Implementation Feasibility Report
Work Package Reference 2.1
Document A

Scope

This document examines the feasibility of performing remote Internet based collaborative computer aided design and highlights the issues that need to be addressed in the baseline implementation. It should be noted that the objectives of this project are to develop the technical basis, human capacity and protocols needed for the distribution ('outsourcing') of Computer Aided Design/Draughting (CAD) workloads from engineering companies in Europe to specialised companies in Developing Countries (DC). They are not to develop advanced computing solutions to concurrent engineering in construction.
The document is a review, a definition and an assessment of the feasibility of using the technologies of relevance to our work. The partners in the programme have a wide variety of expertise and knowledge and this review sets out to establish a common understanding definition of those aspects that are "in" scope and those that are "out" of scope.
The purpose of the feasibility study is to define the state of the art methods and tools, and assess their configurability to support the activities that are to be carried out in the Task 3 Pilot projects.

Technology Review

CARIBCAD aims to apply state of the art technologies in three main areas, working practice, techniques and IT tools.
In each of these three aspects we aim to move from what is widely accepted as current practice to what might be described as state of the art. It is not feasible within our resource envelope to develop new working practices, techniques or IT tools rather we set out to determine the feasibility of applying what is leading edge practice to a collaborative venture in a developing country context.
This technology review sets out to identify what is the "state-of-the-art" in the working practice, techniques and the software tools used in Architectural computer aided design. These three facets can be thought of as

- "**What is done"** (working practice)
- "**How it is done"** (Techniques)

And

- "**What it is done with"** (I.T. tools)

They can be thought of as the axis's which define the boundaries for this technology review.

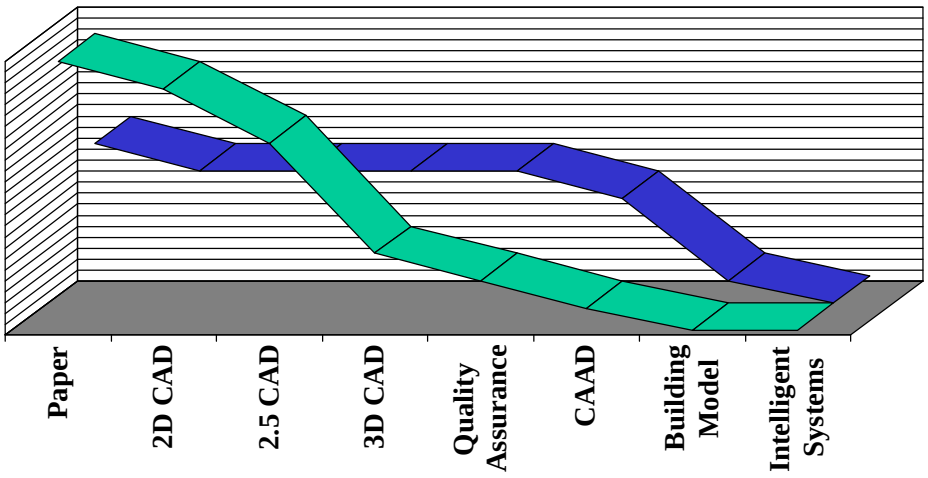
The purpose of ***Task 2.1 Feasibility Study*** is to define where the state of the art boundaries lie, this technology review introduces the components which make up these three axis's Figure 1.

"What it is done with"

Figure 1 Axis of Scope

Working Practice

The diagram below represents an assessment of the current "state-of-the-art" in architectural working practice(shown in green) and the level which it is technical feasible to progress this within the scope and resources of the CARIBCAD project (Shown in blue).



The first goal of the feasibility study is to determine the "reality" line which will lie somewhere between these two lines. A prime determinant in making this evaluation will be the "Requirements Analysis" being carried out by Task 3.1a and 3.2a. The following is a brief description of each of these categories.

Paper

This refers to traditional drawing preparation on paper media. It is thought that this is still the most common form of exchanging information within the construction industry. It is also the biggest barrier to remote internet based CAD. A clear objective of CARIBCAD is to reduce the dependency on paper based production information.

2D CAD

The most widely used form of CAD. In most 2D CAD environments the output of the software is a traditional paper drawing. AutoCAD and Microstation are perhaps the most popular CAD packages and these provide a high level of support for 2D CAD. The objective of CARIBCAD is not to reduce the use of 2D CAD but to reduce the dependency on paper based output. This will be achieved by increasing the support for electronic drawing file exchange.

