Integrated Submission System being developed in Singapore and the electronic bid submission system proposed by the Japan CALS project will also require attention to the legal validity of documents transmitted electronically.

9.2 Current Problems and Gaps encountered

9.2.1 Risk versus Convenience

At present, there is no legal support for the exchange and sharing of information electronically. This means that, where electronic exchange and sharing is used, it is at the risk of the sender and receiver of the document and has the status of 'convenience' rather than good working practice.

9.2.2 No Support for Electronic Signature

There is no legal support as yet for electronic signature and therefore drawings and documents distributed electronically cannot be used as contract documents.

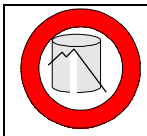
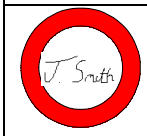
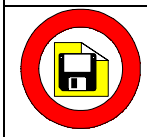
9.2.3 Need for Paper Copies

In every interview where this subject was discussed, study participants identified that they always sent paper copies of the document or drawing to accompany electronic copies and that on receipt of information they always checked electronic copies against paper copies very carefully.

9.2.4 Slow Communication

The need for paper copies of drawings and documents as well as electronic copies to satisfy the need for legally binding contract documents acts to slow down the communication process.

9.3 Future Vision

	Risk associated with integration of information will be reduced by the development of a legal framework that recognizes how it is used and its value.
	To a large extent, this will come about through a clear definition of ownership and liability with respect to information that is stored and shared electronically.
	Use of electronic signatures will be legally supported.
	Legal systems will recognize the validity of information distributed on electronic media (either magnetic or optical). It is recognized that various safeguards will need to be incorporated into any such legal recognition.

10 Training Issues

In order to get the best results from IT systems, users must be trained in their use. Organizations do routinely undertake training for their staff. Yet there are issues concerning the effectiveness of this training. Principally, these issues concern the IT methodology used within an organization and the differences in the ability to use IT systems between different generations.

10.1 The As-Is situation

10.1.1 Training Location

Some organizations carry out training in-house whilst others use external training specialists. A common feature however is that all organizations require training to be away from the normal working environment to prevent day to day work affecting the training process.

10.1.2 Training Approach

A key factor identified by many organizations is that the training approach causes users to learn the basic software functionality and not the methodology of its use within the organization. This is particularly the case with CAD where training focuses on how to draw a line or define a layer but does not include aspects such as what type of line to draw in which circumstances or how to use the organizations standard layer convention. Several organizations did identify that methodology was included as part of the training for a project team (in which case in-house training was invariably used).

Those organizations that have documented standards for IT use find that these are critically important in the training of methodology and their use on a project reinforces what has been learned.

10.1.3 Continuous Development

All organizations indicated that training is not a one-off situation. Policies are normally in place to ensure continuous development of staff capability. One organization in Germany ensures that its staff are trained in the use of new versions of software before they are brought into use.

10.1.4 Generation Differences

Generation differences are frequently apparent in training. New entrants to an organization coming from a college or university will have used IT systems as a normal tool within their education. They expect to use similar IT systems in their work. But they have to work with older generations who have not received the same level of training. Since the older generation will normally be in the senior position, frustrations can arise. Therefore, training has to take account of the needs of older generations who may lack the basic familiarity with the software tools that younger generations possess.

One organization in Japan has an employee grading system for IT based on perceived computer literacy. The content and extent of training can then be developed around these grades so that everyone can develop according to their own capabilities.

10.1.5 Multiple Applications

The use of multiple software applications within an organization (see Contractual Issues) can lead to the requirement for more training and higher training costs simply to maintain the skill base.

10.2 Current Problems and Gaps encountered

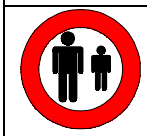
10.2.1 Need To Focus on Methodology

Training does not provide sufficient focus on the methodology of IT use and the importance of standards.

10.2.2 Training For Older Staff

Older generations lack the training and familiarity with IT that new entrants to the industry possess.

10.3 Future Vision

	Training will focus more on the methodology and use of structured data and on the use of standards than on the basic functionality of software (this does not exclude the need for basic functionality training).
	Training will take account of and make allowances for the views and abilities of different generations within an organization.

11 Summary of Visions

This section brings together all of the Visions outlined in the various sections of the study into a single reference.

