Automatically generating computer simulation models from business process models.

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Automatically Generating Computer Simulation models from Business Process models.

By

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A thesis submitted in fulfilment of the requirements of Sheffield Hallam University for the degree of Master of Philosophy

Abstract

Automatically Generating Computer Simulation Models from Business Process Models

In a modern business environment it is common place for organisations to use both Business Process Modelling and Simulation tools for a variety of business operations. Although these tools are used for different purposes, they are often used on the same projects, but at a different point in its lifecycle.

Business Process Modelling is a static modelling tool, which is *process* orientated and models current business processes. Whilst Simulation is a dynamic modelling tool, which is *system* orientated, testing current and future operations. Although the modelling tools are different the process definition within both methods contain the same data. Currently that data is not reused and simulation modellers will often reproduce that information from scratch. Therefore a successful integration of the modelling methods would extend the capacity of Business Process Modelling tools and make Simulation more acceptable among reengineering practitioners.

A literature review was carried out to identify the capacity of different modelling methodologies, identifying the variances between the modelling procedures and substantiate the need for an integrated solution. Based on the structured research programme, experimentation was undertaken evaluating the proposed method of integration. The results of the research were then documented, evaluating its advantages, disadvantages, limitations and the requirements for any future research.

The research identified the potential of an integrated system and the problems that restrict a solution. From the experimentation it became apparent that integration of two software packages is a feasible option, and could potentially enhance both their capabilities.

Acknowledgements

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Finally the author would like to thank the companies and software vendors that have provided valuable resources and opinion for the completion of the investigation.

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1.1 Introduction

In many organisations Business Process Modelling (BPM) and Simulation tools provide valuable process analysis capabilities. Organisations use BPM techniques to gain knowledge of their business operations, using that knowledge within business process re-engineering projects to optimise their operations. The techniques also provide a valuable tool for manages, enabling understanding and interoperability of their processes, which often support decision-making activities (Dennis et al. 2000). Simulation techniques are used to plan operational resource requirements, improve performance of processes and test new ideas. As a consequence simulation is often used to evaluate improvement plans and match resources to workloads

Currently both modelling techniques are often used within the same project, but at different points of its lifecycle. BPM tools are used to document current business processes, analysing structures and relationships from a static perspective. Simulation is system orientated, modelling processes in a dynamic environment that enables complex analysis, testing processes under operational environment.

Although both methods are often used on the same projects, process-mapping information is created separately and project data is rarely shared. Among many managers and engineers Simulation is regarded as complex and sophisticated modelling tool. As a result its use is often limited to specialists and outside consultants. Whilst BPM has become popular within many organisations as a consequence of its comprehensibility and ease of use. Due to its popularity BPM vendors have significantly enhanced their products, creating industry specific solutions and features that extend its main objectives to increase its popularity.

Therefore integration of the modelling methods could greatly reduce man-hours, resources and the budget required to complete a project. The successful integration of the modelling methods may increase the popularity of Simulation among a variety of industries, extending the capacity of BPM software and increase the effectiveness of reengineering projects.

1.2 Project Objectives

The aim of the dissertation was to examine the feasibility of Automatically Generating Computer Simulation models from Business Process Models. To achieve the ultimate goal of producing a simulation model directly from a business process model, the project follows a structured approach that extensively researches the components involved, their potential suitability and options available for integration. The structure of the project is based on the following objectives:

1. ***Evaluate the dynamic features of Business Process Modelling (BPM) within the business environment.***
2. ***Benchmark the built-in Simulation capability of BPM tools.***
3. ***Develop a methodology for integration.***
4. ***Construct a prototype for integration, validating and refining the tool.***

It has become apparent through various discussions with industrial representatives and software vendors that the integration of Business Process Modelling and Simulation packages is an issue of great interest. Potentially expanding their use, providing consistency within an organisation's operations. Currently organisations are producing models within each format, reproducing the same information within each model, presumably creating inconsistency between the different formats. Therefore integration will provide the capability for information sharing, reducing the information reproduction and potential errors.

Through preliminary investigations it is apparent that although Business Process Modelling (BPM) packages offer simulation capacity, that capacity is rather limited, generally focusing on Activity Based Costing. There have been efforts in the past to integrate both technologies, but because of incompatibilities between both the purpose and model, the success of these investigations has been somewhat limited. However there are parallels between both models, which will enable integration, providing process definition, not only defining what happens to entities within the model, but defining how, where and when the entities pass through a system.

1.3 Evaluate the Dynamic Features of BPM within the Business Environment

In order to understand the issue's involved in the integration of business process modelling and simulation tools, a literature survey will be conducted, investigating the current tools available within each discipline, any previous developments and possible issues which will require consideration within the research. The investigation will include company and vendor visit's which will be used to extensively evaluate varying perspectives. Through investigation it is apparent that there are many circumstances that could effect integration. (E.g. the structure of the package would determine the approach for the problem.). There are currently structured and unstructured BPM packages available on today's market, which provide different issues. Therefore the selected packages would require extensive analysis to identify key issues, which may influence the specific approach taken. From initial discussions with industrial representatives it is apparent that there has been preliminary investigations concerning the integration of the products and they have indicated that they would be very interested in future research on the topic.

1.4 Benchmark the Built-in Simulation capability of BPM tools

To develop an effective integrated solution it is essential that the products available within each discipline are evaluated to assess their current capabilities and specific issues that could effect integration. Therefore it is essential that an extensive benchmarking study is undertaken, investigating the capacity of current BPM packages and their present/future simulation capabilities. Identifying parameters for benchmarking, to construct an effective study. This study will focus the project's attention on quality and planning improvement activities, clarifying the perimeters for further research activity.

1.5 Develop a Methodology for Integration

At this stage the tools that will be integrated will have been selected based on their suitability for the problem, and the most appropriate method of integration will have been identified. The project will aim to develop a methodology for integration identifying the method for the transfer of data/logic, which will allow models built within each medium to be transferred from one package to another. Enabling data to be shared within differing organisational requirements, potentially increasing consistency of the information produced for process and physical flows within the organisation.

1.6 Construct a prototype for Integration, Validating and Refining the tool

The final object of the research is to develop an integrated prototype from the defined methodology, using VBA/XML to achieve physical connection between the different packages. Once solutions have been developed it is then essential that the solutions are validated and refined to ensure the transference of data is accurately implemented for the intended purpose. After evaluation the next step would be to assess future possibilities, identifying possible improvements to the solutions developed, or changes that could be made for varying circumstances.

1.7 Chapter Review

Objectives of the research will be achieved through a series of Chapters, which will be constructed in a methodological manner that will ultimately answer the question ***"is a fully automated integration process between a Computer Simulation model and a Business Process Model possible?"*** The project will include the following Chapters:

- Literature Survey
- Benchmarking
- Methodology
- Practical Experimentation
- Validation and Verification
- Conclusion

1.7.1 Literature Survey

The primary aim of the Literature Survey is to support the need for research into the development of a fully automated integration process between the two modelling tools. This investigation will be supported through the evaluation of Business Process Modelling and Simulation concepts, identifying their purpose and role within a variety of industries. Identification of their roles within industry should establish the shortfall between their methods, but identify the similarities in modelling approach. Potentially similarities could be used to extend their purpose beyond their current markets, extending individual capabilities and increasing the effectiveness of both modelling approaches, reducing the repetition of information when building models in the different formats.

Research will also evaluate the opinions of industrial representatives, software vendors and academics to substantiate the investigation. Providing a valuable insight into understanding the preceding objectives and approaches to be taken.

1.7.2 Benchmarking

The Benchmarking study will evaluate five leading Business Process Modelling tools through common benchmarking practices, which will be used to define their true Simulation and Integration capabilities. Product assessment will identify the most suitable tool for the integration experimentation, through evaluation using predefined categories that will compare the tools via a detailed scoring system.

1.7.3 Methodology

The main objective of the methodology section of the research is to identify a suitable integration method, which will achieve successful integration. This Chapter will introduce the two modelling tools, their methods and available data transfer capabilities. Once the respective methodologies have been evaluated a mapping process will be undertaken to identify the correlating modules. Through the accumulation of methodological data the final stage will be the proposal of the integrated method, which will be used within the practical experimentation.

1.7.4 Practical Experimentation

Within the Practical Experimentation the proposed method will be tested, developing an automated integration process, evaluating its potential and developing the solution to increase the efficiency of the process.

1.7.5 Validation and Verification

The Validation and Verification Chapter will analyse the practical experimentation, evaluating its level of success, defining the advantages and limitations of the approach taken.

1.7.6 Conclusion

The Conclusion will review the value of the research defining the new knowledge gained from each Chapter to ultimately identify whether a full-automated integration process is possible? Once the value of the research has been identified the next stage is to suggest Future Research and Expansion that could precede the project.

The Literature Survey will used to evaluate Business Process Modelling (BPM) and Simulation methods to ultimately justify the research into the *Automatic Generation of Computer Simulation models from Business Process models.* Research for the literature survey was conducted through the investigation of academic publications, articles, and company visits. The chapter will be structured around the following areas:

- Business Process Modelling
- Simulation
- Evidence to support the Research Project

The survey will evaluate modelling methodologies, their purpose and capacities. Substantiating the need for research by identifying there respective characteristics, defining compatibility from supporting evidence and preceding research.

2.1 Business Process Modelling:

Business Process modelling is defined in the following terms: 'A **Business Process** is the definition of the tasks and sequences of those tasks necessary to deliver a business function. **Process Modelling** is the documentation, analysis and design of the structure of business processes, their relationships with the resources needed to implement them and the environment in which they will be used. Understanding the individual components of the Business Process and Process Modelling is not enough on their own. The user must understand the relationships and interactions between the components to achieve effective Business Modelling (Hammer. 2003).

In a modern business environment it is very important to understand not just the business process, but data, systems, organisation, business objectives, products, matrices, risks, regulation, interfaces, skills, the environment and culture. However understanding these on there own is not enough, their relations and interactions between them are very important, which is the role of 'Business Process Modelling' (Davis. 2001).

Through the development of a business, processes develop in many different ways. Manufacturing organisations will operate with rigid processes that are dictated by their operational environment, which operates using high investment resources that often defines the development of processes. In such circumstances it is not a viable option to rearrange resources around the operating processes, such developments can only occur prior to the development of the manufacturing facility. Service providers develop their processes through an ad-hoc approach, which is not restricted by complex resource structures, enabling a flexible approach for their development. Production processes will have been deliberately designed and optimised, but many businesses will have become established through the tradition and practice of the business environment (macro/micro). As a result businesses may produce processes without realising. Companies like BT who are currently in the process of decentralising from a large nationalised company are currently using Business Processing modelling to accurately map their processes to enable the separate organisations to work individually and react quickly to their changing markets.

In an increasingly competitive market it is very important that businesses are able to react to their environment and the competition within that market place. In modern business it is no longer viable to let business processes grow and develop through tradition and practice. Legal requirements and regulation often overwhelm businesses large and small, whilst they also need to compete within their market sector (Davis. 2001). Therefore if businesses are to operate under this environment they must document their processes (Hammer. 2003), at the very least to comply with the legal requirements demanded of them (e.g. ISO 9000). After discussions with Local Government Employees it is apparent that they are legally bound to meet ISO 9000 standards by 2005 and as a result Business Process Modelling tools will be used to a greater extent within those organisation in the near future. Therefore it must be assumed that many other government and UK companies are also obliged by such regulations in the near future.

Due the demands on organisations most businesses have some sort of process documentation (documents, forms, spreadsheets, e.t.a.), which often provide limited capabilities. The majority of these process documentation tools are separate and independent, making the process relationships and interactions difficult to verify. Therefore this kind of model does not constitute a business model, which means that when business models are being planned the question is not should you model the business, but how and to what extent should it be modelled. Without knowing and understanding how a business works it is very difficult to automate a company and build complex business interfaces with other businesses or business units.

Rob Davis from British Telecom has said that every business should have some sort of business model and should consider 'serious business modelling' if a business has one or more of the following uses (Davis. 2001):

- Large, multi-national or global.
- Highly regulated.
- Have significant commercial or legal liabilities.
- Wants to use a high degree of automation.
- Have complex interrelationships with other businesses.
- Wants to deliver high-quality customer service.
- Wants to be an e-business.

Therefore from these guidelines it must be presumed that many companies could use BPM methods to support present and future business activities. Currently there are many organisations of different sizes, from varying global locations that are successfully using BPM techniques. Companies like IBM, American Express, General Motors, Swiss Telecom (etc) are using the techniques to undertake process analysis for daily actives and future projects.

Currently many organisations are using Business Process Modelling tools to support their Business Process Reengineering (BPR) projects. The tools were developed partly through the development of BPR concepts, which are used to capture, document and analyse the business process for reengineering purposes (Hulpic et al. 2001).

Through the introduction of BPR, some companies came through the changes with improved business processes, which made them competitive within their market sector. However many businesses went into BPR blindly, without any benefit focusing on a small number of goals, which often missed the true value of the organisation (i.e. the intangible capital). Therefore today's businesses have realised that the implementation of BPR projects requires a comprehensive review of the business, which has brought rise to the use of the Balanced Scorecard and the European Quality Award, enabling a realistic review of the overall business performance. As a result BPM tools are now incorporating such techniques to enhance the process analysis features. To successfully use BPM tools with BPR the process models must be linked to targets and objectives, with matrices gathering built into them.

2.2 Tools for Process Modelling:

As a result of the increasing importance of Business Process Modelling methods, modelling techniques are becoming widely developed by many software vendors. However organisations have different goals and those goals are met by a variety of software platforms, which cater for many different purposes, resulting in many modelling methods. Due to increasing competition in the current BPM sector it is predicted that the current number of vendors will reduce by a third in 2005 (www3.gartner.com).

In the process modelling sector the methods extend from simple *drawing* packages through to the most complex *simulation* models, which model processes as a physical flow of entities in a dynamic representation. However there is a significant gap between the two methods, which is separated by *mapping* and *modelling* techniques. *Drawing*, *mapping* and *modelling* techniques are static models that are defined under the BPM method, used for the logical representation of processes.

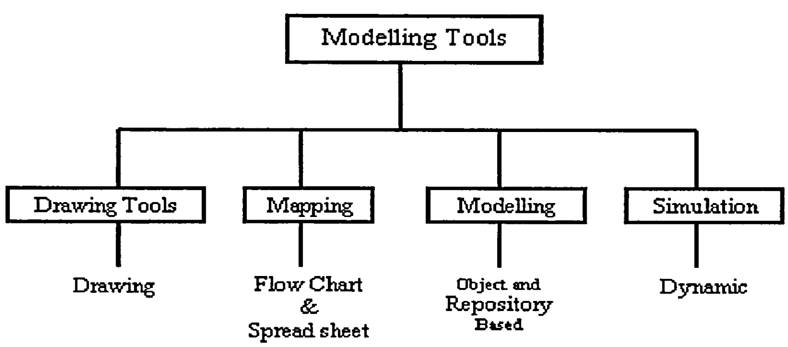


Fig 1: Process Modelling Tools

Drawing tools are the simplest process modelling methodology, which provides the basic functionality required, portraying a process as a picture often provided by standardised templates, containing the icons and images that meet the users needs. The functionality of the *drawing* tools can be extended by *mapping* tools, providing spreadsheet functions that allow data entry and basic calculations. Within these tools there are methods that can be used to validate the structure of the diagrams created through the ability to search and report on the data stored.

Modelling tools are usually described as object and repository based, which means the objects being used within the modelling process are stored in a database (repository). Using the database as the core of the modelling tool provides a system that can manipulate, search and report on data in a flexible manor (www.enix.co.uk). Some modelling tools provide fixed database structures, whilst others allow customisation of structures, which provides extended analytical capabilities, enabling increased flexibility.

The method of performing calculations in a model is commonly described as either 'static' or 'dynamic' in nature. Static calculations is a result of data that is fixed at a single point in time, whilst dynamic reflects the changes of data over a period of time. Dynamic modelling is the most complex form of modelling, which is carried out by *simulation*, whilst static modelling is suitable for almost all BPM purposes except where high volumes of short time frame transactions occur when dynamic analysis may be required. Many of the leading BPM providers advertise simulation capabilities, but that capacity is limited to static modelling, which is often used for Balanced Scorecard activities.

Business Process Modelling Tools			
Drawing	**Mapping**	**Modelling**	**Simulation**
ABC	Optimal	Mood	SES Workbench
Visio	Process Wise Workbench	Grade	Sparks
Process Modeller	Action Work Flow Analysis	Workflow BPR	ARENA
Process Charter	Raditor	Enterprise Modeller	Witness
		ARIS	Rethink
		BPA	First Step
		Casewise	Process Wise Workbench
		BDF	Extend+BPR

Table 1: Modelling Tools

Although there are several modelling methods currently available to the market sector, it is only the most robust and comprehensive solutions that will survive in the future. Currently the leading software producers are those who provide comprehensive repository based systems, whilst simple drawing packages will seize to exist if they don't move on to meet their customers future requirements.

2.3 Approach to Modelling

Although the modelling technique used for a BPM project is very important, a successful project cannot be produced without the people who understand that process and modelling approach. In BPM and Simulation projects the approach to modelling is very important and very similar in method. Without the project structure and the support of the people within the organisation, successful modelling is very difficult. They often become bogged down because the people building the model don't understand the company and as a result the model will not accurately reflect the business.

Business Process Modelling utilises a normal project lifecycle approach and continuous improvement techniques, the project lifecycle is illustrated by diagram below (Marvin. 2000*)*.

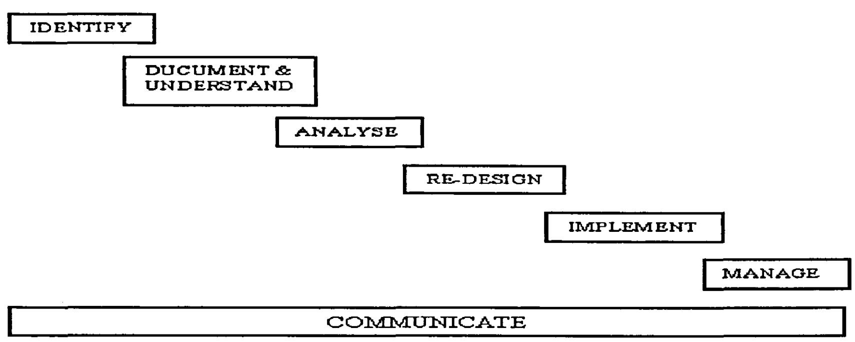


Fig 2: BPM Project Lifecycle

Currently many modelling practitioners have a variety of project recommendations, *Pegden, Shannon, Sholten* all have published project planning guidelines specific to their specialise modelling technique (Pegden. 1990, Shannon. 1990, Shrader. S 2001). However the author feels the lifecycle demonstrated by *Marvin*, suitably demonstrates an effective approach for each concept.

In both BPM and Simulation projects the lifecycle is very important and in both cases similar information will be gathered, which would indicated that if an organisation was to build two different models much of the data will be reproduced. Therefore from this perspective an integrated project and model would provide considerable value to an organisation, saving considerable time and manpower.

2.3.1 Identify

The first stage in a Business Process Modelling project is to identify the relevant business processes. Identification of those processes would require a set of process diagrams to describe how the different processes work. A model will enable diagrams to be drawn quickly and easily, capturing information that describes how the process works, linking those processes together to provide the capability to find interactions.

2.3.2 Document and Understand

After relevant business processes have been identified the next stage in a Business Modelling project, is concerned with identifying additional information and combining that information with the process diagrams to produce an integrated business model. This information can then be used to understand how and why the processes involved operate. Providing a combined understanding of more quantitative aspects of the process, such as costs and times, with more qualitative aspects, such as legal requirements, systems limitations, or training requirements. To produce such business models, the modelling tool should ideally (Marvin. 2000)

:

- Provide a single, managed source of information.
- Have a database that can be customised to store information appropriate to the process being modelled.
- Provide the ability to link parts of a model to external sources of information.
- Generate user-defined reports showing information stored in the model database.
- Produce various graphical views of the model showing information stored in the model database.

To accurately document and understand an organisation to such an extent would demand capabilities that could not be provided by many of the modelling techniques discussed earlier. Drawing and mapping tools would not provide customised databases, reports, etc. Therefore in detailed projects only modelling tools (e.g. ARIS) would provide the required capabilities to achieve a successful project. These tools would also provide the potential structure to store the additional data required for future simulation projects, either within its modelling structure or linked external files.

2.3.3 Analyse

At this stage of the project the aim is to identify the performance of the processes being modelled, which would result in identification of areas that don't meet predefined targets. To achieve effective project analysis, a suitable tool should be able to (Marvin. 2000):

- Produce a "benchmark" that clearly illustrates the qualitative and quantitative aspects of the processes.
- Define formulas within the process model that can be used to calculate the performance of the processes.
- Set targets for each performance measure within the business model and then monitor the process performance against those targets.

2.3.4 Re-design

Through the analysis stage of a business modelling project the processes that don't meet the required performance targets are identified. The next stage is then to re-design those areas, which may produce one or more designs that are improvements of original processes or a totally new process could be designed. At this level a project a modelling tool should be able to (Marvin. 2001):

- Compare and contrast the new designs against the benchmark of the original process.
- Produce "what if" analysis to assess the impact of any proposed changes.

At this stage of the project lifecycle simulation could enhance the redesign process of the process modelling tools by enabling dynamic testing that evaluates the physical flow of entities through the logical process. This testing models the role of time within the process and potential random distributions that may effect the efficient running of the new system.

2.3.5 Implement

Once the design for the new process has been identified the next stage of a project is to implement the process. A business model can be used to support implementation by describing the operation of the process, but to be successful at this level of a project, the business-modelling tool must:

- Generate a clear picture of the process that will be implemented.
- Identify the real world constraints, which may be placed on the process.
- Provide a simple approach and syntax for the communication of the business model.

The risks of introducing a project designed under BPM conditions can be limited through Simulation testing, which will greatly increase the potential for success.

2.3.6 Manage

After a new process has been implemented that processes must then be managed to ensure performance targets have been met. Therefore it is then logical to use the business model that constitutes the main knowledge base of the process concerned to help the management of the process. To manage the process effectively the modelling tool must (Marvin. 2000):

- Help communicate and identify areas for improvement.
- Provide a benchmark that reflects the constraints of the real world process.
- Provide decision support on the performance of the process.
- Provide the means of comparing the process within the business model and the real world process.

2.3.7 Communicate

Throughout the business-modelling project and after its completion it is essential that the people responsible for delivering the process are involved in the modelling development. Communication ensures that the model being built is accurate and a valid representation of the real world. To achieve effect results at this stage of a project, a modelling tool should:

- Provide simple communication syntax.
- Use the language of the user.
- Provide a package, which is easy to understand for an inexperienced user.
- Allow the user easy access to the information stored on the models database.
- Provide the user with the capability to search and report on specific information stored in the database.
- Provide a mechanism, which can allow the distribution of information across the organisation.
- Be method and industry independent.

Although BPM and Simulation tools are used at different points of a project lifecycle it is apparent there are numerous similarities in their approach. When the projects are run separately information is often reproduced.

2.4 Simulation:

Definition of Simulation (Pegden et al. 1990)**:** Simulation – "the process of designing a model of a real system and conducting experiments with the model. Which can be used to develop an understanding of the behaviour of the system or to evaluate various strategies (within the limits imposed by a criteria or set of criteria) for the operation of the system."

Simulation can be used to study and compare alternative designs or to troubleshoot existing systems, whether the system is a production line, distribution network or communication system. Simulation software provides its users with the capability to examine how existing systems may perform if the original system is changed. Such packages allow the construction and execution of models, which can generate statistics and animation, providing a very useful decision making tool.

In the modern business environment simulation has become a common place at all stages of product and process development throughout the entire lifecycle of production facilities or services. This growth has established because the modern organisations have developed their systems, both in size and complexity. As a result simulation and Business Process Modelling has become a necessity in many industrial sectors, potentially increasing its value in the future. E.g. the US Department for Defence has realised the importance of simulation and plan to use it throughout their acquisition process in the future (Evaluating designs (including operational aspects), manufacturing, maintenance, tactical doctrine and training).

Once simulation has been chosen as a decision making tool within an organisation, there are many barriers to overcome if the goals of the project are to be achieved. Barriers within an organisation may include acceptance from staff, availability of staff to describe various operations, existence of useful data and management expectations. Before a simulation project is started the user must be aware of what simulation can and cannot achieve. They must be aware that simulation cannot be used to optimise a systems performance (it can only describe the results of "what if" scenarios or questions), provide accurate results if the inputs are inaccurate, or describe results that have not been explicitly modelled (Hulpic et al. 2001).