2.5D CAD

This term is often used to describe a use of traditional CAD packages that lies between 2D CAD and 3D CAD. It allows the user to produce a simple three dimensional view of their building without them having to enter their design into the CAD package as a true 3D model. In essence the user works as normal in 2D and then extrudes the 2D graphics to give an isometric or axonometric view. Therefore each object in 2.5D CAD has a X and Y position in 2D space and a height as opposed to the 3D CAD in which each object has X, Y and Z.

It is not thought that this will have serious technical implications for CARIBCAD but is here merely for clarification

3D CAD

This is just starting to be used in architectural practice but the adoption is very slow. This is most likely because constructing correct 3D models of buildings is extremely time consuming, error prone, they are also difficult to check and there is almost no established skill base in the construction industry that can take advantage of them. At present there value is almost totally constrained to visualisation and simulation. For these applications there is a need to be able to transfer information from a 2D CAD model to a 3D model and vice versa. This transfer is merely a labour saving device there is no demand at present for anything more than a brief exchange of data.

Quality Assurance (QA)

In the northern hemisphere quality assurance is currently of significant importance and becoming even more so. It relates to, but is not the same as quality control. Cynical commentators on QA have observed that

> "*if your company produces a poor product, the application of QA does not mean that you will produce a better product, rather you will produce a poor product* ***consistently***"

In essence QA is about documenting the working procedures of an organisation, stating to what standard these procedures are carried out and monitoring the work against these standards and procedures. The driving force for QA are the clients who commission buildings and architects are often compelled to have in place a QA scheme in order to obtain work. The most widely used QA scheme is ISO 9000.
QA will be of great importance to CARIBCAD as it provides a general framework for formalising the CAD procedures. Such a formal framework would have wide applicability in the industry and would give CARIBCAD a high degree of relevance to industries needs.

CAAD

Computer Aided Architectural Design, is slowly becoming established in architectural practices. It means little more than CAD packages that are theoretically designed to meet the needs of building designers. These packages come in two distinct flavours

- Large CAD packages with a customisation to suit the **A**rchitecture, **E**ngineering, **C**onstruction (AEC) market
- Specialist (often small) CAD packages targeted at the AEC market

Both of these have their critics and the relatively slow uptake in CAAD is clearly a reflection of the inadequacies of both types. In general architects are attracted to the specialist packages but are concerned that they will move out of mainstream CAD and not be able to communicate effectively with other members of the design team. On the other hand they must take on a large overhead in terms of cost and training to use the large mainstream CAD packages and often find the AEC component not entirely suitable to their needs.

The extent to which CARIBCAD supports CAAD will be a critical issue to be resolved by Work Package 3. It would appear that the mainstream CAD vendors are looking to Building Models to resolve the situation.

Building Models

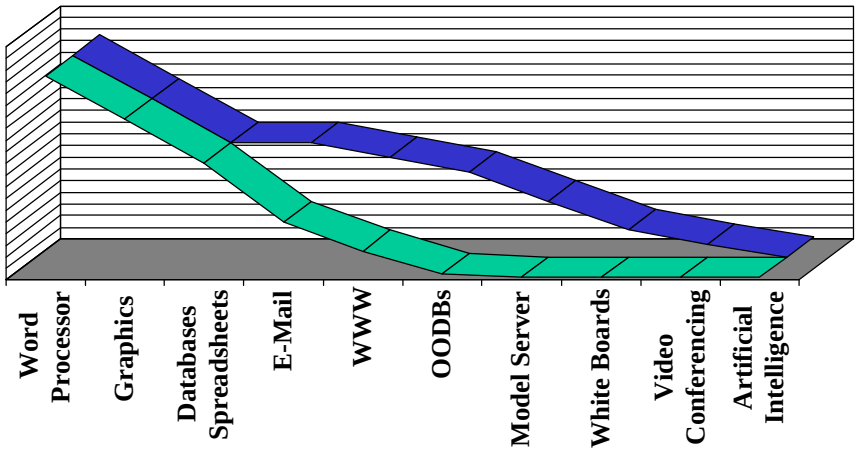
During the last twenty years there has been considerable effort in the I.T. community to move towards a new computer paradigm called object oriented programming (OOP). OOP encourages software designers to think of their programs as a collection of objects (rather than functions and procedures) that model the characteristics and behaviour of real word entities. E.g. there may exist objects in the program which correspond to a man, a door or an entire building.
In parallel with these I.T. developments researchers from the construction industry working in areas such as building energy simulation, facilities management, design support have determined a need to have a common description (model) of a building in order to pass information between different software packages. The COMBINE model is a good example of this approach as are the Building Core Model and the IAI model.
In the last few years these two routes have begun to converge as researchers and commercial CAD software houses look towards creating computer software applications that are Object Oriented in nature and the definition of these objects is based upon the building models that are defined by and meet the needs of the construction industry. Examples of this can be found in the work of the IAI and STEP communities and in commercial products such as Bentley's Objective CAD