11.1 Computer Aided Design

1. The future CAD technology is object oriented. The object-based approach should deliver means to structure design/ production/ maintenance information and allow seamless and continuous use of design/ production/ maintenance information during the life cycle.
2. Information sharing should accomplish the link between design, management and schedule data, including such data as used or generated on the building site.
3. A project server and data pool from the beginning to the end of the project is envisioned from which all applications can get and send their data. Further the use of design data as input into the facilities management process is expected.
4. The needs to allow collaborative work (multi-user access) has been raised.
5. With IFC the great chance is there to have a supported standard at the time a new generation of software is introduced. This chance is there only once. If IFC fails the same will happen as with layering technology.
6. Better co-ordination between CAD and HVAC is the first priority
7. An automatic comparison between design and production drawing versions, such as highlighting changes made during last session(s), or differences between two versions during data exchange
8. Establishment of bi-directional links between CAD system and other applications to reflect the consequences of design changes
9. A major push in efficiency is expected when it will become possible to electronically access and use external library data, e.g., part library, manufacturer data, etc. A possibility is seen in using a bar code in paper based catalogues (as technology for the transition time towards fully electronic catalogues)

11.2 Electronic Document Management

1. A project-centric approach that unites team members across corporate boundaries
2. Simplified responsibility for all project team members to participate in EDM
3. A distributed database that could be shared across intranets and the internet for project team members
4. Flexible and easily configurable for handling varying workflow processes
5. Integration with corporate project-related email systems
6. Resolution of issues surrounding archiving

11.3 Networks

1. Expectation that web technologies will become even more critical for project coordination both internally and externally
2. Less dependency on paper as all corporate standards, policy, etc. are published on the corporate intranet
3. Expanded use of project servers and extranets
4. More widespread use of active services for real-time update of content
5. Fast migration of XML into the workplace
6. Continued experimentation with alternative platforms and services (e.g., Handheld computers, Linux, etc.)

11.4 Process

1. There is a requirement for one or more process models that define good practice for working within the industry and that allow the identification of use of IT.
2. Definition of these models at a generic level will allow individual organizations to map their methods of working to established industry best practice.
3. IT processes will form part of quality assurance and quality management initiatives within an organization and they will be an integrated part of ISO 9000 series certification.
4. National and international initiatives for information submission in support of particular processes will identify key points in generic process models.

5. The understanding of process will enable the definition of information supporting particular processes. This understanding will be translated to information exchange and sharing (databases) technology that will remove the need to re-enter information multiple times.

11.5 Culture

1. Professional and trade bodies representing different disciplines within the AEC/FM industry will work together to define common philosophies for information use.
2. Organizations will recognize that their future well-being depends on project performance and will give equal emphasis to Project Information Systems as they currently give to Management Information Systems.
3. The development and use of Project Information Systems will be represented at executive level within organizations.
4. Information about the development and use of new technologies will be presented to industry in appropriate form (marketing and language) that enables them to better identify business benefits and so overcome the reluctance of blockers within the organization to the introduction of such technology.
5. Model based working will become more effective with better user interfaces so that it can take a more prominent place in the set of tools used by an organization (along with current drawing technology).
6. Tools and techniques for the management of distributed working will become available and useful.

11.6 Contractual

1. Rewards for integrated working will be redefined to reflect more closely the distribution of effort that is required to achieve it.
2. New or revized contract arrangements will recognize for IT use and will be written to encourage it.
3. Improved methods of data exchange and sharing will be developed that allow organizations to maximize the investment of their system of choice. This can only come about if the difficulties of information exchange that are now known can be overcome in new and/or improved exchange formats.
4. Electronic submission of information will become normal for many information requirements.

11.7 Legal

1. Risk associated with integration of information will be reduced by the development of a legal framework that recognizes how it is used and its value.
2. To a large extent, this will come about through a clear definition of ownership and liability with respect to information that is stored and shared electronically.
3. Use of electronic signatures will be legally supported.
4. Legal systems will recognize the validity of information distributed on electronic media (either magnetic or optical). It is recognized that various safeguards will need to be incorporated into any such legal recognition.

11.8 Training

1. Training will focus more on the methodology and use of structured data and on the use of standards than on the basic functionality of software (this does not exclude the need for basic functionality training).
2. Training will take account of and make allowances for the views and abilities of different generations within an organization.