2.4.1 Advantages of Simulation

The following list describes the advantages and disadvantages of Simulation tools:

1. *Choose Correctly:* Allows the user to test designs without committing resources or acquisitions
2. *Time Compression & Expansion:* Processes and shifts can be evaluated in short periods of time during a simulation activity.
3. *Provides understanding:* Simulation can be used to model a real world system to answer the specific questions of the user.
4. *Explore Possibilities:* Once a real world system has been modelled, the user can then explore new possibilities, observing the results through computer simulation.
5. *Diagnose Problems:* Provides an increased understanding of the problem, allowing a better understanding of the system being modelled and its interactions, which then serve as a valid representation of reality.
6. *Identify Constraints:* Simulation provides the user with bottleneck analysis, which can be used to identify bottlenecks within a system and discover the cause of delays in work in progress.

7. *Develop Understanding:* Simulation studies can provide the user with an understanding of how a system really operates, rather than indicating personal predictions on how the system actually works.
8. *Visualise and Plan:* Within simulation software there are simulation capabilities available to the user (2D or 3D), which allows the visualisation of the actual system in operation.
9. *Builds Consensus:* Simulation provides substantial evidence, which identifies the performance of a system through modelling, testing, validation and visualisation, supplying an objective opinion. Rather than presenting personal opinion that is not sustained by evidence.
10. *Prepare for Change:* Change can be prepared for by answering "what if" questions.
11. *Wise Investment:* A simulation study is substantially less than 1% of the cost that would be needed to implement a design or redesign project.
12. *Train the Team:* Simulation can be an excellent job-training tool when specifically used for that purpose. A team or individuals can learn by their mistakes and learn to operate better. Which is less disruptive and expensive than learning on the job.
13. *Specify Requirements:* By simulating different capabilities for a machine, requirements can be established.

From the advantages it is apparent that Simulation tools provide numerous benefits, possibly extending the potential of BPM tools. BPM tools primarily focus upon documentation and analysis of current systems identifying relationships between process resources. However Simulation provides the capacity to take that information and test future systems, through what if analysis (Banks.1999). The technology could significantly increase the success of many BPR projects using BPM tools and potentially enhance their reputations for future projects.

2.4.1 Disadvantages of Simulation:

Although Simulation has numerous advantages, it also has limitations that include:

1. *Model Building Requires Special Training:* Model building is a skill and can take a great deal of time to develop, which can make its introduction into projects very difficult.
2. *Simulation Results may be Difficult to Interpret:* Due to most simulation outputs being random variables, it may be difficult to determine whether an observation is as a result of a system interrelationship or a randomness.
3. *Simulation Modelling can be Time Consuming & Expensive:* Skimping on resources for modelling and analysis may result in a project that is not sufficient for the task.
4. *Simulation may be used Inappropriately:* Sometimes simulation can be used when other methods are more appropriate.

Many of the limitations of Simulation are a direct result of the complexities of the technology, which will only be overcome through education and training. Although there are limitations, Simulation is a valuable tool that can greatly increase the value of many projects, providing implementation is introduced correctly (Banks. 1999). However these disadvantage may become less relevant in the future, because today software vendors are now developing models that only require input data for there operation. These models have generic tag "simulators" or templates.

2.5 Simulation Methods:

Like BPM modelling tools there are a variety of Simulation tools, which are developed for a diverse range of industries and purposes. There are currently several different classifications of simulation modelling techniques that include *Static, Dynamic, Continuous, Discrete and Deterministic* (Kelton et al. 2002).

The research will investigate and conduct its experimentation using *Discrete Event Simulation*, which is extensively used within similar business areas to those used in BPM projects. Therefore providing a platform, which will enable suitable integration.

Although there are many different *Discrete Event Simulation* vendors, each tool consists of basic components that combine to provide comprehensive analysis of physical systems (Ingalls. 2001). These components define the Simulation method to enable *Discrete Event Simulation*. The Simulation capacity and structure is created through a combination of *Entities, Activities, Events, Resources, Global variables, a Random number generator, Calendar, System State Variables and Statistic collectors.*

The function of an *Entity* is to cause a change in state within a simulation model, without those entities nothing would happen. Entities have attributes, which are there unique characteristics. An entity is something that is passed through a system, which could include parts within a manufacturing system or calls within a call centre. There attributes would typically be made up of there arrival and leaving times through the system.

Activities are the processes and the logic in the simulation, whilst the *Event*s are the conditions that occur at the point in time that causes a change in state in the model. There are three major types of activities within a simulation model, which include *delays, queues* and *logic*. A delay activity is when an entity is delayed for a defined period of time and that delay can be for a constant or random period of time. Queues are the places within a simulation model that are waiting for an unspecified period of time, where entities can be waiting for specific resources or for a specific condition to occur. Logic activities allow the entity to effect the state of the system through the manipulation of state variables or decision logic (Ingalls. 2001).

In a simulation model a *Resource* represents anything that has a restricted capacity. Common examples would include workers, machines, nodes in a communication network, traffic interactions, etc.

The *Global Variables, Random number generator, Calendar and System State Variables* combine to provide the platform to model the changes that occur in relation to time. Producing the random generation of behaviour and flexibility to model real world systems, using system constraints that may occur.

The *Statistics Collectors* are the part of the simulation that collects the state of certain statistics (e.g. resources) or the value of global variables, or certain performance statistics based on attributes of the entity. Three different statistics are collected, counts, time persistent and tallies. Counts simply count (e.g. calls waiting at a call centre), time-persistent statistical collectors provide the timeweighted values of different variables within a simulation model, tally statistics are collected one observation at a time without regard to the amount of time between observations.

From the definition of *Discrete Event Simulation* tools it is apparent that their methodologies are complex and require extensive knowledge of the tool to build an effective Simulation model. The identification of the elements that contribute to building a project defines the contrast in complexities between Simulation and BPM tools. BPM tools do not provide the opportunity to test the movement of entities and the effect of random behaviour within a system.

Although it is apparent that both techniques are used for different purposes, both methods follow similar project lifecycles, where their success is strongly determined by system definition and data interpretation of the processes that they are modelling. Therefore organisations that are using the tools will often evaluate and prepare the same information to use in different projects. The research has shown that the automatic generation of computer simulation models from BPM models will increase their individual capacities and may reduce their limitations.

Currently BPM tools are limited by their capability to test process redesign prior to its implementation, whilst Simulation is limited by its complexities and training requirements (www.enix.co.uk). Therefore a fully automated system may reduce their individual limitations and promote their future use. These theories are supported by numerous industries and universities, which have previously researched or considered integrated solutions (Field, Harrel. 2001).

2.6 Research into the Integration of Process Mapping and Simulation Tools
(Field, Harrel. 2001)

Although there has been little research into the integration of the two modelling methodologies, there are papers that have investigated its potential (1996 Winter Simulation Conference). One paper present the issues involved in the integration of two case studies, which have attempted integration of process mapping and simulation tools. The presentation discusses the two case studies, their characteristics and the approach that was taken within each case. Each example uses a different process-modelling package, attempting integration with

ProModel simulation. The first integration example investigated integration of Meta software's design/IDEF with ProModel, whilst the second investigation integrated ABC Flowcharter from Micrografx Incorporated. Both of the tools used are based on different paradigms, which provide different problems for the issue. One of the case studies uses a modified process modelling tool, whilst the other uses OLE automation, which requires no modification to the process mapping or simulation software.

Previous attempts to integrate both technologies have identified incompatibilities in the purpose and the model, where success was limited. Within process modelling technologies there is insufficient data for the production of a simulation model and as a result information had to be added, requiring extensive knowledge of both products in use. Successful integration of the products would extend the usefulness of process mapping, making simulation more acceptable among those doing process reengineering. Process mapping tools can be classified as structured (IDEF) or unstructured (e.g. ABC Flowcharter), structured methodologies impose a specific methodology for representing processes, whilst unstructured tools leave it to the modeller, on how they want to represent a process.

Advantages of Structured Methodologies:

- Imposes structure and provides categories for all areas of the process.
- Standardises process mapping, so diagrams are easily communicated and constant.

However in terms of simulation, the use of structured packages may require changes to the methodology of the process-modelling package. Although changes to the package may be required when using structure process mapping, there are parallels between IDEF and simulation models.

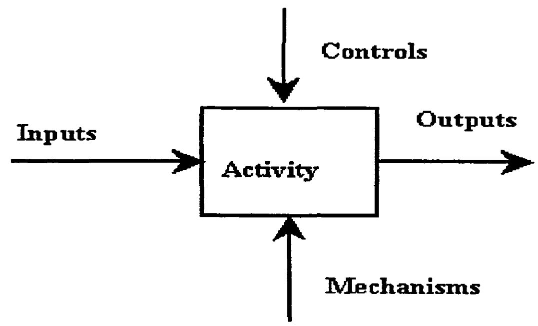


Fig 3: IDEF Methodology

As described in Fig 3 it is apparent that there are parallels between both IDEF and Simulation, which include:

Both packages utilise inputs and outputs.

- Both have activities.
- Both utilise mechanisms or resources in performing activities.
- Both use controls to determine, when, where and under what conditions the activity is performed.

However although structured packages provide notable advantages and significant parallels, the article suggests that unstructured diagramming tools are more suitable for integration with simulation because they are easier to adapt to a simulation paradigm. The fundamental difference when shifting between simulation and process mapping is that, process mapping is process orientated, whilst simulation tend to be system orientated. Process orientated system focuses on the logical flow of entities or work items through a series of activities. Systems orientation is based on the physical flow of entities through a series of workstations. The difference between the packages is a direct reflection of the nature and purpose of the activities that they are modelling. Process mapping tools generally define what happens to entities within a process, but doesn't identify how, where and when those entities are developed. Simulation must have the information on the mechanisms of the process, in order to initiate the actual drivers for the process.

2.6.1 Case Study: Integration of Design/IDEF and ProModel Simulation

The challenge when integrating ProModel simulation with Design/IDEF was to extend the definition capacity, whilst deviating from the basic IDEF methodology. The following extensions were made:

- The addition of entity attributes.
- The addition of input buffers to every activity.
- A method of modelling different entity types.
- The addition of data fields to capture dynamic information.

The purpose behind the integration was to have the entire model built using Design/IDEF, which could then be used to create a simulation model file that could then be read in and executed by ProModel. Through the project development, the developer enabled a solution that provided the user with the capability of producing a model through the one interface (Design/IDEF) for both process mapping and simulation. However in this approach the Design/IDEF code had to be significantly modified to allow input data required to run a simulation model within Design/IDEF.

2.6.2 Case Study: Integrating ABC Flowcharter and ProModel

ABC Flowcharter is a process-modelling package that is based on an unstructured methodology, which in this case was integrated through OLE automation technology, which required no modification of either application. A separate application was then written that communicated with ABC Flowcharter using OLE automation to display simulation related property sheets, which are displayed as shapes and connections created in ABC Flowcharter. Once the model is defined it is then translated by this separate application to a ProModel model and simulation.

The definition of the simulation is in a very similar format to that used to define a flow diagram, the OLE automation enabled intelligent connections to be made based on the objects connected. Graphic properties of the connections could then be modified automatically to provide feedback to the user as to the type of connection made.

Research has identified numerous considerations and problems that occurred within past investigations, which cannot be ignored. However it is apparent that the research was conducted prior to 1996, which researched modelling methodologies that have significantly advanced their techniques. Therefore the research project is justified in conducting experimentation into the subject area.

2.7 Summary

The Literature Survey has comprehensively evaluated the potential of Automatically Generating computer Simulation models from a Business Process Modelling format. Research has been substantiated through analysis of both methods, past research and support from related parties.

At the current time it is apparent that leading Simulation companies are providing the capacity to import data from tools like VISIO. Simulat8 and Witness (www.simul8.com & www.lanner.com) provide the capability to transfer VISIO data into their Simulation package. Although VISIO is only a simple drawing tool, it is within the BMP family, indicating a potential market, support for a fully automated solution and the capacity to exchange data between packages. There are many examples where data and software have been connected to provide a variety of capabilities. Simulation tools like ARENA are often interfaced with external software; connecting spreadsheets, databases and IT systems (Seppanen. 2000).

From the investigation it is apparent that both modelling tools provide valuable solutions for their users, but research has identified a gap between the methods. BPM tools define the tasks and sequences necessary to deliver a business function. Analysing the structure of the processes, their relationships and interactions. These tools evaluate processes from a logical perspective, evaluating their current organisational structures, which allow static modelling capacity that represents the perceived ideal processes, without enabling suitable system testing. Simulation systems permit experimentation from the physical position, providing the capacity to model entities passing through a system, testing the effect of real world bottlenecks, using time dependent conditions and random behaviour.

Through the research it is apparent that both methods are used for different purposes, but the information that they use is essentially reproduced. The BPM tools use the information to define tasks and the sequences necessary to deliver a business function (Hulpic, N. 2003), whilst Simulation focuses upon the resources within a system and their effect on its efficiency (Pegden, C, D.). Both methods build projects through flow diagrams and connections, providing potential capacity to connect the tools through a mapping process. From the research it is apparent that integrating the two modelling methods could dramatically reduce their combined project lifecycle, reducing the repetition of information, increasing their popularity within industry. The next chapter in the research will benchmark the current BPM packages to identify the most suitable tool for integration.

After the evaluation of Business Process Modelling (BMP) concepts and past integration research it is evident that a detailed investigation into current modelling tools is required. Analysis has identified the importance of the modelling method and the effect that approach has on the potential integrated solution. Currently there are many modelling methods available targeting a variety of markets and as a result the research will target the BPM tools, evaluating their limitations, advantages and simulation capabilities. The investigation will also evaluate the companies that use the software, their requirements and the impact that those solutions have had on their particular organisation. The benchmarking study has been conducted through extensive research, which has included software/company meetings, product testing and analysis of current documentation.

The following diagram identifies the organisations currently competing in the Business Process Modelling market, and possible future challengers to their market shares. (IDS Scheer, www.idssheer.com)

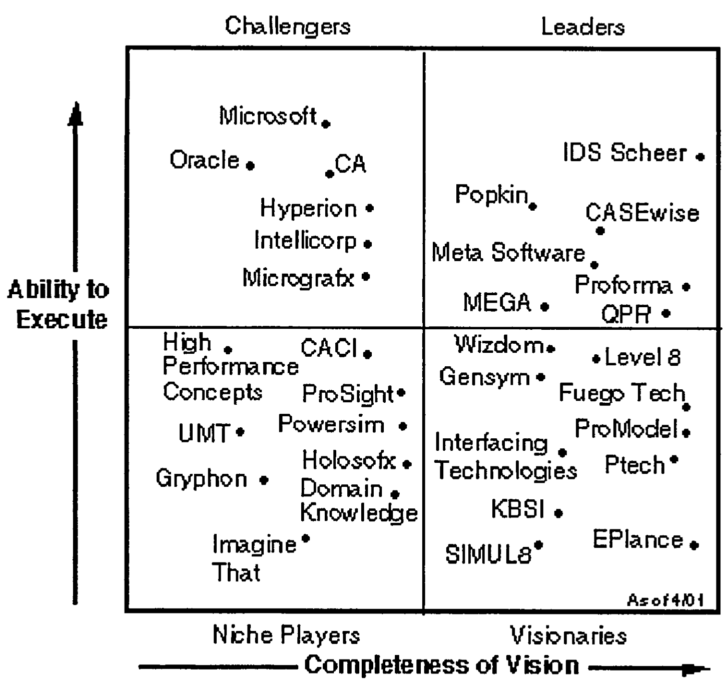


Fig 4: Leading BPM Software Providers

Traditionally Business Process Modelling was used for implementation, mergers, acquisitions, and the design and optimisation of workflow. However today such packages are now being used by enterprises to create new and adaptable work flows to remain competitive. Due to the requirement of today's businesses for richer process design and implementation, Business Process Management packages have developed, offering sophisticated workflow design features.

Revenue In Millions for Vendors			
Year	2001	2003	2005
Revenue	$500	$600	$700
Number of Healthy Vendors			
Year	2001	2003	2005
Number	35	25	15

Table 2: BPM Market Trends (www.idsscheer)

A recent report predicts that the use of BPM software will continue to grow over the next few years within a variety of industries, increasing potential revenue for vendors, but possibly reducing the number of those vendors to only the strongest companies within the sector. The following investigation will attempt to benchmark five of the strongest companies within the sector, evaluating the strength of their product and particularly their simulation capacity. The five products that will be benchmarked include:

1. Proforma
2. Popkin
3. Casewise
4. MEGA
5. ARIS

The Chapter will summarise the findings of the investigation, including the detailed product analysis within the appendix 1.

3.1 Benchmarking

In order to accurately achieve the author's goal of integrating a Business Process Modelling package with ARENA simulation it is very important to assess the current BPM market and the products that are currently available to industry. Therefore the author has chosen five leading software vendors within the sector to benchmark in an attempt to achieve the project goal.

Benchmarking was a term that became fashionable in the 1990's as a means of an assessment of a company's performance. Since this period benchmarking has developed a considerable influence on many companies as a means of continuous improvement within both their internal or external markets. Within the concept of benchmarking there are three distinct areas that include process, performance and strategic benchmarking, which target specific areas of investigation.

The following investigation would be classed as 'Performance Benchmarking', which provides a reference point for the project through measuring the capabilities of software vendors that are documented as being the best in the sector. 'Performance Benchmarking' enables business managers to assess their competitive positions through product and service comparisons. Usually such a study will focus upon elements of price, technical quality, ancillary product or service features, speed reliability and other performance criteria. The primary techniques for performance benchmarking are reverse engineering, direct service or product comparisons and analysis of operating statistics. Currently there are many industries that employ performance benchmarking as a standard competitive tool, some of which include automotive, computer, financial services etc.

The aim of the benchmarking study is to investigate several BPM vendors to ascertain the capacity of their products, methodologies and simulation capabilities. The following study will evaluate the software vendors through the following criteria:

- Company Overview
- Product Overview
- Operating and Support Environments
- Product Details
- Simulation Capacity
- Integration Capacity
- Organisational Use

Company Overview: The aim is to identify the company's background, which includes when and how they were established. This section of the investigation will also evaluate the company's presence worldwide and identify any partnerships that may influence their customer base. It is felt that this section of the study will provide a background to the company and develop an understanding of their brand strength. Identifying possible influences on the product and the effect that those influences may have on their customer base.

Product Overview: This section briefly describes the BPM vendor's products that are being offered to their customers.

Operating and Support Environments: Provides a brief description of the operating environments, platforms and memory requirements for the particular package. The aim is to identify requirements for operating the software.

Product Details: This section will investigate the product structure, methodology and capacity to meet their customer requirements. The aim is to develop an understanding of the product, its modelling capabilities, and flexibility to react to varying customer requirements and the ease at which new customers can use the product.

Simulation Capacity: This section focuses upon the simulation capacity of the BPM tools, their target area, methodology, product features and comparison with dedicated simulation packages. This will establish the true capacity of their simulation capabilities and identify the need for an integrated solution between the disciplines.

Integration Capacity: Within this section of the investigation the aim is to evaluate the capabilities of each package to import and export data from external sources. This will establish capacity for integration and options available.

Organisational Use: Through the investigation of customer profiles and past projects the author would hope to ascertain a detailed evaluation of the products on offer. Developing conformation of the industrial sectors that they target, the project that have been implemented and establish the role in which their simulation capacity has played within those projects.

3.2 Software Review

In the analysis of the available products the research has primarily focused upon Integration capacity, Simulation capabilities and organisational use, which answer the primary objectives of the study. These objectives were also supported by the assisting benchmarking categories, which established valuable product and company information that substantiated the findings. A full and detailed analysis of each tool is located within Appendix 1. The objectives of the study were:

- Identify the product Integration capability and its compatibility for data transfer.
- Establish the true Simulation capabilities of the BPM tools in comparison to a dedicated solution.
- Evaluate the Organisational Use of the BPM tools to establish the role of their advertised simulation capabilities and their industrial focus.

When considering the capabilities of the tools investigated it is apparent that each company offers similar solutions, and it is very difficult to select the best package based on those solutions. In a decision between the best package it is apparent that customer must have a clear idea of their requirements in order to make the decision most suitable to them. However through careful analysis the author feels that for integration of an external simulation package there are clear benefits to using a particular package and the study has also identified the limitations of the simulation capabilities within their solutions.

Through the benchmarking of the five BPM packages it is apparent that there are a variety of common trends that occur within each company, which must be considered when investigating the different criteria within the study. Comparing the packages that have been investigated within this study in respect to the Gartner report, it is apparent that the leading BPM providers are strongly related to their market experience.

1. IDS Scheer (Est.1984)
2. Popkin (Est.1988)
3. CaseWise (Est.1989)
4. Proforma (Est.1994)

5. MEGA (Est.1991)

Therefore it could be assumed that the market sector is very difficult to enter and the products may not be sold on their superior features. This argument could also be supported by the fact that the customer base of the benchmarked companies is strongly related to their country of origin and company headquarters. It is apparent that a large proportion of ARIS client base is German and MEGA's is largely French.

Benchmarking BPM tools has indicated that the companies investigated are all targeting an international presence, which they have all supported through strong technical and consulting partnerships. However in retrospect it is also apparent that each company is targeting slightly different markets, which would mean that corporate benchmarking studies should be influenced by their requirements.

Through evaluation of the products that have been investigated it is apparent that there are distinct differences between the methodologies, which the top two companies (as state by the Gartner report) and their rivals have implemented. Popkin and ARIS provide structured methodologies that require comprehensive knowledge of their method, including associated rules. Whilst their competitors (Proforma, Casewise and MEGA) provide products, which are flexible to their customer requirements, whilst enabling UML languages within there solutions. Therefore supplying their customers with software that is easier to use and understand, without the need for extensive training.

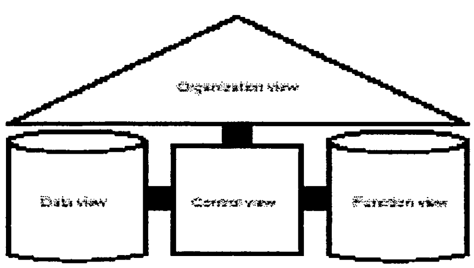


Fig 5: The ARIS House

When considering these characteristic's in respect to the integration of external software it must be assumed that a structured approach must be the most practical method, because increased flexibility would provide greater complication to the problem. If the packages with a flexible methodology are to be used it could be assumed that the best approach would be to use their UML as the method of transfer. However this approach restricts the user and looses the advantages of using such packages.

3.2.1 Integration Capabilities

From the evaluation of the integration capacity of the products investigated it is apparent that all the BPM packages enable integration with external products for the presentation of information within varying formats and their use within different software packages.

Proforma	
Import:	Export:.
Visio	MS Project
	HTML
	RFT
	Access or a common delimited format file
	bi-directional Rose and Erwin
	Interfacing with leading application can be provided through Rational
	Erwin
	C++
	DDL
	XML

Table 3: Proform's Integration Capacity

Proforma provides a variety of export facilities and languages that allow its users to transfer information to suit their requirements. These capabilities are a result of their technical partners, which include Microsoft, IBM and Rational. The integration options available are heavily targeted towards specific market sectors, but do provide a variety of data transfer options.

Within *Popkins* Systems Architect a data dictionary is used across all modelling domains, which shares all objects in the business process, functional and UML systems. This dictionary can then be used to generate reports, which can be exported directly onto MS Word. Through the use of VBA the Systems Architect users can extend functionality, connecting to other applications to develop integrated solutions. Therefore VBA can interface with tools such as Excel, Access and ASP.

Casewise's corporate modeller has the capability to integrate with many Microsoft Office products, which can be used to gather information, analyse processes and produce documentation. The package can also link to many code generation applications including:

- Sybase's Power Designer
- Rational Rose
- Staffware
- Oracle Designer
- J D Edwards
- SAP ERP Technology

MEGA Integration provides the capacity to export modelling data into Word and produce HTML documentation for structured Web sites.

ARIS products have the capability to integrate with the Internet and company Intranets, which allow the integration of Process Models/Documentation through the use of Java and HTML exports that are supported by a Web publisher. Providing easy-to-read formats, regardless of the complexity of the models. The package can also interface with data transfer from systems of all types, enabling Data Exchange with Microsoft Office products (e.g. Excel, Word, Access etc.). Individual Workface interfaces can be established via API, OLE, ASCII, XML etc.

Although all the software tools investigated provide integration capacity it is apparent that each company provides solutions that are a direct result of their technical partners (Appendix 1). For example Proforma has strong alliances to Microsoft, IBM and Rational, which is reflected by their import/export capacity. From the investigation integration is possible from either BPM tool, but only Popkin and ARIS provide suitable integration methods to comprehensively transfer the level of modelling data required. Both companies provide a comprehensive modelling methodology, which is well documented and easier to match with simulation modules. They also integrate to external packages using common solutions and languages, which correspond with those, used by the dedicated simulation tool.