Intelligent Systems

This is a general term for all computer environments that aim to add intelligence, reasoning, knowledge, expertise to their operation. Whilst such systems are being slowly taken up in diagnostic applications, such as General Medical Practice very few, if any, of these systems have achieved any success in the construction industry. More specifically, in the area of building design they have been found seriously wanting. It is unlikely that we encounter the need to use such systems in CARIBCAD at the architectural practice side, however, there may be some application of these systems in the area of information management and distribution.

Information Technology Tools

The diagram below represents an assessment of the current "state-of-the-art" in the software tools used in architectural practice(shown in green) and the level which it is technical feasible to progress this within the scope and resources of the CARIBCAD project (Shown in blue).



The first goal of the feasibility study is to determine the "reality" line which will lie somewhere between these two lines. A prime determinant in making this evaluation will be the "Requirements Analysis" being carried out by Task 3.1a and 3.2a. The following is a brief description of each of these categories.

"Office" software

Word Processing, graphics, spreadsheets and databases fall into the general category of "Office" applications. In the EU they are to be found normally in most organisations. The use of these applications from the viewpoint of CARIBCAD is constrained mostly by the level to which they are integrated into design practice, there is a great level of support in the best of these types of application (e.g. Microsoft Office and Lotus Notes) for group or team working as well as software integration. For example, it is possible with applications to create a software tool set that would provide integration between, say, a project specification in a document, an accommodation schedule in a spreadsheet, material costs in a database, work flow in a scheduler and a layout drawing in a CAD package. However, this method of working has not yet been fully absorbed by the architectural profession. CARIBCAD could provide a framework for this kind of integration. There is little doubt that we have considerable use of these tools and that they will create problems due to their different versions and configurations. Guidelines will be required to advise on how they should be used.

E-mail

Just beginning to be used in practice, but it is not really at the desktop of every architect nor is it yet an intrinsic part of their working communication. Typically there will be one person in the organisation who acts as the "gate keeper" for e-mails and then passes hard-copy to the real recipient. This is a major barrier to proper integration and remote working, in order to overcome this CARIBCAD must address issues relating to the

control of information, in and out of, an organisation and provide a framework that reassures those in overall control that their information handling procedures are not being by-passed. It is likely that e-mail will be in wide usage by the end of the project, several of the more sophisticated tools sit on top of e-mail through special configurations. It is possible to configure email systems to suite some of our specific requirements.

World Wide Web (WWW)

Originally intended as a mechanism for co-operating researchers to share information, this has now at the vanguard of a world-wide IT revolution. Whilst the most visible component of the WWW at the moment is the marketing of organisations and their products, its basic functionality is still to share information. Appropriate use of the WWW technologies will be core to the work in CARIBCAD.
The following list is the free software extensions to Netscape and Internet explorer that support the viewing of AutoCAD and Microstation Drawings over the WEB

- AutoCAD WHIP 2, allows AutoCAD files to be viewed quickly over the WEB, not all data is transferred. Download now.
- AutoCAD DWGx, allows full AutoCAD DWG files to be viewed over the WEB, all DWG data is transferred. Download now.
- Bentley Model Server Publisher allows Microstation and DWG files to be viewed over the internet only using Netscape Navigator. Download now

It is clear that WWW Browsers are becoming common interfaces to many other software environments, they are highly configurable through the HTML, JAVA and VB and other scripting languages. They have considerable potential as a major component of the baseline toolkit for CARIBCAD.

Object Oriented Databases (OODBs)

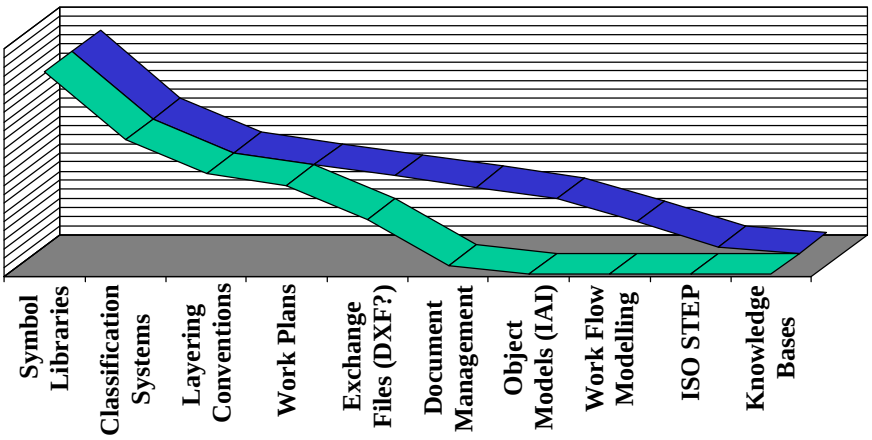
The drive towards OOP in the IT arena has created a demand for a mechanism to store these objects in a persistent file store. An OODB is a database of computer software objects. They are a relatively new computer technology and at present are normally found in "high end" applications. However, it is clear that there will be much wider use of OODB technology in the next few years. Perhaps the biggest break-throughs will come with the new generation of computer operating systems which incorporate OODBs and the new CAD packages which use them to store sophisticated models. Considerable effort has been expended by the major CAD vendors to migrate from their existing drawing file structures to OODB type files. In fact AutoCAD 14 has a form of OODB already for storing the next generation of object models.
It is unlikely due to cost restraints that a major commercial OODB will be used in CARIBCAD, nor is it likely that one will be required to support the Pilot project scenarios. However, there may be a need to employ OODB technology in the area of information handling, most probably on the server, storing and managing access to the complex project documentation as it is produced.

ModelServer

ModelServer Back office is a range of software tools produced by Bentley Systems. Bentley Model Server Publisher allows drawings to be viewed over the internet. *ModelServer* Continuum is one of several "high end", high cost" applications that aims to integrate spatial data with any other engineering data and to act as an information broker, making this information available throughout and between organisations
"Because ModelServer Continuum interoperates with ModelServer Publisher(TM), it can deliver engineering data on demand to any desktop web browser. Organizations need maintain only one copy of their data. The collective information – now including engineering and spatial data – can be shared throughout their extended enterprises. ModelServer Continuum also provides multi-user access to engineering information with short- and long-term transaction management. It includes Bentley's Open Engineering Connectivity (OEC), an API that makes all server functionality available to other applications."
A white paper by Bentley describes this in some detail more information on this can be found on the Bentley WEB site.

Techniques

The diagram below represents an assessment of the current "state-of-the-art" of the the techniques used in architectural practice(shown in green) and the level which it is technical feasible to progress this within the scope and resources of the CARIBCAD project (Shown in blue).



Symbol Libraries

Essentially these are CAD drawings of standard symbols for inserting onto a larger drawing. These symbols range from internationally accepted standards for electrical fixtures and fittings to proprietary libraries of sanitary ware etc. Symbol libraries in recent years have been extended to hold other parametric data, such as the rating of a socket or the colour of a basin. Most recently these are being developed into complete information packages, these hold full specifications, manufacturers catalogues etc. In addition to standard libraries individual organisations will also create their own in-house standard libraries of commonly used building details.

Classification Systems

These began to be introduced into Europe after World War II. The driving force was the large amount of re-building that had to be undertaken and the need to standardise and rationalise information exchange to make the process more effective. The first major and still the most widely used classification system is the SfB system. Like all classification systems it takes the form of a series of hierarchies of terms. The purpose is to group related information together. Apart from this classification systems provide a good basis for agreeing and understanding terminology used in the construction process.