3.2.2 Simulation:

Evaluation of the five leading BPM tools has indicated that most companies are now advertising some kind of Simulation capability in an attempt to extend the scope of their product. The following section will investigate the true capacity of their Simulation products, comparing their features with a dedicated Simulation package. Therefore defining their true capacity for simulation, which may justify the research into a fully automated integration process.

Proform's simulation capabilities are provided within their Enterprise Pro and Simulation Pro. The Enterprise Pro provides Activity based Costing, using Monte Carlo simulation, whilst the Simulation Pro is advertised as a dedicated simulation package that provides discrete event simulation. Their published capabilities are:

- Scenario Based Simulation – Simulate scenarios to see how the process will behave under specific conditions.
- Resource Constraints and Bottleneck Identification – Vary resource requirements and constraints to analyse potential bottleneck within each process scenario.
- Critical Path Analysis – Visualise the paths through the process scenario that incur the least/most cost and take the least/most time to execute.
- Activity Base Costing (ABC) – Identify all direct, indirect and resource costs associated with an activity.
- Scenario Comparison – Compare the results of all process simulations. This is a straightforward way to see the most cost effective and efficient processes.
- Animation – Visually observe the process running, or run lengthy processes in the background. The data from the simulation is then available for investigation using the analysis and reporting features.
- Analysis and Reporting – Display and analyse simulation results in the form of cost and timing spreadsheets and graphs. These can be combined with narrative process descriptions and visual process models of Pro*Vision* to publish a complete process improvement plan. The spreadsheets also can be migrated to Microsoft Excel for distribution or integration with other applications.

- Opportunity Analysis – Identify and assign opportunities and their costs and benefits to the activities where process improvement prospects exist.

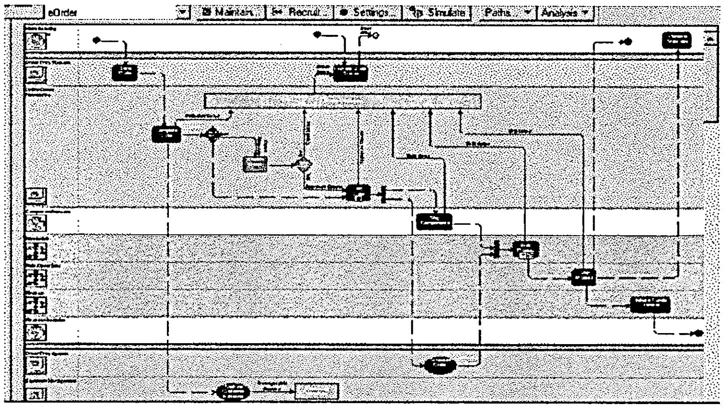


Fig 6: Proforma's Simulation Tool

Through the development of a process model, the building blocks used within the model have the facility to enter the required data for simulation, similar to those provided in a dedicated simulation package. Allowing waiting time in the input queue, delay time, working time and out queue time to be entered into the system. Providing the capacity to change the units used and allows different distributions to be simulated. However the level of detail provided by Proforma's simulation package is currently limited in its capacity, focusing on costing issues, restricted by its business process modelling methodology.

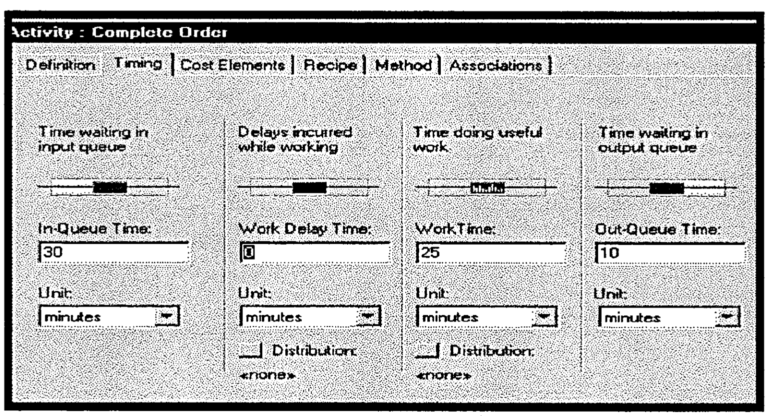
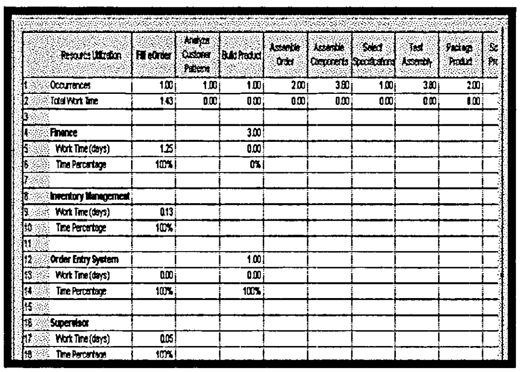


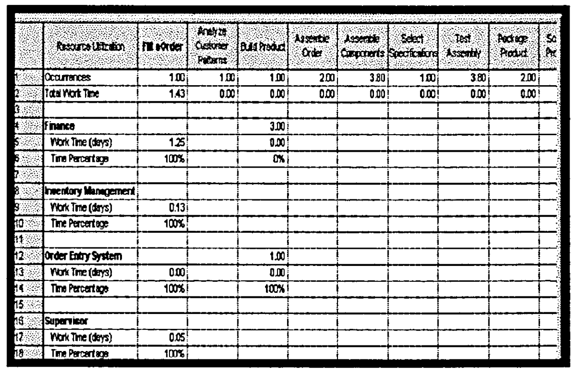
Fig 7: Input Data Window

Within the building blocks of the model there is a detailed level of data that can be inputted into the system, which can be used to calculate direct, indirect and resource costs throughout an operation. Reporting is comprehensive, displayed in both spreadsheets and graphs, breaking down into the following areas:

- Cost Distribution Grid
- Cost Grid
- Resource Utilisation Grid
- Staffing Grid
- Timing Grid
- Cost Chart
- Cost Distribution Chart
- Resource Utilisation Chart
- Staffing Chart
- Timing Chart



	Resource Utilization	Fill eOrder	Analyze Customer Patterns	Build Product	Assemble Order	Assemble Components	Select Specifications	Test Assembly	Package Product	Sc Pr
1	Occurrences	1.00	1.00	1.00	2.00	3.80	1.00	3.80	2.00	
2	Total Work Time	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3										
4	Finance			3.00						
5	Work Time (days)	1.25		0.00						
6	Time Percentage	100%		0%						
7										
8	Inventory Management									
9	Work Time (days)	0.13								
10	Time Percentage	100%								
11										
12	Order Entry System			1.00						
13	Work Time (days)	0.00		0.00						
14	Time Percentage	100%		100%						
15										
16	Supervisor									
17	Work Time (days)	0.05								
18	Time Percentage	100%								



	Resource Utilization	Fill eOrder	Analyze Customer Patterns	Build Product	Assemble Order	Assemble Components	Select Specifications	Test Assembly	Package Product	Sc Pr
1	Occurrences	1.00	1.00	1.00	2.00	3.80	1.00	3.80	2.00	
2	Total Work Time	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3										
4	Finance			3.00						
5	Work Time (days)	1.25		0.00						
6	Time Percentage	100%		0%						
7										
8	Inventory Management									
9	Work Time (days)	0.13								
10	Time Percentage	100%								
11										
12	Order Entry System			1.00						
13	Work Time (days)	0.00		0.00						
14	Time Percentage	100%		100%						
15										
16	Supervisor									
17	Work Time (days)	0.05								
18	Time Percentage	100%								

Fig 8: Cost Grid & Resource Utilisation Chart

The Animation within the package is displayed as flows through the process model, indicated by changing colours. Critical paths can be pinpointed to identify max/min time/costs of operations.

Popkins software enables a limited simulation capacity with animation that can be used to evaluate a systems performance. The simulation package is integrated into the Systems Architect, which incorporates the following simulation features:

- Graphical Process Flow Diagram – Providing data input and modification
- Process Animation – View the process as it runs
- Process Simulation – Product process results and matrices
- Profiles for Simulation Variables – Provides common and reusable information
- "What if" Comparisons – Allows comparisons to be made between alternative processes

- Real Time Graphs and Plots – Provides the capability to track important variables whilst the process is running
- Detailed Reports – Allows process analysis
- Activity Based Costing – Identifies the cost of a process before it is implemented

The Systems Architect can produce simulation models through either IDEF3 or Process Charts. Within the simulation engine there is capacity to set priorities in the model and a warm-up period can be assigned to improve the accuracy of the model.

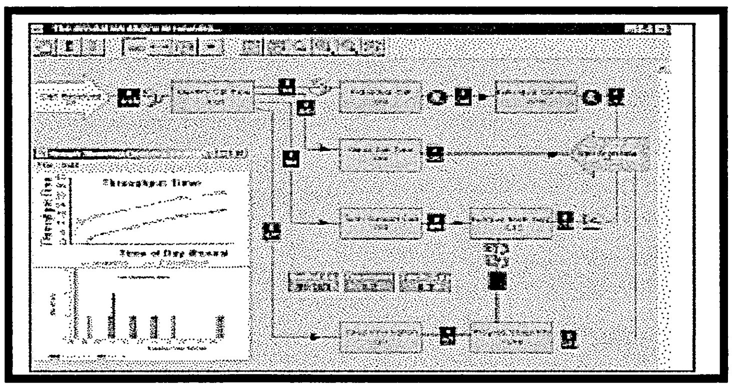


Fig 9: Popkins Simulation Process

The simulation capacity of the *Casewise* Corporate Modeller is built into the Process Dynamics Modeller, providing 'What if' analysis, where changes can be quickly made after considering possible scenarios, animation is available with the package. Changes can then be exported to excel for comparison with existing processes. The Process Dynamic Simulator continually focuses the project teams attention towards critical cost issues, where users can see the results of simulation on the profit and loss statement. Whilst reviewing the profit and loss, an organisation can control the cost metrics associated with each process and resource.

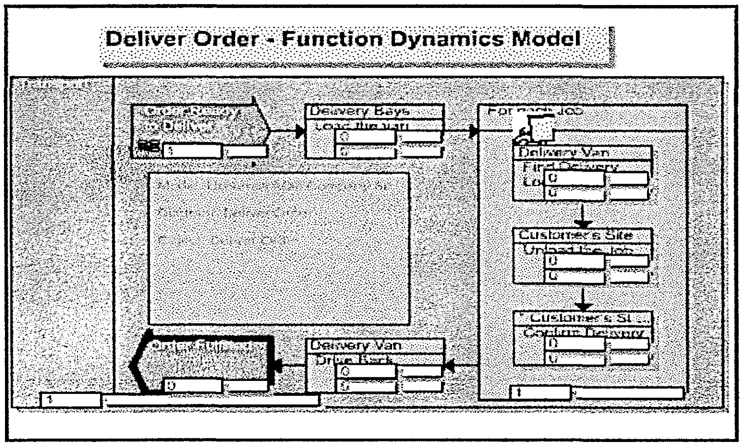


Fig 10: Casewise Simulation Process

ARIS simulation is publicised as a dynamic analysis tool for business processes, which is fully integrated to the ARIS toolset, where data relating to the process can be used for simulation. The simulation will then provide information concerning the production of processes, process weak points and resource bottlenecks, based on the simulator key performance indicators. However from ARIS documentation it is apparent that their simulation tool is a component that is a preliminary step for ARIS Activity-based Costing. Where the frequencies determined in simulation projects are to be transferred to the ABC package to enable a precise cost-based evaluation of the simulated business processes.

ARIS simulation is based on the process models created by the ARIS method, whilst the control flow of the business process is documented in the process models. The process instantiation models describe how processes actually fit with one-anther. Within the simulation tool there is a capacity to simulate across multiple hierarchies and the ability to assign functions of one process to another process, thereby to detail a function. The behaviour of the simulation can be controlled using the attribute of the objects occurring in the model.

Within ARIS simulation there is four different animation methods, which are used to visualise simulation results. The four methods of animation include, object, attribute, statistic and probe. Object animation uses colour in the model to provide the user with an impression of the status of individual objects during a simulated activity. Therefore possibly identifying which processes are used within a business, where functions are over used or when resources have been activated. Attribute animation describes the status of an object within a model in greater detail. Statistic animation is cumulative statistics that are object type specific, providing one statistic for each function, event, personnel resources etc. The probe animation is a graphical device, which specific performance indicators of an object are displayed over a period of time. Simulation can provide statistical and cumulative data about different key information, which can be displayed directly in the ARIS toolset, or exported for further processing in, excel.

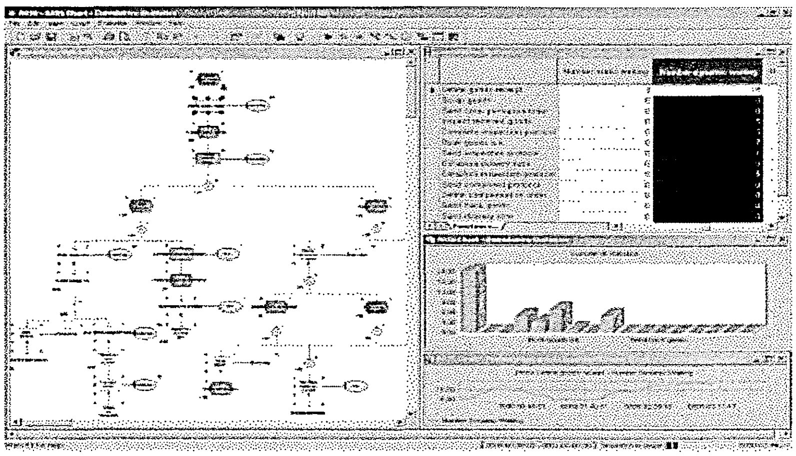


Fig 11: ARIS Animation

Simulation projects can be controlled using ARIS through a multitude of options that can provide a realistic closed loop modelling approach. Its behaviour can be controlled by for example:

- The selection of models to be simulated (e.g. hierarchy depth in assigned processes, all models within shared resources etc.)
- Animation of objects in models
- Simulation times
- Setting of eM-Plant simulation engine.

Highlight of ARIS simulation (www.ids-scheer.com):

- Consideration of organisational charts
- Consideration of process hierarchies and object-model-assignments
- Flexible definition of process frequencies and distribution of process starts
- Interruption functions

- On-line statistics at run time
- Display of simulation results using charts and diagrams
- Simulation results can be saved in *.atf or *.xis format

Integration of tables and diagrams in MS Office products

3.3 Comparison of the BPM Simulation Capabilities

Through the benchmarking of BPM packages it is apparent that the majority of software providers are supplying simulation capacity within their products. Currently MEGA software, a leading BPM company is resisting the trend, focusing on their core competencies. Although Simulation in BPM tools are a common advertising theme it is very difficult to substantiate the tool without testing and validating the products. Therefore the following section will analyse their individual attributes and compare them against a dedication Simulation tool.

	Proforma	Popkin	Casewise	ARIS
Package Type	Dedicated Simulation Package (Simulation Pro), and a package that is part of their Enterprise Pro.	Integrated Simulation package into the Systems Architect.	Simulation incorporated into the Process Dynamics Modeller.	ARIS Simulation is part of the Toolset.
Simulation Type	The Dedicated Simulation package is Discrete Event Simulation. Enterprise Pro is a Monte Carlo Simulation.	Dynamic Simulation package.	Dynamic Simulation package.	ARIS Simulation is a Dynamic Simulation package.
Method	Based on the process model within the BPM package, where resource data can be changed to identify potential bottlenecks	The simulation capacity can be used within either the IDEF3 method or the process flow diagram	The simulation capacity is based on the process diagram.	Through the ARIS Simulation method all models within the organisational charts can be considered, including process hierarchies and object model assignments. Simulation is based on the process models created by the ARIS Method
Analysis and Reporting	Displays automated simulation results in the form of cost and timing spreadsheets and graphs	Automatically displays simulation results using charts and diagrams.	Automatic reports. Reports can include resource utilisation, throughput, costs and performance.	Automatically displays simulation results using charts and diagrams.

Animation	Animation is based on the process model where resources change colour as entities pass through the system.	Animation is based on the process model where resources change colour as entities pass through the system. Queuing can also be graphically identified.	Work packets are animated as they pass through the process diagram, where pictures change according to the status of the system.	Animation is based on the process model, which can provide four different animation methods; Object, Attribute Statistic and Probe.
Purpose	Used to enable Activity Based Costing	Used to enable Activity Based Costing	Focuses upon critical cost issues.	Used to enable Activity Based Costing.

Table 4: Simulation Breakdown

3.3.1 Package Type & Simulation Type

Currently the leading BPM companies who provide simulation capacity are enabling such capabilities through integrated solutions, dictating the method used, possibly reducing simulation options available, but providing consistency through a common modelling methodology. From the packages investigated the only company that provides a dedicated solution is the Proforma (Simulation Pro) organisation, their Simulation Pro uses discrete event simulation, whilst their integrated package uses Monte Carlo Simulation. ARIS, Popkin and Casewise simulation packages are classified as Dynamic packages.

3.3.2 Method

Proforma and Casewise's simulation is based on their process model, which is their core modelling technique for their main business activities. Within the model simulation data is catered for through the attribute section, which contains the data for the solutions core purpose. Pokins modelling engine allows its users the capacity to produce simulations through either their IDEF3 or process flow diagrams. Although ARIS simulation is also based on their process models, simulation has the capacity to recognise organisational charts, including process hierarchies and object model assignments.

3.3.3 Analysis and Reporting

All BPM packages provide automatic spreadsheets and graphs that report information from the simulation projects. Each software provider supplies various automatic analysis options, which will target their users specific requirements.

3.3.4Animation

As a result of the method used by each company, animation is based around their process model, where work packets pass through the system and change colour in relation to there status. In the case of Casewise, as their packets pass through the system pictures change with the status of the system. ARIS provides four different animation methods that include objects, attribute statistics and probe's.

3.3.5 Purpose

When evaluating the five BMP packages it is apparent that the main purpose for their simulation capacity is based on costing issues. Each company continually emphasises their ability to provide costing data, where Proforma, Popkin and ARIS target Activity Based Costing, whilst Casewise focuses upon critical costing issues.

From a very early stage it was apparent that the companies investigated targeted their simulation capabilities towards Activity Based Costing (ABC). Providing "What if" analysis for mathematical models through a Dynamic modelling approach. Through discussions with a senior manager from British Telecom it was apparent that they also recognised that simulation capacity within BPM packages was generally focused towards ABC costing.

Through investigating the nature of the selected packages it is apparent that the simulation products being offered by each company is very similar, providing capabilities that are very difficult to distinguish between. When considering the Table 4 Proforma is the only package that provides dedicated simulation, whilst the other companies provide simulation as part of a combined solution. From the companies simulation method it is apparent that Popkin and ARIS allow the most flexibility when building a simulation model. Popkin provide the capability to build simulation through their process diagram and IDEF3, allowing the user the choice of the format most suitable for their required situation. ARIS provides its users with the capacity to consider organisational charts within the ARIS product enabling a more representative simulation within the context of the whole organisation. In terms of analysis and reporting each package provides very similar capabilities, but specific-reporting criteria may vary. In animation terms there is very little to distinguish between the packages, apart from slight differences provided by ARIS and Popkin.

After the evaluation of the current simulation capabilities of the leading BPM packages it is apparent that their true value is difficult to access without comparing their competencies with a standalone simulation package, such as ARENA from Rockwell software. Therefore to evaluate the simulation capacities offered by the leading BPM companies their competencies were benchmarked against a leading dedicated simulation package ARENA (Table 5).

ARENA Simulation an experimental and applied methodology that seeks to describe the behaviour of systems, construct theories or hypotheses that account for the observed behaviour, and use the model to predict future behaviour. I.e. the effects produced by changes in the system or in its method of operation (Pegden et al. 1990).

When benchmarking the current packages against ARENA it is apparent that each company uses a different methodology, which distinguishes their method from their competitors, but provide problems when comparing the different solutions. In such cases the problem was resolved within the table by producing common headings that could be considered by each company. Within this table the categories within the main project simulation section were expanded to include the basic components, which provide increased detail into the solution each vendors provide.

Simulation Benchmark					
	ARENA	Proforma	Popkin	Casewise	ARIS
Analysis & Reporting Capacity:					
1. Categorisation	✓	✗	✗	✗	✓
2. Production of Graphs	✓	✓	✓	✗	✓
3. Ability to Report on:					
Costing	✓	✓	✓	✓	✓
Outputs	✓	✓	✓	✓	✓
Utilisation	✓	✓	✓	✓	✓
Waiting Time	✓	✗	✗	✗	✗
Lead Time	✓	✗	✗	✗	✗
Work in Progress	✓	✗	✗	✗	✗
Individual Methodological Components	✓	✗	✗	✗	✓
4. Report Generation:					
During Simulation Runs	✓	✗	✓	✗	✓
After a Simulation Run	✓	✓	✓	✓	✓
5. Reports can be Exported to:					

Word Processing Database	✓		✓	✓	✓
Spreadsheet	✓	✓	✓	✓	✓
HTML	✓	✓	✓	✖	✓
Standard Exchange Format	✓	✖	✖	✖	✓
6. Report:					
Standard View	✓	✖	✖	✖	✓
Browser View	✓	✖	✖	✖	✖
Animation Capacity:					
1. Animation Entities					
Flowchart Animation	✓	✓	✓	✓	✓
Facility Based Animation	✓	✖	✖	✖	✖
2. Drawing Objects					
Static Graph	✓	✖	✓	✖	✖
Text	✓	✖	✓	✖	✖
Line	✓	✖	✖	✖	✖
Polyline	✓	✖	✖	✖	✖
Arc	✓	✖	✖	✖	✖
Bezier Curve	✓	✖	✖	✖	✖
Box Polygon	✓	✖	✖	✖	✖
3. Importing DFX Files	✓	✖	✖	✖	✖
Import/Export CAD Files	✓	✖	✖	✖	✖
4. Animate separately from Model Logic	✓	✖	✖	✖	✖
Integration Capacity:					
Enables Data Transfer from Spreadsheets or Databases	✓	✓	✓	✓	✓
Operland Value Transference	✓	✖	✖	✖	✖
Utilises Microsoft's Data Access Objects	✓	✖	✖	✖	✖
Imported Data becomes part of the Model Structure	✓	✖	✖	✖	✖
Data Exchange Wizard	✓	✖	✖	✖	✖
Transfer All/Proportion of a Data Model	✓	✖	✖	✖	✓
Transfer Active Data to either Access/Excel workbook	✓	✖	✖	✖	✓
Data Import from Access/Excel Model Database	✓	✖	✓	✓	✓

Table 5: Simulation Benchmark

The table was based around the Integration, Animation, Analysis & Reporting capacities of the competing vendors in comparison with of ARENA software. In the evaluation of the analysis and reporting capabilities of the different software packages the results are comparable, in the vast majority of cases they only differ as a result of their designed application purpose. In the investigation ARIS is the only vendor that provides the capability to categorise sections of the simulation model so information can be reported upon as the whole model, or as individual section within that model. The investigation also indicates that the BPM packages do not enable reporting on waiting time, lead time and work in progress, which are dynamic attributes that are dependant on the input values that are entered into the system. Possibly suggesting that BPM simulation models are in fact static simulations rather than dynamic, which is a direct result of the difference in purpose between ARENA. From analysis ARIS is the only BPM package that enables reports to be produced on individual units within the methodology (e.g. functions, events, rules, personnel, capacity resources and material resources). This capability is as a direct result of the strength and complexity of their method, which cannot be supported by the more flexible methodologies provided by their competitors.

When considering the animation ability of the competing BPM vendors its noticeable that there is a big gap between they're animating capacity and that of ARENA. Each package provides the minimum animation, which animates the flow of entities through their base model. Only Casewise enables drawing objects that include static graphs and text. Each package investigated provides integration capacity within their simulation method, but in comparison with ARENA the level of detail and transference is not comparable to that of the dedicated package.

3.4 Organisational Use:

After the investigation of the software vendor's clients it is evident that each company has a strong international customer base, which generally favours clients from their country of origin. Each company provides a broad range of industries, within a variety of sectors and company sizes, indicating that their products are flexible enough to manage diverse product requirements. The only company that has a strong product focus for their present and the future strategies is IDS Scheer (ARIS). They are currently focusing upon targeting Supply Chain Management, Customer Relationship Management and Lifestyle Management. Supplying E-business services with development and implementation of Web based solutions. In the future their aim is to provide industry specific solutions for a variety of industrial sectors, rather than supplying a flexible product that caters for all sectors. MEGA and Popkin are currently targeting business application modelling and redesigns within IT, whilst Proforma are targeting the improvement of business processes. Casewise is currently targeting business application modelling and redesigns covering business, IT, resource and financial modelling.