Layering Conventions

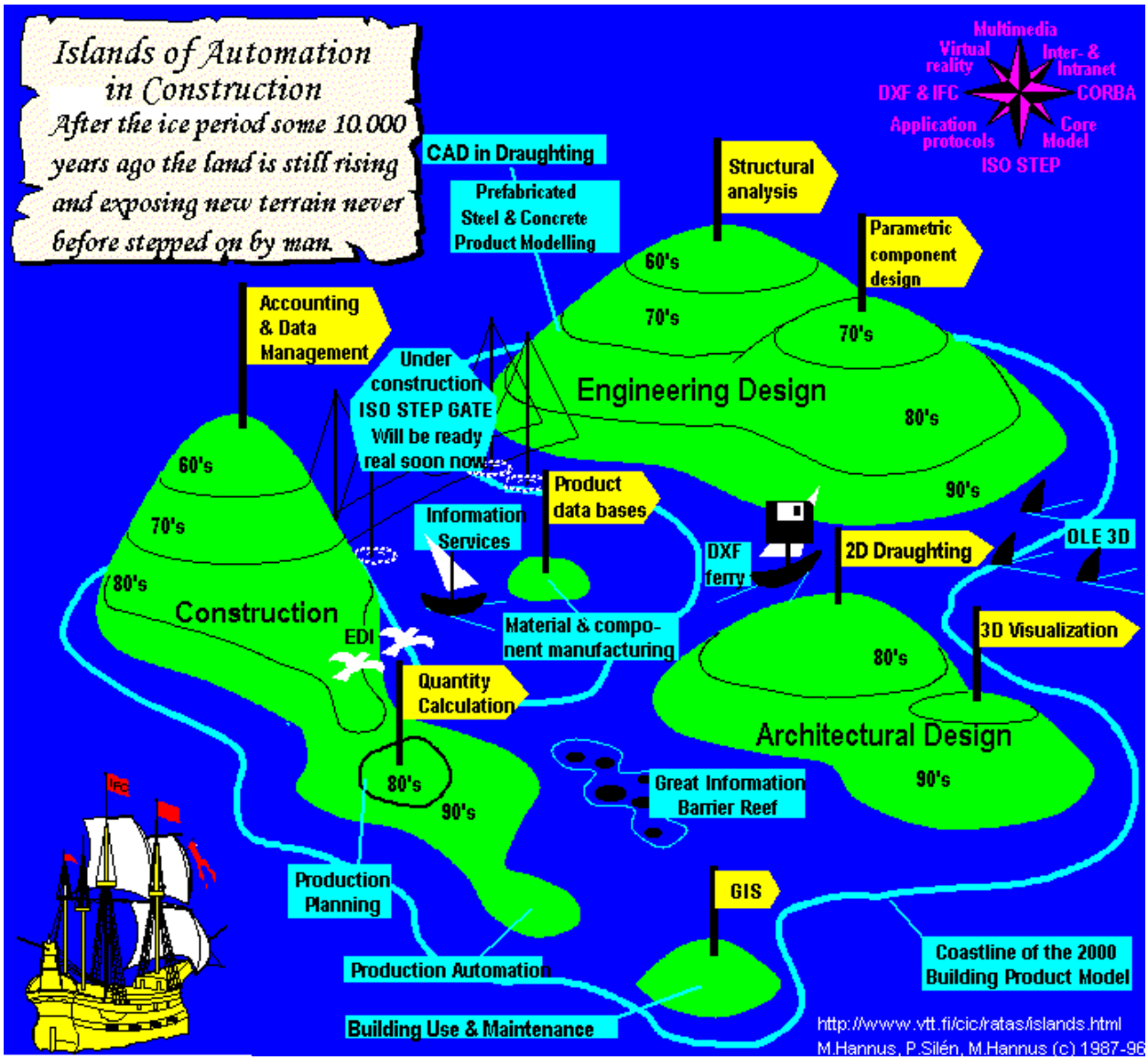
Traditionally construction drawings have always been prepared by producing a master drawing (or General Layout) and then a series of overlays containing specialist data, e.g. Electrical Installation. This was taken on-board by CAD vendors and in some cases taken to the extreme, in these cases every different kind of entity on the drawing is on a different layer. In response to the large numbers of layers that CAD packages could support there was a need to organise these layers so that users could understand and manage them. There are several layer conventions around, ranging again from International Standards that are rarely used to special in-house systems. The reality is that most practices adopt a layering convention which is a sub-set of some national standard.

Work Plans

Work Plans or Plans of Work are guides for practices to help them progress a construction project from inception to completion. Most practices use some of work plan but few implement them rigorously due to the iterative nature of design. Support for work plans is essential if we are to have any form of Workflow Management.

Exchange Files

How is data exchanged from one software tool to another. This is a problem that has a high profile at the moment and is the subject of considerable research. The following diagram by Matti Hannus says it all.



Most architectural practices are still using the DXF ferry, the new work of the IAI discussed later sets out to address this but is unlikely to be a reality in the timeframe of our project. It is really not feasible to exchange data at present in any other form than DXF or perhaps DWG format for CAD reuse. However, there are several formats emerging for exchanging the drawings over the WEB or as plot files. It is feasible to exchange data in these formats but not to reuse it within the CAD package. This will need to be investigated.

Document Management

At present most of the document management that is carried out is paper based. This takes the forms of schedules, checklists, drawing lists, issue lists. There are software packages that can support these activities a few under review at the moment are:

Autodesk Work Center

Microsoft Visual SourceSafe
Xerox Docushare and In-concert

With the costs associated with document management software at the time of writing it is unlikely that full WEB enable support will be feasible within the resource envelope of our project. Careful consideration needs to be given to the real demands we have for document management in the requirement analysis to determine what level of technology is needed.

Object Models - International Alliance for Interoperability etc.

Object models currently have little impact on state-of-the-art practice, they are still in the research domain. It is likely that during the course of the research project they may begin to be available by such organisations as the Industry Alliance for Interoperability (IAI). This was formed to define, promote and publish industry foundation classes (IFC) as a basis for information-sharing throughout a building's lifecycle, across disciplines and technical applications. It is an independent organisation, open to all companies in the building industry. Since it was first announced in April 1995, the IAI has attracted the interest of more than 150 companies and agencies. However, these initial releases will still most probably only be prototypes and is recommended that we do not address this aspect in our research.

Work Flow Modelling

"Workflow Management by definition is the proactive computer system that manages the flow of work among participants according to defined procedures consisting of a number of tasks. It co-ordinates users and systems, participants, together with the appropriate data resource, which maybe directly accessible by the system or off line to achieve defined objectives by set deadlines. The co-ordination involves passing tasks from participant to participant in correct sequence, ensuring that all fulfil their required contributions taking default actions when necessary" (Hale&Lavery, 1991).
Work flow management (WFM) is not a new discipline and over the last twenty or more years there has been available a wide range of WFM software and methodologies. However, these have mostly been highly specialised or proprietary systems. With the advent and establishment of sophisticated group-ware environments WFM has become more mainstream and aligned with these commercial software tools. At first this took the form of extensions to existing group-ware tools such as Lotus Notes, then over time these extensions became an integral part of the group-ware tools. In essence WFM and Group-ware are merging into one solution and it is difficult to draw clear boundaries between the two, we will have to give consideration to groupware for certain choices of workflow tool.
A workflow is a unit of work that happens repeatedly in an organisation, every workflow has a customer and involves the movement and tracking of people, documents, products or information. There are two distinct types of WFM technology, e-mail driven and database driven, reflecting the development from either a communication system which acquired embedded WFM or a WFM system which acquired communication support. Both the tools and the methodologies for Workflow at the time of writing this paper are still emergent technologies and it is envisaged that during the lifetime of this project there

will be significant development. We will have to evaluate these two approaches as part of our pilot projects
As well as technology standardisation there are also moves towards theoretical standardisation through such groups as the WFM coalition.
The WFM Coalition produced a general model of the main components of a work flow environment, the components and relationships between them. (Figure 2)