From the analysis of the vendor's clients it is evident that there is little or no evidence of their simulation capabilities being used within their projects. This may indicate that their clients have no need for the product or that their simulation capacity is not capable of meeting project requirements.

3.5 Benchmarking Summary:

When the benchmarking study begin it was apparent that the exercise may vary slightly from those produced for a corporate business, because the benchmarking criteria differs for the intended purpose and price has little influence on the best product for the project. As the study developed and assessment criteria was selected it soon became apparent which products would become the preferred tool for the project. Although there is little to distinguish between the products there was occasions where one product provided greater suitability for the integration of the BPM and Simulation packages. Therefore a table was created that ranked each product in order of preference for a specific category within the study.

From the analysis of the benchmarking study in the author's opinion ARIS is the most suitable package for the project. The author felt that the product provides a method that is comprehensive, structured and enables extensive options for integration with external packages. Other products may be to flexible for the intended project purpose.

	Company				
	Proforma	**Popkin**	**Casewise**	**MEGA**	**ARIS**
Current Market Position	4	2	3	5	1
Product Structure	3	5	3	3	5
Integration Capacity	3	4	2	1	5
Simulation Capacity:					
1. Package Type & Simulation Type	5	4	4	0	4
2. Method	3	5	3	0	4
3. Analysis & Reporting	5	5	5	0	5
4. Animation	3	3	4	0	5
5. Purpose	5	5	5	0	5
Simulation Ranking	21	22	21	0	23
Customer Target Area	3	4	2	4	5
Total Ranking	**30**	**37**	**28**	**8**	**38**

Table 6: Benchmarking Results (1Weak – 5 Strong)

The next stage of the research project is to analyse ARIS and ARENA Simulation, evaluating their methods. This investigation will assess the modelling tools, evaluating their operating environments and procedures. Once the analysis of the modelling tools has been completed an extensive mapping investigation will be completed to identify their corresponding building blocks.

The aim of this chapter is to identify the best methodology for integrating a Business Process Modelling (BPM) package with a dedicated Simulation package. This will be achieved by evaluating the modelling methodologies involved, comparing the diagrammatic approaches by building models for the same purpose in the different formats. Analysis of the modelling methods will identify the suitability of the data held within the BPM model for data/logic transference, establishing true value of the data held within the BPM model. Therefore providing a good indication of the integration requirements and the possible approaches that need to be taken.

The next step in this chapter is to identify the options available for transferring the BPM model to Simulation for automatic generation. Once potential methods have been evaluated in conjunction with analysis of the modelling methodologies the best solution for automatic generation will be identified and comprehensively appraised.

Integration will be investigated based on ARENA Simulation and the ARIS Business Process Modelling package. ARENA simulation was selected based on the author's experience using the software and experience of the project supervisors within the University. ARIS (BPM) was selected based on a detailed benchmarking study and meetings with BPM specialists within industry and software vendors from competing organisations.

4.1 Modelling Methodologies

4.1.1 ARIS Methodology:

The *Architecture of Integrated Information Systems* (ARIS) Modelling tool was developed to represent business processes in diagrammatic form as chains of Events and process tasks. Although this is the principle aim of the software, the tool provides the capability to accurately model whole organisations and their relationships.

The capacity to model entire organisations is provided through the ARIS framework, which divides the organisation into a structured approach, separating the model into *Organisation View*, *Data View*, *Function View*, *Process Control View and Product/Service View*. This structure provides the capability to accurately cross-reference reoccurring information (e.g. objects, relationships) that is used in multiple areas of a business.

- *Organisational View* - a static model that is used to model the hierarchical structure of an organisation.
- *Data View* - a static model of business information.
- *Functional View* – a static model of process tasks.
- *Process (Control View)* – Dynamic models that show the behaviour of processes and how they relate to the resources, data and functions of the business environment.
- *Product/Service View* – evaluates the performance of products/services.

The following diagram (IDS Sheer, 2003) shows the ARIS house, its structured framework and the method that connects the varying ARIS views to incorporate an entire organisational representation.

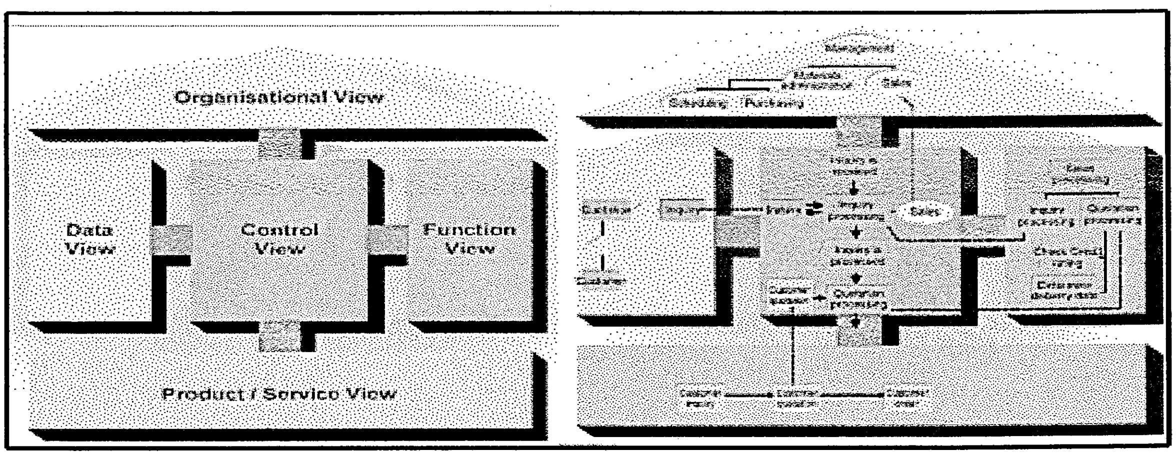


Fig 12: ARIS House and Integrated Method

From the ARIS House it is apparent that the ARIS framework is based around the Business Process, the *Control View*, which directs the entire method that lead to supporting information housed within the *Organisational, Data, Function* and *Product/Service Views*. Within each of these views there are varying modelling methodologies, which provide the user with the flexibility to use their preferable method.

Central to the ARIS method is the Event Driven Process Chain, which is located in the *Control View*. It is a Dynamic model that brings the static resources of the business to organise them into a sequence of processes that add business value to a project (Davis. 2001*)*. In this investigation the author will base practical integration on the *Extended Event Driven Process Chain (eEPC)* method, which is based around four object types; *Events, Functions, Rules* and *Resources,* which combine to create diagrams of business processes.

In the ARIS house business models are broken down into significant areas of interest, organised into the ARIS method as models and databases that are stored on servers. This provides a valuable method that structures an entire project, where extensive cross referencing can be undertaken to pinpoint valuable information; thus allowing the capability to use analysis tools, report generators, etc. Therefore enabling extensive project analysis features, which can document projects in detail and be transferred to external software.

All the information that the ARIS server's store about objects, models and databases is represented by their properties. The properties information includes the appearance of the object, its configuration and specific attributes.

- Attributes – ARIS modelling information stored for ARIS items (Davis. 2001*)*.
- Properties – All information known about all ARIS items.

Attributes are used for storing modelling related information about objects, models and databases, but should not be used for general business information. In ARIS there are many attribute options available that are controlled by method filters and provide the capability to add specific modelling information that targets a particular purpose (e.g. Simulation, Activity Based Costing, etc.) Attributes could potentially be used to match correlating information that appears within ARENA Simulation and ARIS BPM.

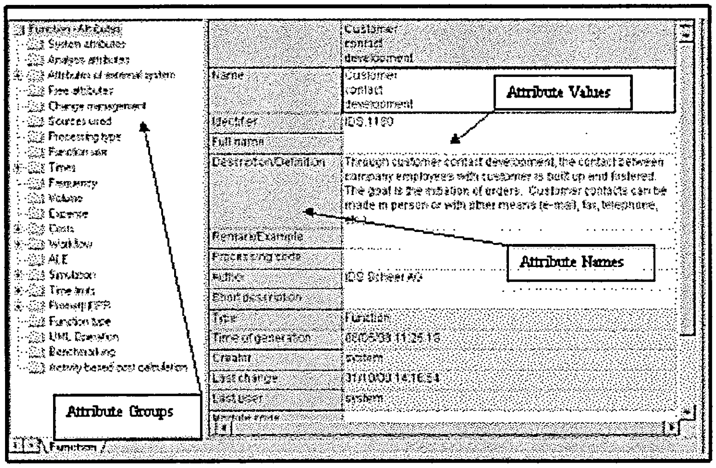


Fig 13: ARIS Object Attribute Display

Although ARIS provides an extensive range of modelling methodologies the range can make modelling unnecessarily complicated and as a result ARIS provide a method filter, which restricts the range of models, objects, relationships and attributes that can be used. This makes the tool easier to use and also enforces corporate modelling standards, which can enable purpose-built Semantic Checks.

4.1.2 ARENA Methodology

ARENA simulation package currently provides a broad range of products that support many applications to meet the needs of a project lifecycle, which integrates with corporate modelling and database systems. The software can be used for process mapping, simulating discrete and continuous simulation models, which is provided from a common software interface. In modern business, simulation is becoming a common tool for many business managers due to demands for continuous improvement, business process reengineering and the need to comply with ISO 9000 (Farrington. 1999). Currently the package is widely used in many industries including; service, manufacturing, communications, government etc.

The software vendor offers a family of products that include ARENA: Business, Standard and Professional versions, which enable discrete event simulation capabilities. The simulation modelling capability is created by input parameters (data) and logic, which can be provided by ARENA templates, SIMAN blocks or

Visual Basic (Pegden. 1990). These building blocks are incorporated into five templates that include; common, support, transfer, blocks and element modules.

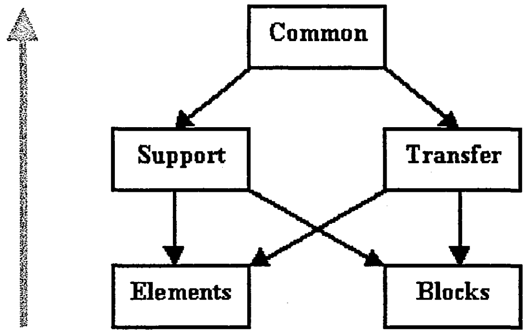


Fig 14: ARENA Template Structure

In ARENA the template structure is based on the level of complexity, where the highest level provides the capacity for *Common* templates, which are used in most modelling projects. The next level within the structure is the *Support* and *Transfer* templates, which are customised to the users needs, but are still common within many projects. The lowest level templates in ARENA are the *Elements* and *Blocks,* which are the basic statements of SIMAN, and enable the capability for complex algorithms or loops. *Block* modules define the logic and the characterisation of different objects that are used within a simulation model, whilst the *Elements* module is used to add additional information that is not represented by higher level modules i.e. tallies and frequencies (Farrington. 1999)

ARENA Simulation is based on a language known as SIMAN, which was developed in 1981 and is a powerful general-purpose simulation language. The SIMAN method is designed around a logical framework, which is segmented into *'model'* components and *'experiment'* components (Pegden et al. 1990). *Model* components describe the physical elements of a system, they may include; machines, workers, storage points, transporters, information, parts flow etc and their logical interrelationships. The *Experiment* component is the experimental conditions within the simulation model, which includes initial conditions, resource availability, type of statistics and length of run. Within this framework SIMAN links and executes the *model* and *experiment* once they have been defined (Pegden et al. 1990).

In the ARENA platform Discrete Systems are modelled by *process orientation*, which is built *using Entities, Attributes* and *Processes*. Process orientation studies the movement of *Entities* that pass through a system, where an *Entity* causes a change of state within that system by entering and leaving the modelling environment, which creates a dynamic presence. Within the SIMAN method each *Entity* has specific unique characteristics that are referred to as *Attributes*. The term *Process* denotes the sequence of operations or activities through which activities move (Pegden et al. 1990).

Although ARENA and ARIS are built for different purposes and markets they are both based on flow diagrams that use building blocks from the project tool bars. In ARENA these blocks are supplied within the various templates (e.g. common, support etc.) where their shape determines their purpose and arrows represent the direction that the entities take. Therefore by combining the relevant building blocks and connecting arrows processes can be successfully modelled.

4.2 ARENA and ARIS Simulation Comparison

In the following section of the project, the aim is to evaluate the two modelling methods by developing business process models and simulation models, based on the same examples. Therefore the author will produce a model within ARIS and ARENA to establish common links between the packages. To achieve successful integration between the packages it is vital that both methods are fully understood, and compatibility is identified. Therefore several models will be built with varying complexity's to identify comparable elements and capacity to reproduce the process within each format.

4.2.1 ATM Machine (Fig 15)

The following example was produced as a high level process that modelled the withdrawal of money from an ATM Machine. In ARIS this process was built using the *Event Driven Process Chain* (eEPC) method, where the two models have been compared at a basic level, where the process flows in one direction, without the complexities of changing decisions or loops.

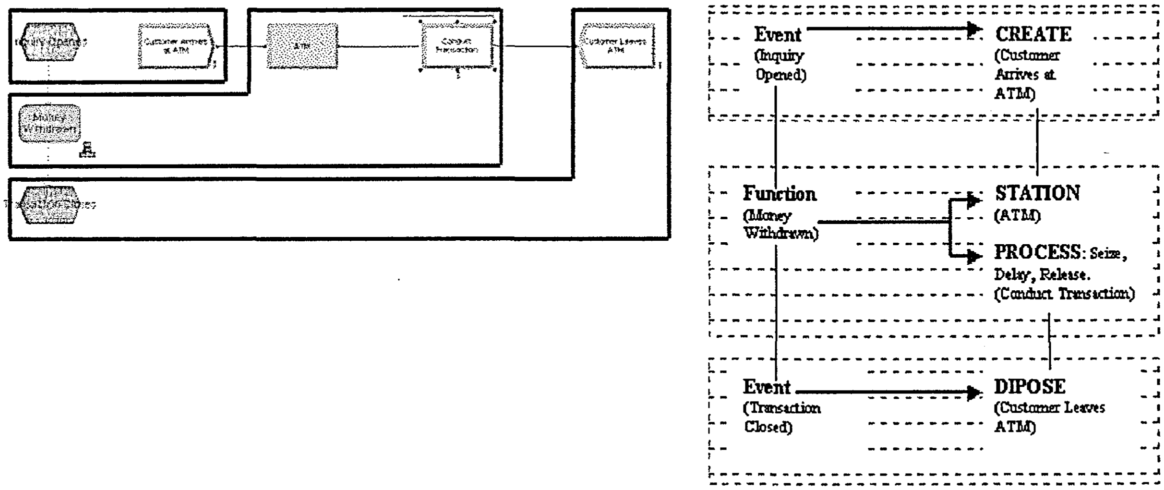


Fig 15: ARIS/ARENA ATM Machine Diagrams/Corresponding Building Blocks

In ARIS the ATM Machine is modelled at a high level where the logical process of withdrawing money is represented within a sub-process. The ARENA flowchart is built by representing the customer arrival at the ATM Machine, conducting their transaction and leaving the facility. At this level the corresponding diagrammatic elements are relatively easy to match, the triggering Event in ARIS directly corresponds to the CREATE module within ARENA. The withdrawal of money, represented by a *Function* in ARIS correlates to ARENA through the STATION and PROCESS modules, where the ATM Machine is *Seized, Delayed* and then *Released*, representing the physical movement of entities through the system. The closure of the transaction is represented by an *Event*, which directly relates to the DISPOSE Module in ARENA. The following diagram shows the available input data within the CREATE Module and corresponding Event building block:

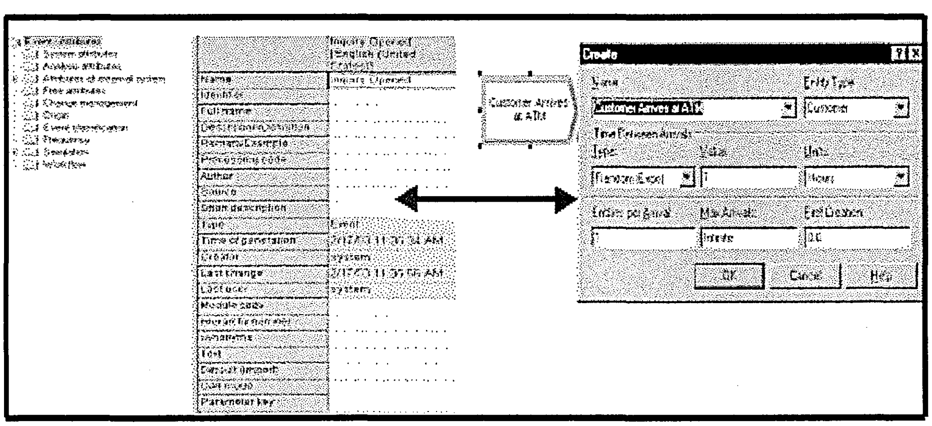


Fig 16: Customer Arrival at ATM Machine

The diagram represents the input attributes available within the ARIS model based on the full method filter. At first glance the available input data looks comprehensive, providing capacity for time, frequency, Simulation (etc), potentially matching corresponding criteria within the simulation model. The diagram below demonstrates the corresponding modules responsible for producing the transaction, where the ARIS *function* is equivalent to the STATION and PROCESS module. In the modelling example to follow, the detail of ARIS and ARENA input data would be investigated comprehensively to evaluate the amount of transferable information.

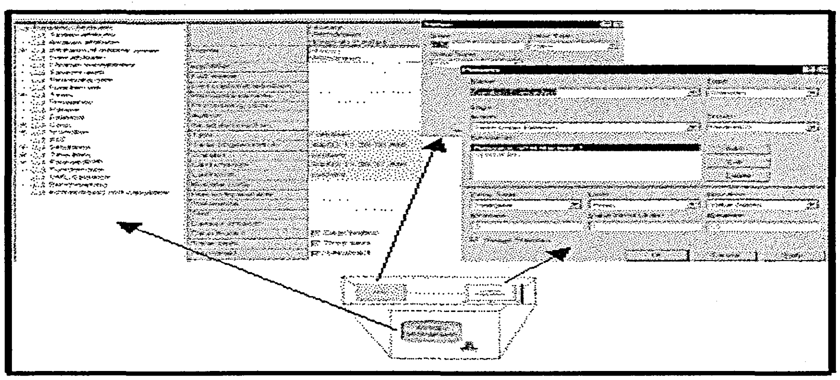


Fig 17: Production of Transactions

4.2.2 Mortgage Application Example

The following example evaluates the process of opening a Mortgage application, identifying common building blocks, input data, and the potential to reproduce everyday decisions that may occur within very different modelling concepts. In business processes it is very rare that only one possible process path can be followed, therefore it is essential that such possibilities are investigated to examine common elements that could be used in data transfer.

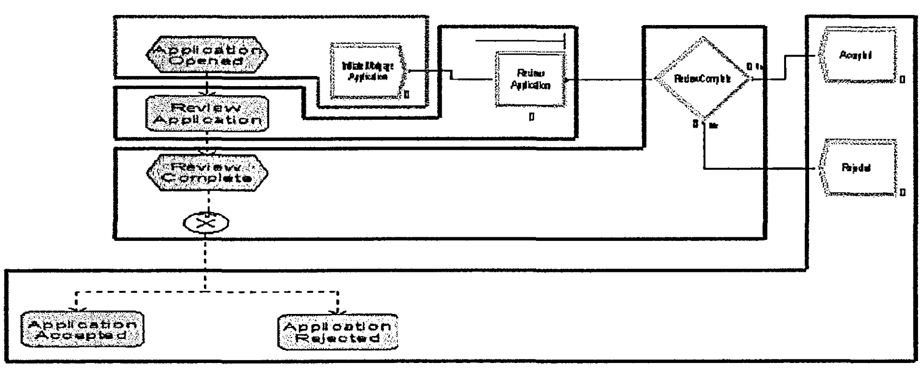


Fig 18: ARIS/ARENA Mortgage Application Diagrams/Corresponding Building Blocks

In the example the process of opening a Mortgage application was modelled within ARIS and ARENA, identifying the building blocks that are responsible for the same processes. The example shows that the *Initiation of the Mortgage Application,* where the *Create* building block in ARENA is comparable to the *Application Opened Event* in ARIS, in both models this is the point where the model starts.

The model produced within ARIS was built using the *Event Driven Process Chain (eEPC)* Methodology, using the *Entire Method* to demonstrate the full range of attributes that could be entered into the diagram and compared to the input data within ARENA.

Initiate Mortgage Application	
ARENA Input Data	ARIS Input Data
Create Module:	Event
Name: Initiate Mortgage Application	Name: Application Opened
Entity Type: Application	
Time Between Arrivals:	
Type: Random (Expo)	
Value:1	
Units: Hours	
Entities Per Arrival: 1	
Max Arrival: Infinite	
First Creation:0.0	

Table 7: Corresponding Input Data for Initiating a Mortgage Application

When comparing the starting points of the two models it is immediately noticeable that there are few attributes that provide matching information. The only attribute that matches that of ARENA is the naming of the *Event*, leaving a massive short fall in information between the two starting points, which is a direct result of the purpose of each package. ARENA focuses on the physical flow of entities through the system, whilst ARIS targets logical flow in a static view.

The *Application Review* block using the *Process* module within ARENA directly relates to the *Function* object, which provides many attribute options, however there is limited data that accurately matches that provided by ARENA. Only naming attributes match directly, whilst although timing options are available they are provided for static diagramming purposes rather than discrete event simulation.

Process Module:	Function
Name: Review Application	Function Attribute
Action: Seize, Delay, Release	Name: Application Review
Priority: Medium (2)	Description: Review by Mortgage Review Clerk
Resources: Resource, Mortgage Review Clerk	
	Times
Delay Type: Triangular	Processing Time:
Units: Hours	Avg.PT 1(Hrs)
Allocation: Value Added	Min.PT 0.5 (Hrs)
Min: 0.5	Max.PT 1.5 (Hrs)
Value (Most Likely): 1	Simulation
Maximum: 1.5	Station Waiting Time (Provides Distribution Options)
	Orientation Waiting Time (Provides Distribution Options)
	Processing Waiting Time (Provides Distribution Options)

Table 8: Corresponding Input Data for the Application Review

To review the mortgage application the ARENA model uses the *Decide* building block, which provides the capacity to model decisions through percentage allocations, whilst the ARIS uses the *Event* and *XOR* objects to model the decision. Within ARIS there is capacity to use probability options in the *Simulation Attribute*.

Decide	Event
Name: Review Complete	Event Attribute
Type: 2 Way by Chance	Name: Review Complete
Percent True (0-100: 50%)	Description: Accept or Reject
	Simulation
	Probability: 2 way by chance
	Priority:

Table 9: Corresponding Building Blocks for completing the Review

The *Dispose* modules represent accept or reject process of the Mortgage Application, whilst in ARIS they are modelled by *Event* objects that identify both circumstances.

Dispose 1 & 2	XOR
Name (1): Accepted	Name: Chance
Name (2): Rejected	Description: 2 way by Chance
	Simulation
	Provides Distribution Options
	Event
	Name: Application Accepted/Rejected

Table 10: Corresponding Building Blocks for ending the Application

4.3 Available Data Transfer Methods:

4.3.1 Interfacing through ARIS

When investigating the possible methods for transferring data between ARIS and ARENA it is apparent that there are many possibilities. Each vendor provides various options for importing and exporting data to external software packages.

ARIS provides its users with the capability to interface with external software through ARIS Reports, Export/Import, Process Generator, ARIS Script, Tool Integration, AML/XML, Web Publisher, ARIS for mySAP.com and Lotus Notes Connectivity. However each option may not be suitable for the projects goal, but without assessment of the options available their true value will be unknown, therefore suitability will be assesses within this section

ARIS Reports can be produced through ARIS Easy Design and ARIS Toolset, the Report components allows model data to be selected in text form and edited within external formats. They can be edited within Word, Excel or an HTML editor. Reports are produced through Report Wizards that help the user meet their specific criteria, through the use of filters. The Wizard does this through assessing report scripts, which have been created by their Script Editor and ARIS Script.

The Script Wizard helps create and edit scripts that are written within a language similar to Visual Basic. These scripts can then be used to evaluate the contents of the ARIS database, where they can be transferred as a report to an application that supports OLE automation (e.g. excel, word). The ability to create and edit customised reports enables specific and extensive analysis of business processes (e.g. objects and models).

Import/Export: The *Import/Export* facility provided by ARIS allows context-dependent text export and import of database data, where wizards are used to assist the user to select the data they require for *Import/Export.* If the user wants to transfer selected database contexts to another database this is done through the Merge or Administrator facilities.

ARIS Merge allows a controlled transfer of models and objects from one database to another. This facility is enabled by Global Unique Identifiers (GUID), which are given to all ARIS objects, models or groups.

All data transferred through the Export/Import facilities are exported to an ASCII file, which allows text to be translated through the ASCII file and lets other applications access ARIS data via an interface.

Processes Generator: ARIS process generator has the capacity to create completely new objects and models. Those objects and models can then be transferred to excel with the help of ARIS reports, where they can be modified and synchronised with excel data.

ARIS Script: ARIS Script is a programming language based on Visual Basic for Applications, which can be used to access ARIS items such as databases, models, objects etc. This provides the capability to interchange information from ARIS to ARENA via supporting OLE automated technology (e.g. excel).

OLE Objects: OLE objects are objects from various different applications that can be used within the ARIS format. They would be used to insert excel tables or Word documents at particular areas of a model, which automatically connects to that object within the external package.

Tool Integration: ARIS Tool Integration allows information about business processes to be transferred between ARIS and partner systems (e.g. SAP). Tool Integration makes all the data relating to database transference available, where semantic checks are undertaken to examine semantic correctness with its partner system.

AML/XML: AML/XML can be used to export and import database contents in XML format, which allows other programs to access ARIS data via an interface.

4.3.2 Interfacing through ARENA Simulation

Through the investigation of ARENA simulation it is apparent that the software provides two interfacing techniques that allows data to be imported and exported from external packages. The available interfacing technology includes *Module Data Transfer* and *Exporting to and Importing from Model Database*.

Module Data Transfer: Module Data Transfer utilises Microsoft Data Access Objects (DAO), which enables data to be written to or read from outside data sources directly, without the need of an intermediate ASCII file. This facility supports the exchange of module operands (e.g. text strings, values of check boxes), but not animation.

Regardless of the method of data exchange between external software ARENA structures model data in a standard manner, incorporating imported data into that structure, which provides consistency for data exchange. Data exchange through this method can be supported and simplified by the Module Date Transfer Wizard (Rockwell Software, 2002).

Exporting to and importing from Model Database: Exporting to and importing from Model database enables extensive capability to interface with external software. Active models can be exported to a new database and a new database can be imported from an Access or Excel database. Imported Access or Excel databases would include the following information:

- Modules from any panel (including co-ordinates and data).
- Submodels (including co-ordinates and properties)
- Connections between modules and submodels.
- Named views.

- Project parameters, replication parameter and report parameters specified in the ARENA run/set up option.

In the Import/export database transfer method animation is not supported and regardless of the destination platform the data is organised into a standardised set of tables (Rockwell Software, 2002).

PanelName	ModuleName	TableName
BasicProcess	Create	BasicProcess_Create
BasicProcess	Entity	BasicProcess_Entity
BasicProcess	Process	BasicProcess_Process
BasicProcess	Resource	BasicProcess_Resource
BasicProcess	Queue	BasicProcess_Queue
BasicProcess	Decide	BasicProcess_Decide
BasicProcess	Dispose	BasicProcess_Dispose

Table 11: Mortgage Application Export Table (Module Table section), produced from the Model Database Method

In addition to the interfacing technologies, ARENA also provides two Windows technologies that are designed to enhance the integration of desktop applications. The first technology is Active X automation, which allows applications to control themselves via a programming interface. Types of actions that an application supports are defined by an object model, which includes:

- A list of application models that can be controlled (e.g. Excel worksheet, chart cell). (Kelton et al. 2002)
- Properties of those objects, which can be examined or modified (e.g. name of worksheets, title of chart, value of cell etc).
- Methods (of action) that can be performed on the objects or that they can perform (e.g. delete a worksheet, create a chart, merge cells). (Kelton et al. 2002)

The second technology that works with Active X automation is a VBA programming language, which is used to write code that automates other applications, written directly from ARENA.

4.4 Transfer Method

After reviewing the ARIS and ARENA methods, compatibility and potential data transfer options it is apparent that integration is feasible. Therefore this section of the chapter will propose the transfer method for practical experimentation. To achieve the project goals the approach must meet the following objectives:

1. Export the ARIS model
2. Read the ARIS file and withdraw the relevant project information
3. Input the corresponding project data into ARENA for project generation.

The following diagram represents the proposed transfer method for integrating an ARIS project into the ARENA format, it identifies the movement of data between the two packages.

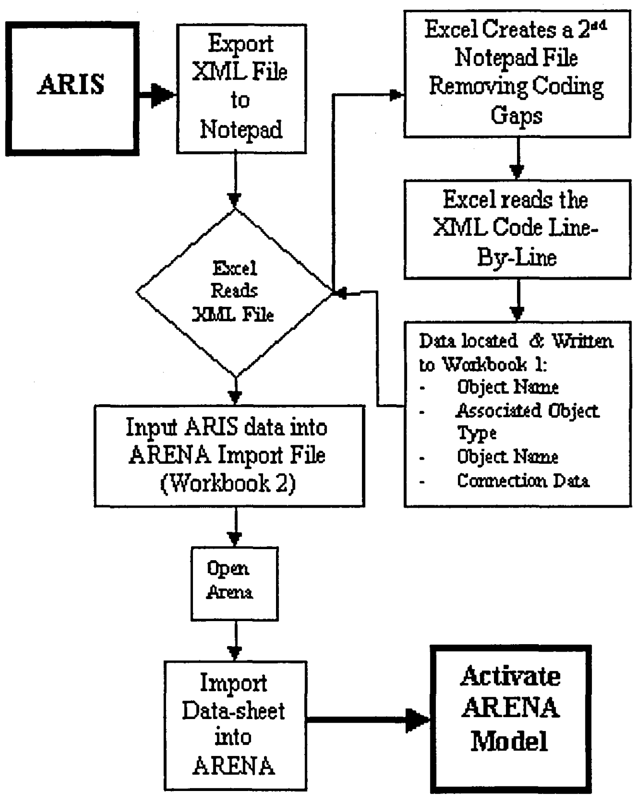


Fig 19: Project Transfer Method.

The first stage of the proposed integration is the export of ARIS modelling data, in a format, which comprehensively documents the selected project data. At this stage project, data will be exported using the ARIS XML interface, which produces a detailed and structured document that can be read by external applications. With this export facility the required project data can be selected, to focus on database, group or model data. However this capacity does not allow Table objects (Simulation and/or ABC table), OLE objects or Visualisation groups to be considered in the XML export.

The exported ARIS file will be transferred directly onto a notepad file that can be manipulated and read for potential requirements. Manipulation will be achieved through an Excel file that reads the XML data, identifies the required ARIS information and writes that data onto separate spreadsheet files. The next stage of the integration process is to transfer the extruded ARIS data into the ARENA import format, which will be situated in a separate Excel file. Once this process has been achieved the final stage is to import the data as an ARENA project file.

The practical experimentation followed a series of stages that attempted to meet specific targets that would ultimately integrate the two modelling packages to reproduce the project developed in ARIS within ARENA simulation. This Chapter will focus on the integration from the operational level, evaluating the process that user takes to generate a Simulation model directly from the ARIS platform. The evaluation will focus on the following:

1. **Creating an ARIS Export File**
2. **Produce Data Transfer through Excel**
3. **Create the ARENA Model**

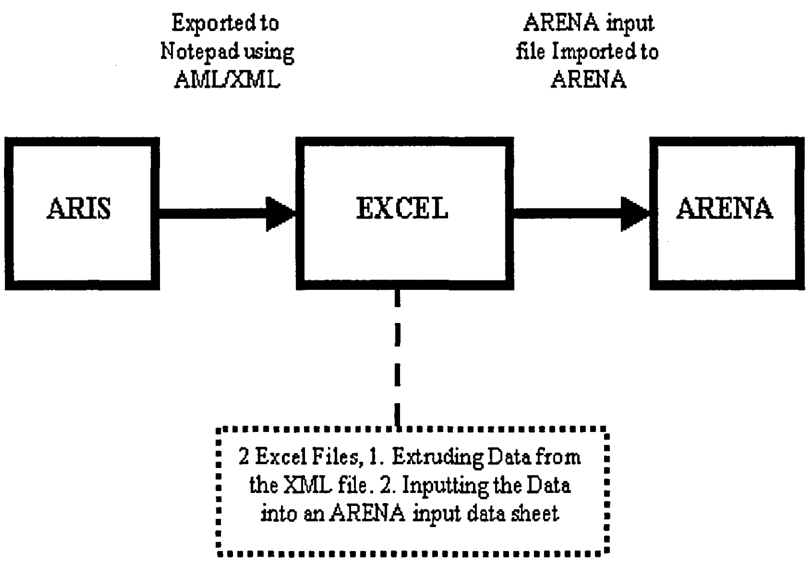


Fig 20: Operational Model Transfer

At each of these stages there were numerous complexities that required considerable investigation and analysis. In this section of the project each process will be investigated individually and the complexities will be discussed accordingly. The investigation was based around transferring a simple ARIS model to establish the processes required to complete data transfer.

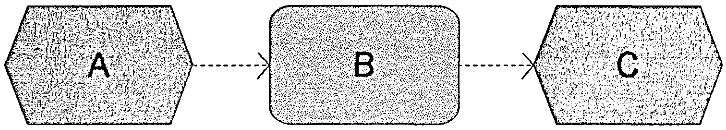


Fig 21: Example of the Simple ARIS Process

5.1 Creating an ARIS Export File

At this stage of the integration process the ARIS project is exported, generating an ASCII data format file that describes the models (diagrams) created by the user, including its contents (IDS Scheer, 2000). The export process is automatically generated by the Export Wizard, which will transfer the file to the desired location.

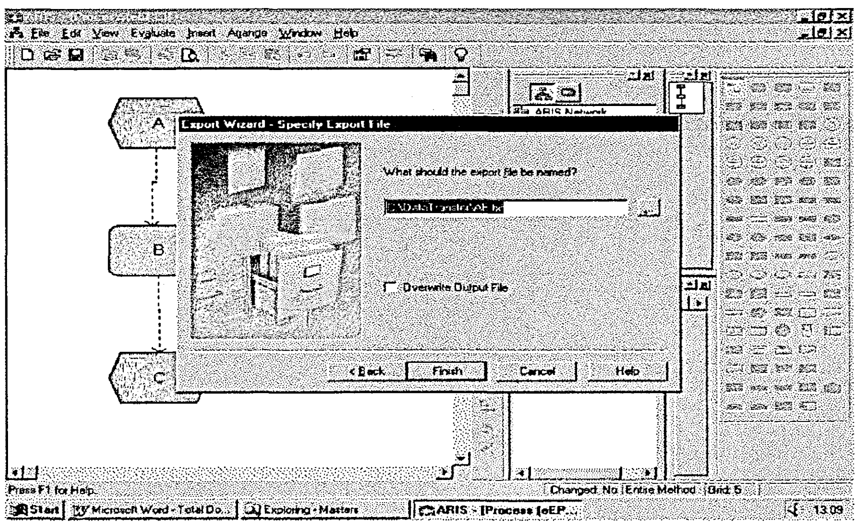


Fig 22: ARIS Export Process

When the user exports the ARIS ASCII file only the object definitions that have occurrences in the database will be exported. Therefore the following information was not considered within the models exported file (IDS Scheer, 2000):

- Table Objects (Simulation and/or ABC tables)
- OLE objects (Object Linking and Embedding, which could include, Word Documents, Excel Spreadsheets etc.)
- Visualisation groups

The advantage of the exported XML ASCII file is that the data is extensively structured, broken down into individual sections that contain specific elements of the ARIS project data, which provides a valuable method to enable the required data to be identified. The ARIS export file contains the following sections:

Export File Sections		
1 Control	10 Object Definitions	19 Graphics
2 Local Infos	11 Connection Definitions	20 Free Form Text Definition
3 Used LocalIDs	12 Text Definitions	21 Free Form Text Definition
4 Localeld	13 Objects	22 Free Form Texts
5 Language	14 Connections	23 Model Reference Links
6 Groups	15 Fonts	24 Object Definition Reference Links
7 Models	16 Texts	
8 Columns	17 Object Definition Model Allocation	
9 Industry	18 Object Definition Links	

Table 12: ARIS Export File Sections

From the structure of the exported file, locating the required data is relatively straightforward once the definitions are understood. This is due to organisation of the data held within the export file. Under each category definition each section defines a project meaning by a series of numbers and letters that are pre-defined values, which represent a particular project section. These values are defined by the ARIS method, documented as *Allocation Tables*, which contain *Model Type Numbers*, *Object Definition Numbers*, *Connection Definition Numbers*, etc. These unique values become invaluable when reading the XML document to identify the data required. For example the connection definition section of the document defines objects and the connection details through a series of numbers that combine to achieve Modula connections.

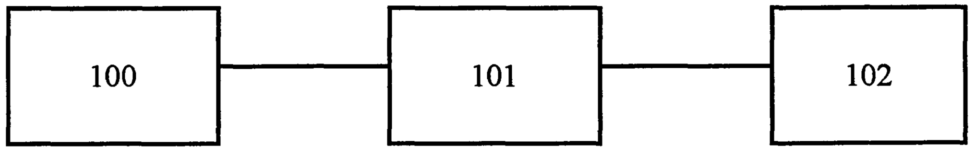


Fig 23: Connection Definition, defining Connections

Each section of the export file follows a similar format, but is used for varying purposes, which combine to document the project in its entirety. Although this approach is complex, the method provides a file that is suitable for identifying specific project data within a comprehensive structure.

5. 2 Produce Data Transfer from Excel

At this stage of the integration process the user instructs an excel file to conduct two different operations. The first operation searches through the exported ARIS XML file locating the required project data. The second section inputs the extracted data into the ARENA import file, which is contained within a new Excel document.

5.2.1 Identifying the ARIS Data

Once the user has instructed Excel to begin the data transfer process the file conducts the following operations:

- Match the XML values with the ARENA import method
- Opens the Notepad file containing the ARIS XML data
- Identifies the data within the XML structure
- Builds the VBA code that reads the data into a spreadsheet

These operations combine to extract the ARIS modelling data in preparation for its import into the ARENA modelling file.

5.2.2 Matching XML values with the ARENA import method

The first stage of this process is to identify the data that needs to be extruded from the XML export document, matching that information with the ARENA import format. A mapping investigation had been evaluated earlier in the report, which concluded that due to modelling differences and purpose there are few corresponding attributes. Therefore the integration will be primarily focused upon the reproduction of the model structure. As a result the initial targets within the ARIS export file are:

1. *Object Number*: A unique identification number that is given to each object within an ARIS model. ARENA also assigns each object within its model a unique object number, but the user can change these numbers. Therefore the Object number created by ARIS will be assigned to ARENA to match corresponding building blocks.

2. *Associated Object Type:* This number identifies the building block that is used within the model, which will in part allow corresponded objects to be matched between the methods.
3. *Object Name:* The object name is the name given by the user and the model information that they will identify with. Other names are part of the model logic and users may not understand its meaning.
4. *Connection Data:* This information represents the connections between objects, including the *Connection Definition Number*, *Start Object* and *Target Object*. The connection method in ARIS is mirrored in the ARENA import file, which follows a similar structure.

5.2.3 Open the Notepad file and identify the Data within the XML Structure

At this point of the integration process the VBA code within the Excel spreadsheet opens the XML file to read the ARIS output data and locate the required information within its structure. Each section within the file describes a specific area of the exported document, from the Control section (describing when the model was built, the model name, etc.), Language, Groups, Models etc, which combine to describe the model in its entirety.

When the user activates the data transfer process the automated program searches defined sections within the ARIS export file. These sections are found using VBA programming, which searches for the target information contained within the XML structure. In the experimental examples the user is searching for modelling data that is contained within the following categories:

1. *Objekte (Objects)*: Containing the Object Number and Associated Object Type
2. *Textdefinitionen (Text Definitions)*: Containing the Object Name
3. *Kantendefinitionen (Connection Definition)*: Containing the Connection Definition Number, Start Object and Target Object

These categories provide the structure to identify the required project through VBA code, which counts through sequences in the XML document to locate the required object. The following table identifies the search criteria within the VBA code.

XML Data	XML Start Section	XML End Section	Section Line Number
Object Number	Objekte	Kanten	1
Associated Attribute Type	Textdefinitionen	Kanten	2
Connection Definition Number	Kantendefinitionen	Textdefinitionen	1
Start Object	Kantendefinitionen	Textdefinitionen	3
Target Object	Kantendefinitionen	Textdefinitionen	4
Object Name	Textdefinitionen	Objekte	6

Table 13: Location of the required ARIS data

The table identifies the locations of the required information contained within the ARIS XML export file, this data is vital when reading the contents of the file because it is used to locate the beginning and ending of each subject area. Once the start definition is located in the input file the next stage is to count through the file to find the required data. When that data is located, then the code loops through the file to find the next stage in the process until the end of file, so all modules are documented. After all modules in the subject area (e.g. Object Number) are located that section of the loop is closed and another reading method is started.

5.2.4 Write Data to the Excel Worksheet

The purpose of this stage of the integration process is to write the extracted XML data into the spreadsheet format so that the data can be written into the ARENA import file. This process is activated from the user's instructions to start data transfer, preceding the extraction of the data from the XML document. In the experimentation two excel sheets were created called the 'Block' and 'Connection' sheets.

Writing to the required spreadsheets was straightforward, at each section of the coding a declaration was made to define the sheet. When the required information had been read that data would then be sent to the specified location, by definition.

Object Name	Associated Object Type	Object Name
100	18	A
101	22	B
102	18	C

Table 14: Example of the exported XML data within the Blocks Spreadsheet

5.3 Input the ARIS data into the ARENA import file

At this point in the integration process the objective is to transfer the corresponding project data from the ARIS model through to ARENA, automatically generating the same modelling building blocks within the physical environment, rather than the logical environment of ARIS. This section of the evaluation will be divided into the following sections:

- Evaluation of the ARENA import file
- The code used to transfer the modelling data
- The method used to match the corresponding building blocks
- The code used for matching and selecting the relevant modules

5.3.1 ARENA Import File

This section of the chapter will demonstrate the complexities of the ARENA import file, demonstrating the importance of understanding its structure and Modula attributes. This will be demonstrated by evaluation of the file structure, identification of the information required for successful data transfer and the information that is not required. The analysis is based on transferring the model structure and as a result will only focus on the basic transfer elements to recreate the model in its simplest form. ARENA file structure is demonstrated below, divided into two separate tables:

ARENA File Structure	
File Name	Matching Requirement
1. Module Tables	File Matching required
2. Repeat Group Table	File Matching required
3. Model Levels	Level Numbers Required
4. Submodels	None
5. Connections	Requires Start/Target Object
6. Named Views	None
7. Project Parameters	None
8. Replication Parameters	None
9. Reports	Nome

Table 15: ARENA Import file section 1

The table identifies the structure of the ARENA import file for the example created within the practical experimentation (Fig 21), although the example is relatively simple the file is very complex and will only increase in complexity for other models. In this file the key section for reproducing the ARIS project is the *Module Tables* (Table 16) and *Repeat Group Tables,* which defines the ARENA template and modules to be used. In this case the transfer process must create the correct panel, by accurately matching the panel required with the ARIS modules.

PanelName	ModuleName	TableName
BasicProcess	Process	BasicProcess_Process
BasicProcess	Create	BasicProcess_Create
BasicProcess	Dispose	BasicProcess_Dispose
BasicProcess	Entity	BasicProcess_Entity
BasicProcess	Queue	BasicProcess_Queue
BasicProcess	Resource	BasicProcess_Resource

Table 16: Module Table defining the ARENA panels

The next section in the import file that requires input data is the *Model Level*, which reoccurs throughout various files and without that data transfer will not be achieved. This data is a simple one-digit number that can be incorporated easily, but cannot be matched with the ARIS export data directly. The *Connection* file is the first file that requires data directly from the ARIS method, this data includes the *Connection Definition Number*, *Start Object* and *Target object,* which defines the connection configuration of the imported project. Remaining files within the first table are irrelevant for the current targets of the experimentation and do not require project data. Such data does not match with the ARENA method, but could be investigated for future evaluation.

ARENA File Structure	
File Name	Matching Requirement
10. BasicProcess_Process	SerialNo, ModelLevel, Name
11. BasicProcess_Process_Resources	SerialNo, ModelLevel, Name
12. BasicProcess_Create	SerialNo, ModelLevel, Name
13. BasicProcess_Dispose	SerialNo, ModelLevel, Name
14. BasicProcess_Entity	SerialNo, ModelLevel, Name
15. BasicProcess_Queue	SerialNo, ModelLevel, Name
16. BasicProcess_Reresource	SerialNo, ModelLevel, Name
17. BasicProcess_Resource_Failure	SerialNo, ModelLevel, Name

Table 17: ARENA Import file section 2

The remaining file names from the ARENA file structure (Table17) is created by the *Module Tables.* These tables define the module to be used and where that module will be situated. Data within these files are unique to the building block being used and are difficult to match with the ARIS method. However to reproduce the ARIS model within the ARENA environment this file will be created to its simplest form, adding the corresponding *Serial Number* (ARIS Object Number), *Model Level and Block Name* (ARIS Object Name).

SerialNumber		ModelLevelID	X	Y	Name	Max Batches	Interarrival Type
28		1	1050	926	A	Infinite	Random
Schedule	Expression	Value	First Creation		Units	Batch Size	Entity Type
Schedule 1	1	1	0.0		Hours	1	Stuff

Table 18: Basic Process Create Module

Table 18 is an example of a *Basic Process Create module,* which is typical of the import file structure. In this case the *Max Batches, Interarrival Type, Schedule, Expression Value, First Creation, Units, Batch Size and Entity Type* will not be edited from the data transfer, because these have no effect on the structure of the model. This type of data is not present in the ARIS method due to differences between their logic.

5.3.2 Code to Transfer the Modelling Data

This stage of the transfer process uses the data read from the Notepad file, which is located in the Excel Worksheets to create a accurate ARENA import file. The transfer process is achieved by declaring the data to be transferred, its destination file the worksheet and the cells where the data is to be sent. This process takes place at the end of each section of the coding.

5.4 The Method to Match Building Blocks

At this stage the integration process the data transfer is at its defining point, declaring the modules to be used within ARENA, matched with the ARIS building blocks.

In this part of the investigation the two projects were matched through the use of a stencil, contained within the Excel spreadsheet. This stencil contained the ARENA module panel that defined the building blocks and their location within the ARENA software method. The stencil provided the building blocks contained within the *Basic Process* panel, which are the fundamental modules used within most ARENA simulation projects. A stencil in this form can be easily expanded to include all the ARENA methods, which would be used within varying complexities of models.

The mapping process was achieved by matching the unique ARIS *Object Number* contained within the intermediate spreadsheet with the corresponding building block, which was identified through the stencil. That process is demonstrated in the diagram below:

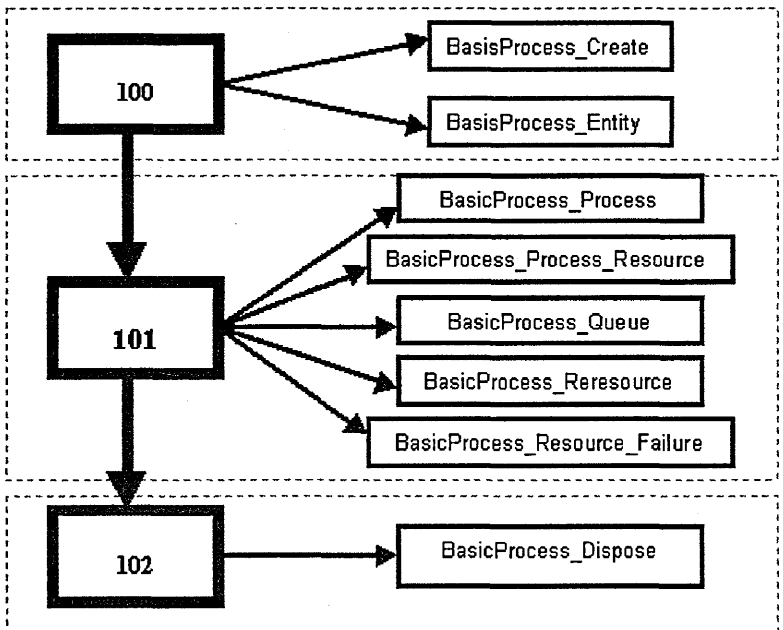


Fig 24: Mapping Process

5.4.1 The Code used for Matching and Selecting Modules

This section of the integration process uses the data collected from the XML output file and maps that information with a stencil sheet containing all the ARENA module building blocks. The code required to achieve the mapping used an Array to define the location of the source data. Once the Array had been defined the next stage was to identify the data to trigger the mapping process and then define the destination location. Once the ARENA import file has been created the user must then import the file into the ARENA Simulation tool through its import facility.