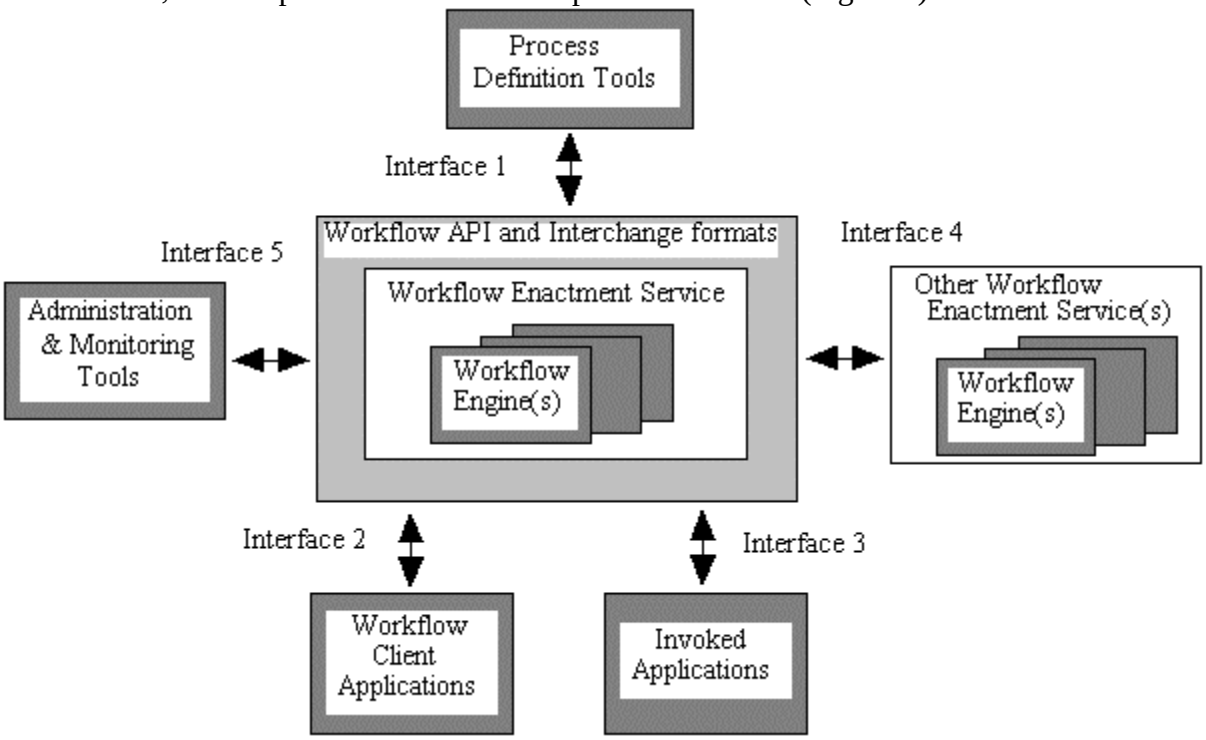


Figure 2 Work Flow Components and Interfaces

This is a good basic model to describe the CARIBCAD workflow components, it is useful to outline the relationships between the tools we use in CARIBCAD and the interfaces described here.

Workflow Enactment Service: at the core is the Workflow engine, enactment service and interfaces. This is in essence the group-ware tool in CARIBCAD, the solutions considered were Lotus Domino, Microsoft Exchange and Novell Inc.'s GroupWise.

Interface 1: The Process Definition tools are the tools used to develop the models of the Pilot projects. These range from informal modelling tools such as flow charts, through more formal diagramming techniques such as the WEB based view of Pilot 1 and 2 to formal models created with a WFM tool such as the Action Workflow process builder.

Interface 2: These are the mail reader tools such as Eudora, Exchange, Pegasus, WEB browsers as well as more sophisticated tools that handle calendars/diaries, tasks, CAD file viewing, PDF file viewing. They run on the local machine in the CAD.

Interface 3: For CARIBCAD examples of these are the CAD applications, AutoCAD, Arkey, Microstation etc as well as document editing tools such as Word or Excel. They are third party applications for specialised tasks. A simple interface to these may be "execute the program and open this document", a more complex nterface may be a task that happens in background such as "convert this file from DWG to DXF"

Interface 4: This is communication between two or more enactment services, for example the server in CAD bureau 1 may need to synchronise the data it contains with that in CAD bureau 2 or request an action from a user in that office.

Interface 5: Essentially this involves administering and monitoring activity in the enactment engine, typical examples are adding new users, responding to non-delivery of mails.

An investigation of the different work flow paradigms will need to be carried out as part of the baseline implementation.

ISO STEP

STEP is a similar but wider development than the IAI. It is a developing international standard that allows companies to effectively exchange information with their worldwide partners, customers and suppliers, as well as internally. Unlike other data transfer standards, STEP is computer sensible. It supports design reuse, data retention, and provides access to data across a product's entire life cycle. Product development strategies, such as concurrent engineering, enterprise integration, electronic commerce and quality function deployment, will significantly benefit from the use of STEP -- allowing them to have a broad impact within enterprises.
There is a great deal of information on the Internet, some starting points are PDES Inc , PDT, SGML and STEP, NASA. It is unlikely that STEP developments will effect our research and if they do it will most probably be through their impact on the IAI or vice versa. The majority of its impact appears to be in the more industrial / manufacturing sectors.