5.5 Results of the Practical Experimentation

The practical experimentation has identified the potential for the integration of the two-software packages, but has also established the true complexities of the project. In the experimentation several models were built within both formats mapping their similarities to investigate the potential complexities from a variety of modelling occurrences. In the example below the model is very simple, containing a basic ARIS process flow and its comparable method within ARENA

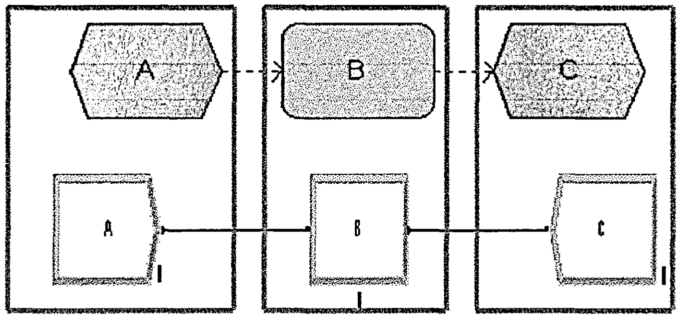


Fig 25: Integrated Project

In this example the integration process has been completed instructing ARENA to build a model that uses a *Create*, *Process* and *Dispose* building blocks from its *Basic Process* panel. These instructions were established from the ARIS model, which through the intermediate file establishes that the *Event* (A), *Function* (B) and *Event* (C) of the input file is then matched with its corresponding modules within the ARENA method (*Create*, *Process* and *Dispose* respectively*)*.

However because of the differences in the software purpose the mapping process is not that simple, the complexities of the ARENA model requires additional project information and as a result requires additional modules to those that they directly match. In Dynamic Simulation the model evaluates a process through the use of many variables and entities that pass through the system, because these methods are not present in the ARIS method they must then be generated to be included in the new model.

In the experimental model the ARIS method required the addition of *Entities*, *Resources*, *Queues* and *Failures*, which are automatically part of an ARENA project when a model is created from the ARENA Template. Therefore in the experimentation the method needed to generate comparable modules by matching them with their associated building block (i.e. the *Create* panel generates the Entities used in the model, see Fig 24.

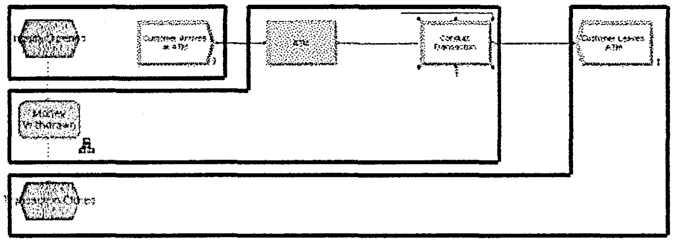


Fig 26: ARIS/ARENA ATM Machine Comparison

The mapping investigation in Methodology section evaluated two project models, which established the differences between the software methods. Those examples included an ATM machine process and a Mortgage Application process. When integrating these two models the basic data transfer process does not change, but the complexity of the import and export files increases.

In the ATM machine example the ARIS process is a high level diagram that is used to create the ARENA model. In this example the XML output format does not effect the current transfer method because the file is a similar process to the previous investigation. However the complexity of the import process into ARENA is increased because the ARENA model is expanded in size and as a result required additional modules. Therefore additional entries were required to include modules from the advanced transfer panel (*Station*) and the code needed to be expanded to include the module. The new ARENA import file required expansion from the previous example to include the station module data, within a new worksheet and the connections would increase in the number of entries, but the method would not change.

In the Mortgage Application example (Fig 27) the main difference between the previous examples is that the diagram does not follow a straight process flow, branching off for an *Exclusive-OR trigger*, which in ARENA is represented by a decision. Due to this difference the structure of the ARIS XML export document changes, which effects the reading of the document and the process of counting through the lines of code within the file. This process is accounted for using a select case command that searches for the varying possibilities that effect the order of the objects and their connection definitions.

The ARENA transfer process in this example required additional entries adding to the stencil worksheet so that the new ARENA import file could be created to include the new modules. In this example all modules were from the Basic Transfer panel.

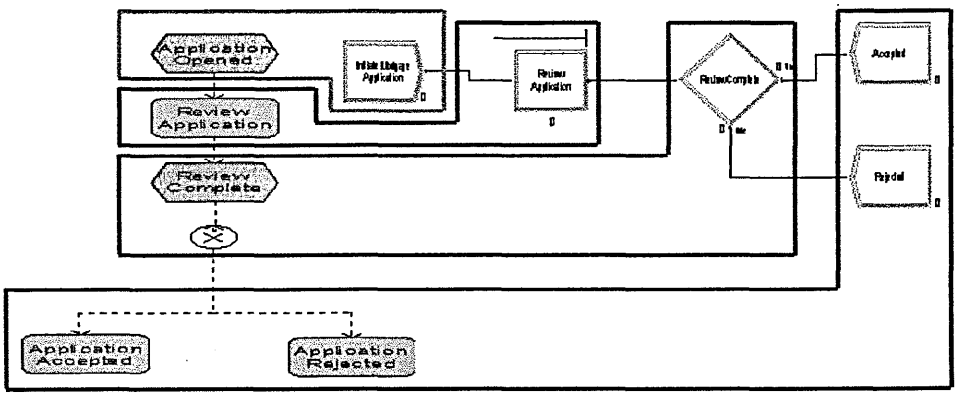


Fig 27: ARIS/ARENA Mortgage Applications

The following Chapters primary aim is to evaluate the capacity of the data transfer and the limitations of the method. From the experimentation it has become apparent that integration of the two software packages is feasible and could potentially enhance their capabilities in many projects. The evaluation will analyse the current Data Transfer method, evaluating the advantages and disadvantages of the approach taken. This investigation will focus on the key elements of the integration process.

6.1 Exporting ARIS data in the XML/AML format:

The ARIS export procedure is very simple allowing its users to select the modelling project, model or specific section of a model to export to an external file. The complexity of the transfer can be controlled by Merge or Administration facilities. Data from the XML file is comprehensively structured and documented (IDD Scheer, 2000) enabling the identification of project information from the Export file.

However the ARIS export facility does not provide the capacity to transfer Table Objects, OLE Objects or Visualisation groups and as a result an entire project would not be transferred. Table Objects include Simulation or ABC (Activity Based Costing) tables that are used within the defined project. In terms of transferring Simulation data from ARIS to ARENA for data transfer the information is difficult to match and therefore provides little value, when used within ARENA Simulation. ABC does not add value to the transfer process, because it will not extend the capability of ARIS, and ABC does not fall within the scope of ARENA.

OLE Objects are objects that are linked to the ARIS model, containing external files that contain project-supporting information, this information may include Word/Excel Documents or Charts. In terms of the model, there is no value in transferring written documentation that has no structure, providing long documents of supporting information. However this method could have been a useful method to enhancing the ARIS-ARENA matching process, by creating a file that contains ARENA related data (I.e. additional attributes for Create, Dispose etc.).

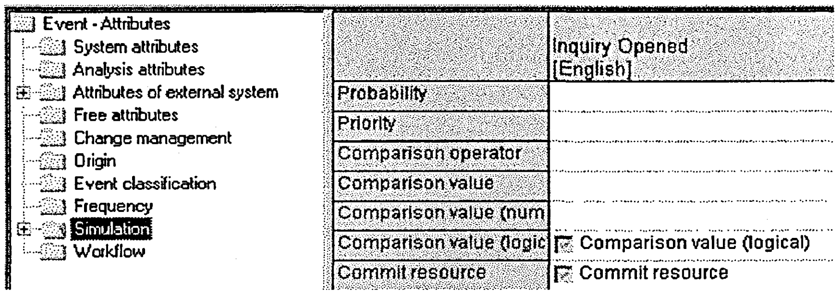
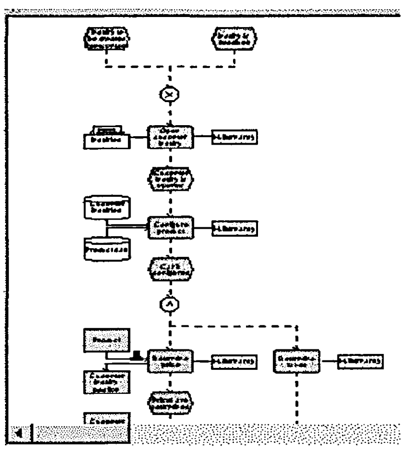


Fig 28: ARIS Simulation Attributes

6.2 Opening the XML Output File to be Read from Excel

At this stage the data transfer process is constant, the XML document is produced defining the project or project area required, and provides an XML structure that is comprehensively documented. The outputted document follows a defined structure that remains consistent and identifiable whatever the size.



1	Number of the Connection Definition	Start Object	Target Object
2	100	105	102
3	101	105	101
4	102	107	109
5	103	105	104
6	104	111	106
7	105	112	104
8	106	110	109
9	107	110	100
10	108	110	101
11	109	110	102
12	110	110	103
13	111	107	100
14	112	108	100
15	113	100	113
16	114	113	105
17	115	101	114
18	116	114	103
19	117	102	116
20	118	103	115
21	119	115	105
22	120	116	105

Sheet1 | Blocks | Connect

Fig 29: Complex ARIS eEPC model and its connection details.

The example represents the process of reading a detailed project, identifying the required information and publishing that detail on an intermediate Excel file. From the diagram the procedure of reading the XML document remains the same and from the code the full connection details have been identified. Therefore the basic procedure for reading the document remains the same, but may need extending in such circumstances. Increased complexity will effect the objects, connections and the interaction between models within the project.

Although the XML document provides an effective method of identifying the required information, the true complexity of the problem can only be identified in detailed projects. Fig 29 represents a customer enquiry model, which is only a small part of a larger project (ARIS Demo50) that represents a large organisation with many departments. This type of diagram uses many ARIS methods that interconnect to many sub-models containing different business units.

6.3 ARENA Import File

Through extensive testing it is apparent that the import file provides numerous benefits compared to its alternatives. The file can effectively produce an ARENA document without a fully complete file, which enables data transfer from ARIS. The code required to transfer the data from one format to the other is straightforward and easy to extend for larger projects.

However there is a problem created by the incompatibility of the two modelling formats, in terms of their X and Y co-ordinates. The first problem is the format that they are presented in, ARIS diagrams are generally built in the vertical format, whilst ARENA processes are built on a horizontal plain and as a result the transferred model will not be efficiently reproduced. Therefore the problem could be solved by changing the ARIS format to the horizontal plain, or switch the X and Y co-ordinates to their opposite plain in the ARENA import file. Without inputting the co-ordinates into the ARENA model the modules will stack on top of each other (Fig 30). Without the inclusion of the X and Y co-ordinates the ARENA model will be built, but the data transfer will not be full automated.

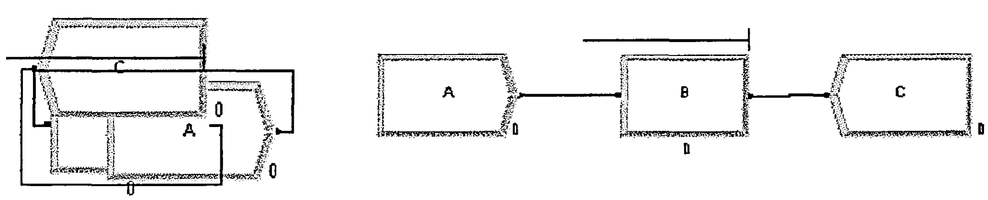


Fig 30: X and Y Co-ordinates of ARENA Simulation

In the practical investigation each of the models evaluated were successfully built using a module stencil, which matched the compatible building blocks.

Although the data transfer process has been proved successful and would add value to many organisational projects, by reducing time and costs of running two concurrent projects based on the same subject. The differences between the modelling methods mean that the stencil process is based on the interpretation of the individual transferring the model. In both modelling formats it is very difficult to consistently match the two modelling methods. An ARIS model may contain many Event building blocks, with many different Object definitions for those blocks, which make the mapping process very difficult because the true representation within ARENA cannot be identified or its meaning may be misinterpreted. Therefore in large ARIS projects they may include many different modelling methodologies, using a variety of building blocks on different levels. In such circumstances the stencil would need to be comprehensively document using all of the ARIS and ARENA templates, which would make the mapping process very difficult.

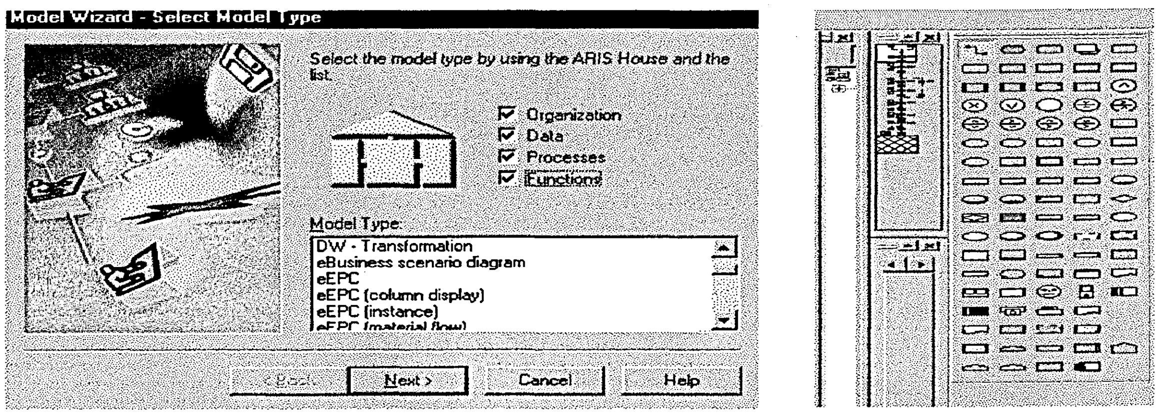


Fig 31: ARIS modelling diagrams and an eECP Template

Fig 31 identifies the breadth of the ARIS method and the extent of its modelling template The left hand snapshot demonstrates the available models in the method, whilst the picture on the right indicates the amount of templates within the eEPC diagram. Whilst fig 32 demonstrates the complexity of the ARENA method and its available templates.

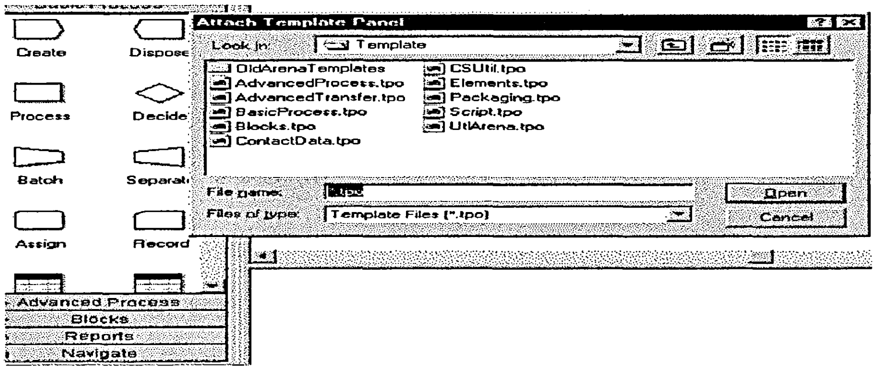


Fig 32: ARENA Import Procedure

6.4 Summary

Through the development process of the research project it is apparent that the integration of BPM and Simulation techniques has huge potential for many businesses. The research into integrated methods has identified the availability of product tools that allow a variety of software connection options. The preferred option was comprehensively tested, using a variety of modelling diagrams, which provided a valuable insight into the feasibility and capacity of integrated solutions.

Although the practical experimentation achieved its goals, transferring an ARIS Business Process Model into the ARENA Simulation format, the research has established the true complexities of the problem, which provide the basis for future investigation and testing. This chapter has evaluated the capacity of the selected data transfer method and assessed its limitations. The conclusion will individually evaluate each chapter assessing its value and potential for future research.

Chapter 7: Conclusion

The following Chapter will conclude the research project, evaluating its individual Chapters and the new knowledge gained from the research. Project categories were designed to extensively investigate the feasibility of *Automatically Generating Computer Simulation Models from Business Process Models.* Industrial feedback was encouraging, many companies were interested in the research and provided a variety of opinions on the subject. Therefore providing a valuable insight into the potential of the project and its effect on modelling practices.

The conclusion will outline the project Chapters and the knowledge gained from those Chapters to answer the question, *"is a fully automated integration process between a Computer Simulation model and a BPM model possible?"* After the Chapters and the objectives of the project have been analysed, the author will conclude the research by identifying future research and expansion of the project. Concluding categories will focus on:

- Literature Survey
- Benchmarking
- Methodology
- Practical Experimentation
- Validation and Verification
- Research Value
- Future Expansion and Research

7.1 Literature Survey

The Literature Survey justified the research project by comprehensively investigating Business Process Modelling, Simulation and previous research into the integration of the two methodologies. Evaluation identified the purpose of each method, their role within industry and advantages/limitations of their solution.

Investigation has established that BPM techniques are used far more within industry than Simulation methods, currently less than 10% of companies use

Simulation. This is a direct result of the disadvantages of Simulation tools, they demand specialised training, they are difficult to interpret, time consuming and expensive. Simulation is often used inappropriately and BPM tools are increasingly used as a direct result of its macro/micro environment. BPM tools are currently promoted by government regulation, which stipulate that organisations document processes to meet their legal requirements and companies are using the techniques to compete within global markets and build BPR projects. However because of BPM limitations 50% of BPR projects fail because of their inability to test the outcome of such changes. These shortfalls are created by BPM methods only focusing upon the process, logically defining the model, which does not identify how, where and when process entities are developed. Only Simulation can successfully test a Dynamic system because it is a System Orientated model that tests its Physical environment, using time and random behaviour.

Although BPM methods provide great value to many organisations, the Literature Survey established the difference between the methods and the shortfall, which undermines BPR projects that are established exclusively by BPM tools. Therefore substantiating the research through analysis of the problem, support from industry and professional organisations.

The Literature Survey also investigated past integration research, the problems accounted, their objectives and the packages used. This research identified the problems created by a variety of modelling methodologies and their limitations. Research identified the problems caused by the BPM methodology, its effect on the approach to be taken and the effectiveness of the solution. In all cases the tools required methodological changes to the BPM package prior to data transfer, resulting in limited success of the research. Therefore the identification of the most suitable BPM methodology was vital, which was established through a detailed and in-depth benchmarking study.

7.2 Benchmarking

An in-depth benchmarking study was created, investigating the current leading BPM tools. Five leading software providers were chosen from the Gartner report and through extensive analysis the most suitable package was selected for future investigation. The study was constructed through meetings with software providers, industrial representatives and experimentation with the evaluation software.

The study outlined the objectives of the investigation defining benchmarking as a concept, introducing the five software tools that were evaluated and identified the criteria that assessed the packages in the Benchmarking study. The five packages that were investigated included *Proforma, Popkin, Casewise, MEGA* and *ARIS*. Performance analysis was based around the following categories *Company Overview, Product Overview, Operating Environment, Product Details, Simulation Capacity, Integration Capacity* and *Organisational Use.*

Although *Simulation Capacity, Integration Capacity* and *Organisational Use* was the primary focus for the Benchmarking study, the author felt that the other categories were required to substantiate the objectives of the investigation. In each case the software's background defined the product, its operational use and effectiveness for the research. In all cases the product was strongly influenced by its experience, national origin and technical partners. For example ARIS from IDS Scheer was established in 1984, the oldest company in the investigation, which currently operates as a global organisation with many technical partners from leading industries. The investigation establishes the company's business targets, which include BPR projects and Supply Chain Management. One of IDS Scheers major partners is SAP, a major German Supply Chain organisation, defining the product capabilities.

The benchmarking study achieved its objectives through the evaluation of each subject area, comparing each area of the study with its competitors. Using a scoring system each package was compared, which established that ARIS BPM was the most suitable tool for the research.

Company					
	Proforma	**Popkin**	**Casewise**	**MEGA**	**ARIS**
Current Market Position	**4**	**2**	**3**	**5**	**1**
Product Structure	3	5	3	3	5
Integration Capacity	3	4	2	1	5
Simulation Capacity:					
1. Package Type & Simulation Type	5	4	4	0	4
2. Method	3	5	3	0	4
3. Analysis & Reporting	5	5	5	0	5
4. Animation	3	3	4	0	5

5. Purpose	5	5	5	0	5
Simulation Ranking	21	22	21	0	23
Customer Target Area	3	4	2	4	5
Total Ranking	**30**	**37**	**28**	**8**	**38**

Table 19: Benchmark Study

The study found that although the majority of the companies promoted their Dynamic Simulation capacity, in reality those packages provided Simulation capabilities that focused upon activity based costing. These techniques were in fact static models that did not account for time and random behaviour, which is established through Dynamic Simulation methods. Therefore these methods could not provide the capability to supply waiting time, lead time or work-in-progress of projects. From the analysis of the Simulation capacity of the software tools investigated the need for research into integrating of BPM and Simulation tools was justified.

Analysis from the investigation established Popkin and ARIS as the leading software tools, providing comprehensive methodologies, integration capacity and organisational use. However from discussions with industry, software providers and university supervisors ARIS was selected as the most suitable option. The company is the leading BPM supplier, current documentation was comprehensive and the university had product licenses readily available.

7.3 Methodology

After the benchmarking study the next stage of the research project was to identify the integration method. This was achieved in three stages, introducing the modelling packages to be used in the practical investigation, available transfer methods and the definition of the transfer method to be investigated.

Evaluation of the modelling methodologies documented each package, their structure and corresponding methods, which included analysis of a variety of modelling examples. The chapter established the similarities between the methods and the objectives for practical experimentation.

The investigation identified that both packages were based on flow diagrams, using building blocks from pre-defined templates, which are linked by connections. Therefore the modelling structure of projects can be successfully matched. However because of the different modelling purpose the analysis identified a shortfall between the 'logical' and 'physical' methods, which meant there corresponding attributes were limited.

The data transfer investigation identified the variety of integration methods available from each package, which established the options available and their value within the research. From the evaluation it was apparent that both packages provided suitable integration methods that extensively structured their import/export capabilities, which enable interfacing through a variety of formats.

After the evaluation of the available transfer methods, the next stage was to define the transfer requirements and the method that will be used within the practical experimentation. The practical experimentation was based around the following stages:

- Transport the ARIS project to Notepad via the ARIS AML/XML format
- Read the Notepad document from an Excel file
- Write corresponding data to the ARENA import file
- Create the ARENA model

7.4 Practical Experimentation, Validation and Verification

The *Practical Experimentation, Validation and Verification* chapters were the testing stages of the investigation. Using the collective research that preceded the experimentation to define the approach that was taken. These chapters documented the method of integration, the processes that took place to define its advantages and disadvantages.

The *Practical Experimentation* successfully achieved its objectives, creating an ARENA model directly from an ARIS export documentation. Experimentation provided valuable insight into the potential of the integration process and capacity to answer the question *"is a fully automated integration process between a Computer Simulation model and a BPM model possible?"*

Integrating the modelling packages has identified advantages of the process, where the import and export file of ARIS and ARENA enables comprehensive structure for the data transfer procedure. The ARIS XML document provides a structured file, which can be used to identify the required information through predefined sections that incorporate a series letters and numbers, which can be read whatever the file size. ARENA import file also provides a comprehensive platform for creating an ARENA project from an external source, investigation identified the contents of the file and the importance of each category for the project objectives.

The ARENA file contains numerous sections that define the project being built, those categories change for each model, but the import file does not need to be fully completed to create a new model. Therefore the ARENA import file provides the capacity to transfer the ARIS data and build a Simulation model within ARENA. Experimentation has established the importance of the Module Table section, which defines the whole ARENA model.

7.5 Research Value:

"Is a fully automated integration process between a Computer Simulation model and a BPM model possible?" Although the research project has achieved the generation of a computer simulation model from a BPM package through integration, the answer to the question is NO. The research has identified numerous gaps between the packages, which is primarily caused by their difference in logic. BPM tools are focused on the Logical process, whilst Simulation represents the Physical process and as a result their will always be gaps in information, unless software vendors begin to produce products that target both markets. ARIS models do not include the experimental information that defines what happens to its entities, how, where and when they are developed. This data can only be added by its creator, at any level the addition of this information will not be achieved automatically, it will require some manual inputting.

The research has also identified another problem that limits the level of automated integration. Due to the greater complexity of the ARENA models, the modules required to build a project are much larger than those within the ARIS format. Therefore the mapping process is subject to interpretation, because within ARIS projects contain many Events and functions, which will not consistently match with its equivalent object (Fig 24).

7.6 Future Expansion and Research

Throughout the research and discussions with industry it is apparent that an integrated system between the two methods would add substantial value to the products within a variety of industries. The research has achieved its objectives, answering the question " *Is a fully automated integration process between a Computer Simulation model and a BPM model possible?"* Although a fully automated integration process is not possible, there is future scope for the research to enhance the current method or change its purpose.

Current research has evaluated the potential of integration, identifying the problems that restrict a fully integrated solution. Future research must focus upon increasing automation, reducing the level of manual interaction. This could be achieved through research into providing an interactive interface that conducts the data transfer process, triggering user forms, which can be used to add the physical data that is missing from the BPM methodology. Ideally such investigation should focus on providing a method filter, which would allow the user to choose the level of automation they required. Future research must also identify a suitable method to accurately mapping corresponding building blocks, currently integration is severely restricted by subjectivity.

Future research could also investigate the potential of automating the two methodologies in the opposite direction, from Simulation to a BPM package. The problems identified in the current research have comprehensively evaluated each method, documenting the findings, which established the difference between the two methods and the problems caused in integration. Therefore research suggests automated integration between the two packages in the opposite direction may increase the level of automation and increase the value of many Business Process Reengineering projects. Increased automation may be achieved as a direct result of the Simulation data, which is superior to the data held within BPM projects and may not require the expansion of the model to achieve an automated integration process.

Glossary

ABC Activity Based Costing

ARIS Architecture of Integrated Information Systems

ASCII American Standard Code for Information Exchange

ASP Active Server Pages

BPM Business Process Modelling

BPR Business Process Reengineering

DAO Database Access Objects

GUID Global Unique Identifiers

HTML Hypertext Markup Language

IDEF Integrated Definition Methodology

OLE Object Linking and Embedding

UML Unified Modelling Language

SQL Structured Query Language

XML Extensible Markup Language

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Appendix 1: Company Review

Proforma (www.porforma .com):

Company Overview:

The Proforma Corporation is a privately owned company, which was founded in 1994 its headquarters are in Southfield Michigan. Within Europe, Africa and the Middle East Proforma's products are distributed through Winsoft (www.winsoft.co.uk), who were formed in 1992 to act as a master distributor for US consultants and software corporations. Proforma has been developed through alliances with IBM, Microsoft and Rational.

Product Overview:

The Proforma Company provides a broad suite of packages for business process improvement, where each package targets a required level of business activity, the suite consists of the following:

- Business Pro
- Enterprise Pro
- Simulation Pro
- The Boss
- Web Vision, which can be used to distribute models across the web
- Data Exchange
- JDE Document and combine business processes with IDE

Operating and Support Environments:

The Proforma suite and the Boss run under the Windows platforms (2000, NT 4, 98 and 95), operating as a 32 bit program that fully utilising latest features, including GUI techniques.

Product Details:

The Boss provides a secure environment for multiple ProVision users to share objects and models, supporting the construction and management of formalised business information for an enterprise. This package works with the entire

ProVision suite, allowing companies to understand, model and improve their business systems.

Capabilities (www.proforma.com):

- Support for connection to an arbitrary number of repositories by multiple users
- Check-in/out locking protocols enforced at the object level
- Account administration, configurable user permission and security
- A seamless migration path from single-user environments

The *Business Pro* incorporates high-level business strategy modellers, process improvement modellers and workflow modellers. Enabling the business to define, document, and improve business strategies and processes. Strategic modellers allow the user to define business objectives, goals, relationships and organisational structures. The workflow modeller can be used to identify potential inefficiencies for design or redesign, to improve the process performance.

Capabilities *(www.proforma.com):*

- Model the vision and strategy of an enterprise.
- Model enterprise-level cross-functional processes that accurately support your strategy.
- Easily identify opportunities for process improvement including supporting costs, benefits and risks.
- Activity Based Costing (ABC) to determine the predicted costs.
- Process models from ProVision can be used for Six Sigma and ISO9000 initiatives.
- Sophisticated repository for storing and reusing process components.
- Publishing facilities to produce high-quality MS office documentation.
- Model distribution via the Internet.
- Customisable methodology support for business process improvement, object-oriented and structured methodologies such as Rummler-Brache, LOVEM, IDEF and UML.

Enterprise Pro is a modelling tool that is used for merging business processes with technology systems, extending process models with UML compliant Use case and Class modellers. Allowing business processes to be further detailed in terms of business objects and automated system functionality. Through the use of a data exchange tool, business and object models can be imported and exported from popular tools, e.g. Visio, Rational Rose, Erwin, Microsoft Project, C++).

Capabilities *(www.proforma.com):*

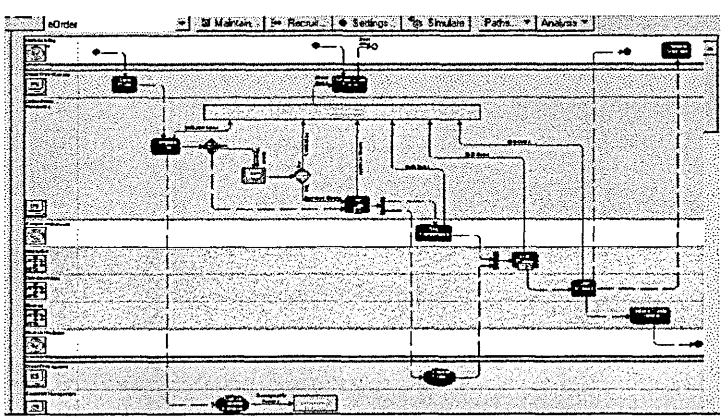
- Model the vision, goals and strategy of an enterprise
- Model enterprise-level cross-functional processes that accurately support a company's strategy.
- Easily identify opportunities for process improvement along with supporting costs, benefits and risks.
- Activity Based Costing (ABC) facilities to determine the *actual* costs associated with producing a good or service.
- Process models from Pro*Vision* can be used for Six Sigma and ISO9000 initiatives.
- Sophisticated repository for storing and reusing process components.
- Publishing facilities to produce high-quality MS office documentation.
- Model distribution via the Internet.
- Import and export data from MS Word, Excel, MS Project, Visio, XML and BPMI formats
- Interface with leading application development environments such as Rational, ERwin, C++, DDL and XML.
- Define and integrate process-to-data requirements via UML class modelling
- Provide a clear definition of system requirements via UML UseCase and storyboard models.
- Customisable methodology support for business process improvement, object-oriented and structured methodologies such as Rummler-Brache, LOVEM, IDEF and UML.

Simulation Capacity:

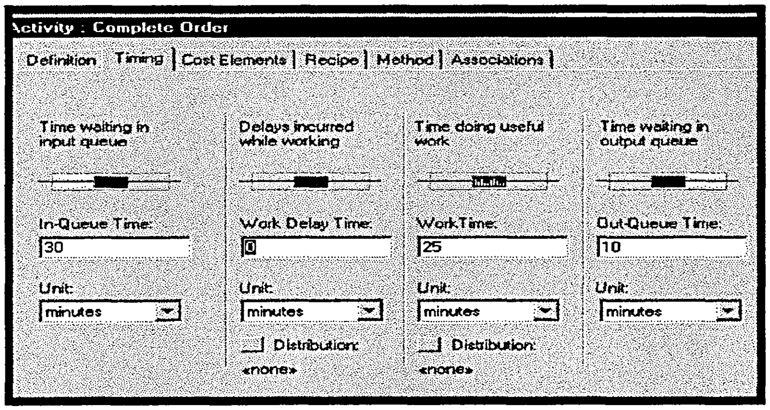
Within the Proforma suite there is simulation capabilities within Enterprise Pro, used for Activity based Costing, using Monte Carlo simulation. However

Simulation Pro is a dedicated simulation package that provides discrete event simulation, enabling organisations to inspect simulated executions of a process. Capabilities *(www.proforma.com):*

- Scenario Based Simulation –Simulate scenarios to see how the process will behave under specific conditions.
- Resource Constraints and Bottleneck Identification –Vary resource requirements and constraints to analyse potential bottleneck within each process scenario.
- Critical Path Analysis – Visualise the paths through the process scenario that incur the least/most cost and take the least/most time to execute.
- Activity Base Costing (ABC) – Identify all direct, indirect and resource costs associated with an activity.
- Scenario Comparison – Compare the results of all process simulations. This is a straightforward way to see the most cost effective and efficient processes.
- Animation – Visually observe the process running, or run lengthy processes in the background. The data from the simulation is then available for investigation using the analysis and reporting features.
- Analysis and Reporting – Display and analyse simulation results in the form of cost and timing spreadsheets and graphs. These can be combined with narrative process descriptions and visual process models of Pro*Vision* to publish a complete process improvement plan. The spreadsheets also can be migrated to Microsoft Excel for distribution or integration with other applications.
- Opportunity Analysis – Identify and assign opportunities and their costs and benefits to the activities where process improvement prospects exist.



Through the development of a process model, the building blocks used within the model have the facility to enter the required data for simulation, similar to those provided in a dedicated simulation package. Allowing waiting time in the input queue, delay time, working time and out queue time to be entered into the system. Providing the capacity to change the units used and allows different distributions to be simulated. However the level of detail provided by Proforma's simulation package is currently limited in its capacity, focusing on costing issues, restricted by its business process modelling methodology.



Picture: Input Data Window (*Proforma's ProVision Workbench)*

Within the building blocks of the model there is a detailed level of data that can be inputted into the system, which can be used to calculate direct, indirect and resource costs throughout an operation. Reporting is comprehensive, displayed in both spreadsheets and graphs, breaking down into the following areas:

- Cost Distribution Grid
- Cost Grid
- Resource Utilisation Grid
- Staffing Grid
- Timing Grid
- Cost Chart
- Cost Distribution Chart
- Resource Utilisation Chart
- Staffing Chart
- Timing Chart

The Animation within the package is displayed as flows through the process model, indicated by changing colours. Critical paths can be pinpointed to identify max/min time/costs of operations.

Integration Capacity:

Proforma provides the following integration capacities:

Import:

- Visio

Export:

- MS Project
- HTML
- RFT
- Excel Format
- Access or a common delimited format file

Bi-directional:

- Rose & Erwin

Organisational Use:

Through the investigation of Proforma's business process solutions it is apparent that the package that they provide is comprehensive and flexible, providing its users with an extensive range of modelling options. From the evaluation of the companies past customers there flexibility is supported by the breadth of industries, which they have supplied (refer to table below). The company has supplied businesses of varying sizes, which have used there package for a variety of projects that have included many BPR projects (analysis & design) and application developments.

Industrial Sector	Company	Project
Manufacturing	General Motors	Used within Business Process Reengineering (BPR) projects for analysis/design of business processes, approaches and methods
Banking /Finance	American Express	Used for BPM projects and application development efforts.
Information Services	IBM	Used as a support tool for there Workflow Management Consultants, based on its drawing and analysis features
Education	Computer Institute of Japan	Selected for analysis of business processes and provide process consultancy. The package was also chosen for

		its suitability within foreign markets.
Healthcare	The Blood Center of South East Wisconsin	Selected to be used for process and data modeling
Information Services	GIGA Information Group	The organisation have selected the package because of its business and systems process modeling capabilities

Popkin (www.popkin.com)

Company Overview:

Popkin was established in 1988 targeting the need for tools and techniques to utilise the software industries need for technical and managerial resources. In 1995 the company developed a UK distributor and successfully integrated it into the company. Currently Popkin have strategic alliances with Microsoft and IBM Japan that design, support and distribute Kanji versions of Systems Architect. An alliance has also been developed with the Computer Science Corporation (CSC) to establish support for enterprise modelling within the Popkin Toolset.

The companies corporate mission is to provide the international market place with a complete package that is powerful, flexible, and affordable. Providing business application modelling and design tools that complement this sector.

Product Overview:

Popkins System Architect provides a broad range of diagrams to enable an organisation to capture an entire enterprise from various business perspectives and in many cases offers alternative notations of presentations, depending on the demands of the users, or their situation. The diagrams provided rang from high-level business objectives, organisational make-up, through to event driven processes and function modelling. To enable the design of applications and databases that will optimise existing or future business processes, which will benefit an organisation.

Operating and Supporting Environment:

The Systems Architect is a 32-bit program, which provides an improved ability to interface with other 32 bit products and execute other software concurrently. The package operates under the Windows platforms (2000, NT, 98 & 95). However when using Windows 95, 98 and NT the company has recommended that the user should use the latest upgrades and service packages.

Product Details:

As with many of the leading packages in this sector Popkin's System Architect provides a multi-user repository, which allows data to be shared within the package and the models that it may contain. A three dimensional matrices enables relationships between objects in the repository to be specified and viewed. Therefore when changes are being made to one element within a diagram the effect of those changes can be quickly identified in other areas of the project, defining which business processes effect different entities. There a number of pre built matrices within the package and additional matrices that allow the user to define their own requirements.

Physical data model diagrams are automatically translated through schema generation, into schema definitions for multiple database management systems, which can be performed live through ODBC connection. Ensuring the integrity of models by allowing the creation and maintenance of schema databases for a wide variety of SQL and non-SQL database management systems. Web publishing can be achieved through an HTML generator, enabling context sensitive reports to be generated, based on the database models. These templates can be customised to meet the corporate image of its user.

The System Architect multiple diagrams and modelling methods, including the IDEF methodology, which specifies a more structured approach, possibly providing increased consistency through modelling.

Standard and customised reporting can be produced, providing publishing through MS Word. Interfacing through VBA provides the System Architect with the ability to integrate with external tools, such as Excel, Access and ASP.

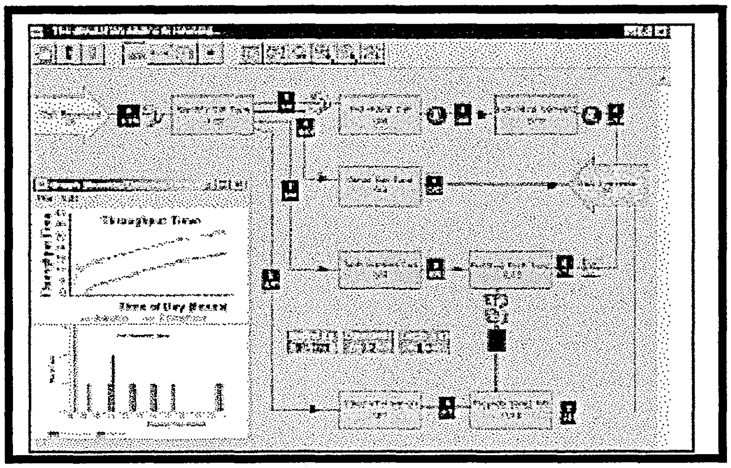
Simulation Capacity:

Popkins software enables a limited simulation capacity with animation that can be used to evaluate a systems performance. The simulation package is integrated into the Systems Architect, includes the following features:

- Graphical Process Flow Diagram –Providing data input and modification
- Process Animation – View the process as it runs
- Process Simulation – Product process results and matrices
- Profiles for Simulation Variables – Provides common and reusable information
- "What if" Comparisons – Allows comparisons to be made between alternative processes

- Real Time Graphs and Plots – Provides the capability to track important variables whilst the process is running
- Detailed Reports – Allows process analysis
- Activity Based Costing – Identifies the cost of a process before it is implemented

The Systems Architect can produce simulation models through either IDEF3 or Process Charts. Within the simulation engine there is capacity to set priorities in the model and a warm-up period can be assigned to improve the accuracy of the model.



Example: Simulation in the Systems Architect *(Popkin's System Architect)*

Integration Capacity:

Within the Systems Architect the data dictionary is used across all modelling domains, which means that the objects in the business process, functional and UML systems can be shared. Reports can be exported directly onto MS Word and through the use of VBA the Systems Architect users can extend functionality, connecting to other applications to develop integrated development solutions. Therefore VBA can interface with tools such as Excel, Access and ASP.

Organisational Use:

Through the evaluation of Popkin's company profiles it is apparent that they supply a broad range of businesses from varying scales. Ranging from small regional companies, such as Yorkshire Electricity through to multinational companies, like BMW. The evaluation of their customer profile indicates that their product provides considerable flexibility, which is reflected by the variety of industrial sectors that they consult with. The company's customer base contains a number of businesses within the following industries: (Refer to appendix for the full list of company profiles.)

- Banking/Finance
- Manufacturing
- Education
- Healthcare
- Utilities
- Government
- Information Services
- Retail
- Real Time & Technical

Industrial Sector	Company	Project
Utilities	npower	Used for mapping, modelling, and analysis of business process systems and data information. Integrating information, bridging the gap between business requirements and IT delivery.
Utilities	UK Patient Office	Used to bridge the gap between business requirements and IT delivery
Banking/Finance	UBC	Used to assist in the structured development and growth of their operations
Education	Computer Institute of Japan	Selected for analysis of business processes and provide process consultancy. The package was also chosen for its suitability within foreign markets and its customer driven approach
Healthcare	The Blood Centre of South East Wisconsin	Selected to be used for process and data modelling
Telecommunications	Cable & Wireless	Used to integrated network engineering and information service organisations. Enable easier product development and produce a measurable increase in company profits.
Healthcare	United Health Corporation	Produce reusable code for a variety of applications. Develop Models/documentation that will simplify product design/maintenance.

Casewise (www.casewise.com):

Company Overview:

Casewise is a global company that was founded in 1989 with head offices in New Jersey and London. They were founded as a result of attaining software rights to a product by Inforem (a British based Consultancy), which in turn had been acquired by CSC. Casewise was then created by a small number of the company's employees, who then developed the Corporate Modeller. In 1989 the product was rewritten for Windows. CSC then became the marketing channel for the product and its main customer. Their consultants used the modeller as its main methodology (Catalyst) and as a result the company were then able to reach major clients.

Since the company was established they have helped thousands of business analysts, data modellers and corporate planners understand their process improvements and redesigns. To help gain an international presence the company has developed numerous strategic and consulting partnerships with industry specific expertise. These partners include:

Strategic Partnerships:

- Visio
- Staffware
- Sybase
- Oracle

Consultancy Partnerships:

- Deloitte and Touché
- Pricewaterhouse Coopers
- CSC
- Headstrong
- Cap Gemini
- Ernest & Young
- Symphoni
- EDS
- A host of smaller, regional consultancies.

Product Overview:

The Casewise Corporate Modeller combines diverse areas of business, IT, Resource and Financial Modelling to form a complete view of operations. Through a central database each model within the Corporate Modeller is linked to permit information to be shared between each model within the organisation. The Corporate Modeller consists of eight modelling elements that combine to provide a solution for an entire organisation, those modular elements are:

- Hierarchy Modeller
- Process Dynamics Modeller
- Generic Modeller
- Data Flow Modeller
- Entity Modeller
- Repository Explorer

Operating Environment:

Casewise Corporate modeller has the following system requirements:

- Windows 98 (or later) or Windows NT4 (Service pack three) or later
- Internet Explorer 4.1 or later
- 266 Mhz Pentium 2 Processor
- 64 MB RAM (128 MB for NT)
- 200 MB free disk space
- Screen resolution 800 x 600, 256 colours

Product Detail:

The Corporate Modeller is the flagship product from the Casewise organisation, integrating business process analysis with enterprise modelling, connecting the objects through a common repository. Components that combine to produce an extensive solution are:

Hierarchy Modeller: The Hierarchy Modeller models the broad view of a business, producing high level processes and primitive processes. Any building blocks/object that are built at this point are sent the central repository.

Process Dynamics Modeller: The Process Dynamics Modeller captures cross-functional business processes and includes a built in simulation engine.

Generic Modeller: The Generic Modeller is an unstructured modelling package that provides a flexibility to change styles, depending on its intended market.

Data Flow Modeller: The Data Flow Modeller is a structured modelling process used for modelling the way information is passed across the business, creating a hierarchical set of data diagrams, maintaining information forms into the central data store.

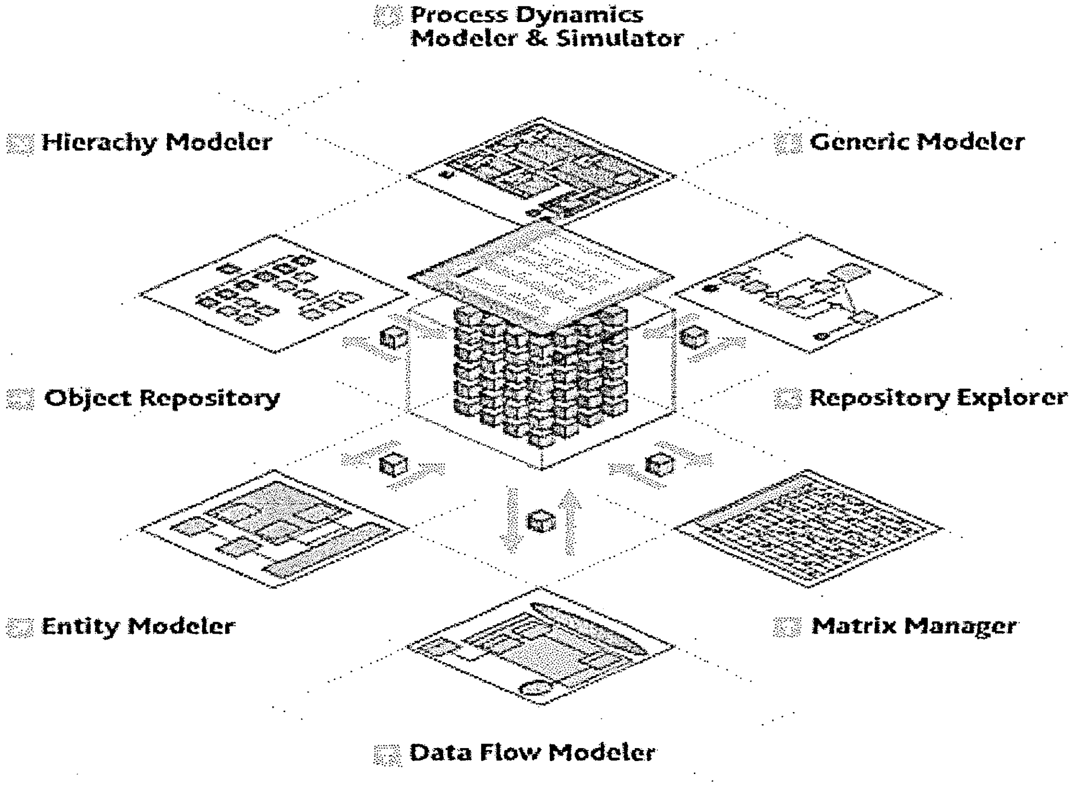
Entity Modeller: The Entity Modeller creates a conceptual model of data structures, allowing the user to select the information they require to store in a there database, working out how each data element relates, then automatically generating database schema for their chosen target environment. Through visualising and capturing of data structures a business can then obtain a clearly defined map of their system and data.

Repository Explorer: The Repository Explorer is a central point for controlling, viewing and reporting on the shared object repository. Models, Sub-Models and Multi-user set-ups are also managed within this section of the Corporate Modeller.

Central Object Repository: The Central Object Repository is a central database that stores diagram objects, associated information and models. Creating an instant library of organisations component parts, providing consistency throughout each process.

Matrix Manager: The Matrix Manager identifies intersection patterns, which is valuable for; consistency, quality checking, scoping, planning and recording interactions between business units.

Components of the Corporate Modeller are connected to provide the following structure*(www.casewise.com)*



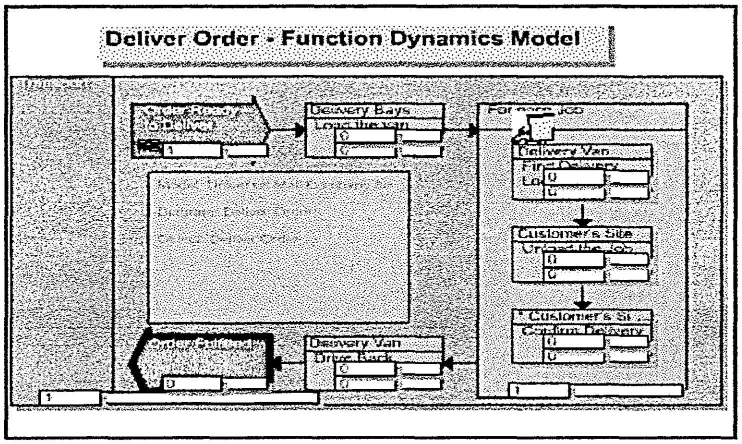
Integration Capacity:

Casewise's corporate modeller has the capability to integrate with many Microsoft Office products, which can be used to gather information, analyse processes and produce documentation. The package can also link to many code generation applications including:

- Sybase's Power Designer
- Rational Rose
- Staffware
- Oracle Designer
- J D Edwards
- SAP ERP Technology

Simulation Capacity:

The simulation capacity of the Casewise Corporate Modeller is built into the Process Dynamics Modeller, providing 'What if' analysis, where changes can be quickly made after considering possible scenarios, animation is available with the package. Changes can then be exported to excel for comparison with existing processes. The Process Dynamic Simulator continually focuses the project teams attention towards critical cost issues, where users can see the results of simulation on the profit and loss statement. Whilst reviewing the profit and loss, an organisation can control the cost metrics associated with each process and resource. Casewise Simulation: *(Casewise's Corporate Modeller)*.



Organisational Use:

Through the evaluation of the Casewise organisation it is apparent that they are an international company which targets process improvement and redesign within service industries. From the company's list of partners and clients it is apparent that they have strong links with consultancy companies, without any history of working within manufacturing sectors. Their list of clients indicate that the majority of their business is based on US and UK organisations, which is possibly a result of the location of their head offices.

Industrial Sector	Company	Project
Banking /Finance	Chase Manhattan	Improve division wide customer service and a process streamlining exercise within the credit card division
Travel & Transportation	Dover Wide Harbour	Used to understand when and why traffic queues occur and validate a number of "what if" scenarios using London Underground simulation
Banking /Finance	Century Life	The package was used to understand there business processes and design IT systems capable of meeting there needs. Providing solutions for there company and other life/pension providers
Consultancy	Deloitte & Touche	Create best practice solutions for consulting
Retail	Clarks Shoe's	Used to model their retail supply chain to obtain best practice processes to resolve data conflicts and scope future ERP implementation
Local Authority	Luton Borough Council	Produce an e-model of efficiency
	Swissport	Plan significant IT cost reduction by sound planning of application architecture

MEGA (www.mega.com):

Company Overview:

MEGA is a privately owned company that was established in 1991, the company is a global provider of process modelling and IT mapping solutions. The company's world headquarters are in Paris and North American headquarters are in Waltham, MA. Unlike traditional business process modelling tools, which only focus upon the development part of the problem. MEGA allows business and IT stakeholders to drive bottom line profits. Unlocking new customer value, minimising the risk involved when changing critical business processes.

The company has aided its global growth through many global partnerships that include technical and business partnerships with the following companies:

Technical:

- Amadeus International
- eXcelon
- Microsoft Biztalk

Business:

- Application Engineers (Belgium)
- Globex International (Austria)
- KTW Consultants Ltd (USA)
- Novabase (Portugal)
- Persys (Mexico)
- Satinfo (Morocco, Tunisia, Algeria)
- Veritaaq

Product Overview:

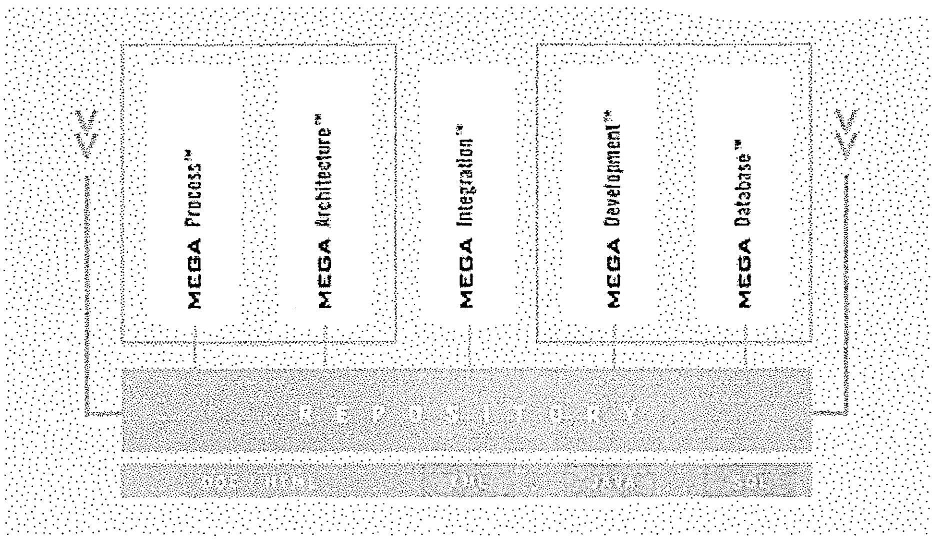
MEGA solutions are targeted at teams of business analysts and IT architects that need to improve organisational efficiency, through the connection of business processes and IT development. MEGA solutions is suite of packages that integrate to provide a successful modelling tool, each package is integrated with a central repository that provides storage, administration, documentation, reporting and security functions to design teams and supporting client administration.

The entire package comprises of five main elements:

- MEGA Architecture
- MEGA Database
- MEGA Process
- MEGA Development
- MEGA Integration

Product Details:

The MEGA package is made up of five components that provide an extensive solution, which targets business analysts and IT architects. The five components are linked together, as shown below, where their particular role will also be identified.



MEGA Process is extensible and customisable, providing analysis and design capabilities. Enabling the mapping, capturing and documentation of business processes/procedures, providing decision support and impact analysis of design scenarios.

MEGA Architecture enables IT designers/architects to analyse and design IT systems, and their relationships, with the targeted business process. The package maps information systems and data flows, providing smooth integration for new applications, exploring ways to reduce costs. Through the processes available maintenance can be improved along with the identification of external systems. MEGA repository automatically produces documentation and information concerning the web sites shared inside/outside the product team. Providing a common view for validation and innovation. MEGA Architect is used in conjunction with MEGA process to provide a coherent view of both IT and business environments.

MEGA *Integration* provides the capacity to design quicker process and application integration. Potentially reducing integration maintenance costs, enabling the improvement of business process and infrastructure assets. The integration section bridges the gap between business requirements and technical implementation. Maintenance is eased through the integration of knowledge from the repository, which defines a search for changes and automates impact analysis. Integration automates the full integration specification of Word documents as well as structured Web sites. Allowing users to access the enterprise from inside and outside the project team

MEGA *Development* provides the capacity to design/generate components, libraries and applications using the UML modelling language. The Development module is designed to manage business critical IT projects in terms of new application/component development, reverse engineering of existing applications, application integration etc, providing consistency between IT and business requirements. These module co-ordinates with MEGA's database providing mapping between code and data, allowing users access to the same diagrams at the same time

MEGA Database is used to design, build and reverse engineering databases. Through the use of relational and class diagrams conforming to UML (Unified Modelling Language) formalisation. The database is integrated with MEGA Development. Any Word documentation associated with the diagrams, or web sites representing all the enterprise data, is automatically generated by the database. Web sites allows the structure of the enterprise data to be shared with participants at any time.

Simulation Capacity:
Currently there is no evidence that the MEGA suite provides any simulation capabilities, as part of an element within the family suite, or as a standalone package.

Organisational Use:

Through the evaluation of MEGA's customers it is apparent that the company has a strong list of clients, which may possibly be a result of the location of there headquarter or business partnerships. The company has many international clients, within the US and Europe, however a big percentage of their clients are from French companies. From MEGA's client base it is apparent that their product provides flexible solutions, because they have supplied many different industries, such as:

- Government
- Manufacturing
- Banking & Finance
- Retail
- Utilities
- Insurance
- IT Services
- Healthcare
- Telecom

Industrial Sector	Company	Project
	Steria	Used for a quality management project to model processes, procedures & all the people involved.
Telecomunications	Microcell Solutions	Used to standardise internal procedures & deploy new procedures quicker. Required because of increased employee/customer growth.
Manufacturing	Usinor Group	Required for current & future global IT approaches. Used to enable continuous adaptation of its information systems & IT, as the organisation and its strategies change.
Information Services	Lucent Technologies	Integrate departments within the company.
Banking/Finance	Credit Lyonnais	Map information systems.
Government	French Department of Transport	Used to design future transportation systems throughout France.

ARIS (www.idssheer.com):

Company Overview:

IDS Scheer is a German based company that was founded in 1984 as a small constancy company, which produced ARIS products. The company is now an international organisation, which currently represents 50 countries, with 15 offices outside Germany.

IDS Scheer's primary business targets are IT consultancy, from strategic consulting through to software implementation and continued improvement of business processes. Apart from the company's primary activities of Business Process Re-Engineering their solutions strongly focus upon supply chain management, customer relationship management and production lifestyle management.

The companies goal is to become the leading European provider of e-business services in the development and implementation of web-based solutions. In the future the companies aim is to provide industry specific e-business products such as E-service caller, or solutions specific to the world of finance, such as e-service bank or e-service insurance. Other specific areas of consultancy may include the following industries: chemicals, pharmaceuticals, finance service providers, utilities, telecommunications and logistics.

Currently IDS Scheer has many technical partners that support ARIS in their product development and they are as follows:

- SAP AG
- HP
- VITRIA Technology: A leading integration service provider.
- IBM: Business process models defined with ARIS Toolset can be transformed into business process templates for automated execution with the MQ series workflow process engine.
- Intershop: Its goal is to develop well-developed e-business solutions.
- Hyperwave
- Staffwave
- Compaq: Assumes control of IT infrastructure.

- Siemens: Work with the company in the field of business process model validation & verification.

Product Overview:

ARIS was developed to provide a framework that bridges the gap between business theory, information and communication technologies. Providing a method of expressing business concepts in a detail that would allow extensive analysis, supplying a starting point for the development of computer based information systems. IDS Scheer defines ARIS concepts as providing the following:

- An architecture for describing business processes
- A set of modelling methods with an associated meta model
- The foundation of the ARIS software system
- A concept for computer-aided business management

The ARIS product range is based around two main products, ARIS Easy Design and ARIS Toolset. ARIS Easy Design is a reduced function version of the Toolset, intended for basic process capture and modelling. The full Toolset is intended for complex modelling, model administration and systems administration. ARIS Toolset has the following add on modules:

- Simulation
- Activity Based Costing
- Web Publisher
- Balanced Scorecard
- ARIS for Intershop infinity
- ARIS for mySAP.com

Operating Environment:

The operating environment of ARIS Toolset and Easy Design is as follows:

Recommended Hardware:

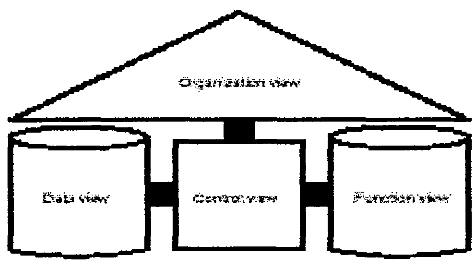
- Intel Pentium Processor, 166MHz
- 64MB RAM
- 120 MB free hard disk space

Operating System (client local):

- Windows (95, 98, 2000, NT V4.0 + Service Pack 4 + MS Y2K Patch, Service Pack 5 or Service Pack 6a).

Product Details:

The ARIS Toolset and add-on components provide a comprehensive solution that enables enterprise wide, global definition and design of business processes. Through the toolset ARIS can be easily customised for the needs of the individual company, including analysis and optimisation. The packages provided by the Software Company have provided solutions for companies within many different industrial sectors, including e-business, supply chain management and knowledge management. Providing organisations with careful analysis, documentation, redesign and optimisation of processes.



ARIS House *(IDS Scheer)*

When modelling an organisation, single large models tend not to be very useful, modelling from the one perspective. Therefore the ARIS products are based around the ARIS house, which links many objects and connections together. Allowing the user the capability to build many smaller models from specific viewpoints, relating them to each other. The ARIS house is made up of four views, providing structure to the product. Those views and their purpose are as follows *(Davis, 2001)*:

Organisation View – static model of the structure of the organisation. Including people resources in hierarchical organisation charts, technical resources (e.g. equipment, transport, etc.) and communications networks.

Data View – static models of business information. Including data models, knowledge structure, information carriers, technical terms and database models.
Function View – static models of process tasks. Includes function hierarchies, business objectives, supporting systems and software applications.

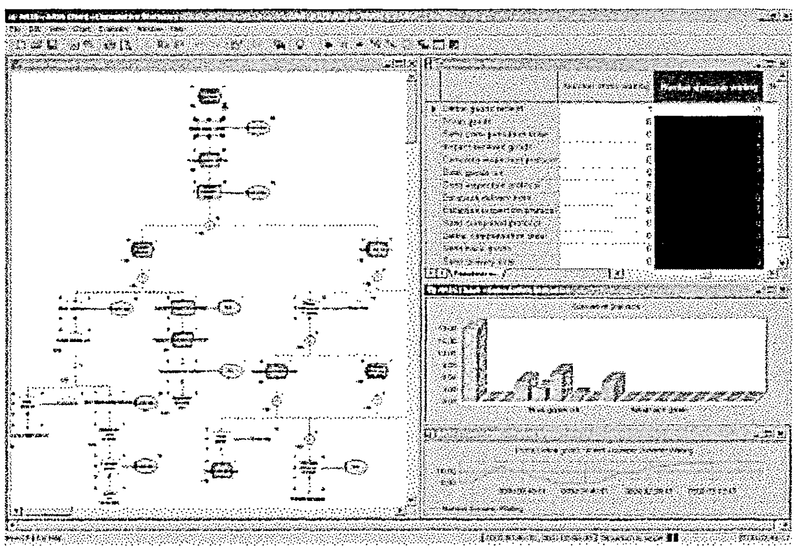
Process (Control) View – dynamic models that can show the behaviour of processes and how they relate to the resources, data and functions of the business environment. Includes Event-Driven Process Chains, information flow, materials flow, communications diagrams, product definitions, flow charts and value-added diagrams.

For organisations with widespread business the Web Publisher can communicate activity information throughout the organisation. Allowing the distribution of important developments quickly and globally, through either the Internet, or corporate Intranets. The Web Publisher provides multilingual capabilities, overcoming all language barriers, enabling international terms to co-operate with each other.

Simulation Capacity:
ARIS simulation is a dynamic analysis tool for business processes, and is fully integrated to the ARIS toolset, where data relating to the process can be used for simulation. The simulation will then provide information concerning the production of processes, process weak points and resource bottlenecks, based on the simulator key performance indicators. However from ARIS documentation it is apparent that their simulation tool is a component that is a preliminary step for ARIS Activity-based Costing. Where the frequencies determined in simulation projects are to be transferred to the ABC package to enable a precise cost-based evaluation of the simulated business processes.

ARIS simulation is based on the process models created by the ARIS method, whilst the control flow of the business process is documented in the process models. The process instantiation models describe how processes actually fit with one-anther. Within the simulation tool there is a capacity to simulate across multiple hierarchies and the ability to assign functions of one process to another process, thereby to detail a function. The behaviour of the simulation can be controlled using the attribute of the objects occurring in the model.

Within ARIS simulation there is four different animation methods, which are used to visualise simulation results. The four methods of animation include, object, attribute, statistic and probe. Object animation uses colour in the model to provide the user with an impression of the status of individual objects during a simulated activity. Therefore possibly identifying which processes are used within a business, where functions are over used or when resources have been activated. Attribute animation describes the status of an object within a model in greater detail. Statistic animation is cumulative statistics that are object type specific, providing one statistic for each function, event, personnel resources etc. The probe animation is a graphical device, which specific performance indicators of an object are displayed over a period of time. Simulation can provide statistical and cumulative data about different key information, which can be displayed directly in the ARIS toolset, or exported for further processing in, excel.



ARIS Animation (*IDS Scheer)*

Simulation projects can be controlled using ARIS through a multitude of options that can provide a realistic closed loop modelling approach. Its behaviour can be controlled by for example:

- The selection of models to be simulated (e.g. hierarchy depth in assigned processes, all models within shared resources etc.)
- Animation of objects in models
- Simulation times
- Setting of eM-Plant simulation engine.

Highlight of ARIS simulation (www.ids-scheer.com):

- Consideration of organisational charts
- Consideration of process hierarchies and object-model-assignments
- Flexible definition of process frequencies and distribution of process starts
- Interruption functions
- On-line statistics at run time
- Display of simulation results using charts and diagrams
- Simulation results can be saved in *.atf or *.xis format
- Integration of tables and diagrams in MS Office products

Integration Capacity:

ARIS products have the capability to integrate with the Internet and company Intranets, which allow the integration of Process Models/Documentation through the use of Java and HTML exports that are supported by a Web publisher. Providing easy-to-read formats, regardless of the complexity of the models. The package can also interface with data transfer from systems of all types, enabling Data Exchange with Microsoft Office products (e.g. Excel, Word, Access etc.). Individual Workface interfaces can be established via API, OLE, ASCII, XML etc.

Organisational Use:

When considering the organisational use by ARIS customers it is very difficult to asses the actual project details, the majority of companies publicised are German based and details of projects are generally unknown. This would possibly be due to the origins of IDS Scheer, the location of there company headquarters and the wishes of their customers to keep projects secret, to establish a competitive advantage on their competitors.

However through the assessment of IDS Scheer's strategic intent it is apparent that the company is focused upon becoming/maintaining a leading market position world-wide targeting a broad range of clients. It is evident that the company is consultancy based where the product requires continued support due to continues improvement. IDS Scheer's client base is impressive containing many large multinational organisations, which will provide future clients with a great deal of confidence. The company has very strong partnerships, which may also encourage future business, because they provide a healthy platform for future products with a variety of industry's and new products.

Industrial Sector	Company	Project
	ABB	
	Bayer	
Manufacturing	Daimler Chrysler	
	Deutsche Bahn	
Telecommunications	Deutsche Telecom	
Manufacturing	Goodyear	
Telecommunications	KPN Telecom	
	Luthansa	
Manufacturing	Nestle	
Manufacturing	Volkswagen	
	Tesion GmbH & KO.KG	
Telecommunications	Swiss Telecom	
Telecommunications	British Telecom (BT Wholesale	1. Assess present systems & processes to maximise efficiency & productivity, or whether restructuring was required. 2. Investigate structures across its businesses and develop new models, which could be thoroughly tested before implementation.

Appendix 2: Business Process Modelling Comparison:

The benchmarking study focused primarily on comparing five leading BPM packages, ultimately to find the most suitable modelling tool to integrate with ARENA simulation. Evaluation was achieved through Performance Benchmarking, which was based on product features that would suitably achieve the project objectives. Objectives were selected based on the project goals, guidance from leading professionals (internal and external to the University) and recent research papers (Cory, T. 1998).

To produce an effective and disciplined benchmarking study it was very important to produce clear focused objects. Therefore the studies aim was to identify the supporting technologies that enable integration with external packages, current simulation capabilities in comparison with a dedicated simulation tool and the organisational use of the BPM packages. The following headings were used to analyse each company within the study, the headings were used to focus software evaluation on particular product characteristics

- Company Overview
- Product Overview
- Operating and Support Environments
- Product Details
- Simulation Capacity
- Integration Capacity
- Organisational Use

Each product was tested independently through evaluation software, research papers, supplier and industrial visits to canvass opinion on the products within the study. Once a fair and detail study on each product was documented a scoring system was developed, which targeted the objectives of the study (Fig 31, the Benchmark Scoring Model).

The scoring system (Table 6) compared each solution based on the their *Product Structure*, *Integration Capability*, *Simulation Capacity* and *Customer Target Area*. *Product Structure* was scored based on the solutions capacity to provide a methodology that was comprehensive and supplied quantifiable data, which could be used within a Simulation model. Within this section of the scoring model, products were scored based on their methodological strength. From literature and past research into the subject, documentation suggests a strong Methodological-modelling tool is the most suitable for an integrated solution. Therefore Popkin and ARIS scored highly on this category, because they provided comprehensive approaches that are governed by a detailed method, which would be quantifiable when transferred to another software package. Both modelling tools were very close in this area and were given maximum points.

Integration Capacity was a very important issue, which was scored based on the software's capacity to transfer data in a variety of formats and through a technique that is comparable with the Simulation software, which receives the data. In this category each modelling tool provided integration facilities, which were influenced by their technical partners. Many of the companies had technical partners with Microsoft and specialist software companies such as SAP, which had a direct influence on the capacities on offer. MEGA scored poorly in this section of the scoring system, because the company provided a one-dimensional solution targeting exports to web sites and Microsoft Word. Pokin and ARIS scored highly in this category because they provided a broad spectrum of transfer methods that enable data export in a format that matched the destination software.

Simulation Capacity was benchmarked based on the capabilities of a dedicated simulation package, where its key competencies were outlined within a table (table 6) and the BPM tools were evaluated in comparison. Each category was equal to a point and the collective scores were used within the final score. This comparison was necessary to quantify the shortfall between the techniques and to identify the potential of the data contained within the model. From the evaluation it was apparent that the technologies contained equivalent features, which are characteristic of static models and as a result the scoring was similar.

The *Customer Target Area* was compared through analysis of the product customer focus, where higher points were allocated based on the product use, the business areas that they target and their future objectives. In this area ARIS was the clear leader, because they currently provide a broad range of solutions and in the future their aim is to provide industry specific solutions to a variety of industrial sectors.

Scoring Model:

The following scoring model defines the allocation of points within the benchmarking study and the comparison of software tools in table 6.

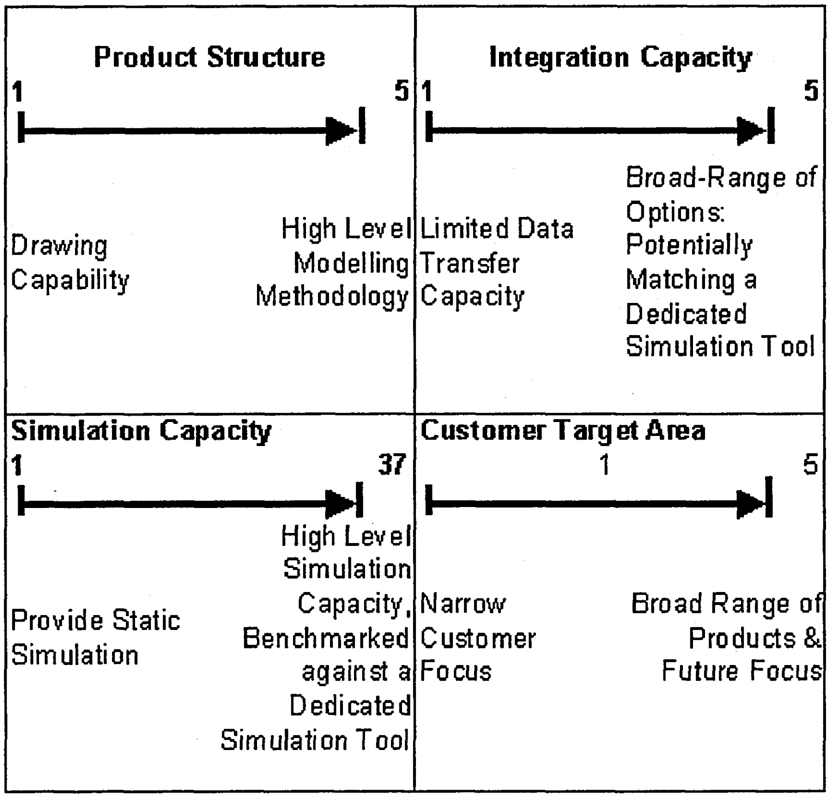


Fig 31: Benchmarking Scoring Model

Within the scoring model comparisons were made based on specific software characteristics, for example the Product Structure was ranked 1 – 5, where 1 represented a Drawing Capacity, 2 Mapping, 3 Modelling, 4 Structured and 5 a High Level Modelling Methodology.

Reliability of the Findings:

The benchmarking study was created to select the most suitable BPM tool for the objectives of the project. Research was comprehensive, testing evaluation software, vendor and industrial visits. However it is apparent that in such circumstances there are many variants that may influence the results. Evaluation software may not provide the full testing capacity to provide extensive testing within large-scale projects. Therefore there may be grey areas if data transfer is used in large complex projects. Interviewing industrial users was a very interesting process, but their choice of software package represented a focused perspective, which would have been chosen based on very different criteria and the opinion may have been one dimensional. Vendor visits provided a useful insight into the capabilities of the software investigated, but evaluation could be influenced by the professionalism and competency of the company to demonstrate their product.

Through analysis benchmarking is a very difficult process, which cannot be one hundred percent reliable, but because the authors objectives were clearly defined and a variety of sources were investigated, the study has achieved its objectives, without bias and in retrospect closely meets the findings of the Gartner Report. (www3.gartner.com).