Model Driven Architectures for Enterprise Information Systems

Judith Barrios, Selmin Nurcan *+

(x) *Universidad de Los Andes, Facultad de Ingeniería,*
Escuela de Ingeniería de Sistemas, Departamento de Computación,
Mérida, 5101, Venezuela

(*) *Université Paris 1 - Panthéon - Sorbonne*
Centre de Recherche en Informatique
90, rue de Tolbiac 75634 Paris cedex 13 France

(+) *IAE de Paris (Business School)*
Université Paris 1 - Panthéon - Sorbonne
21, rue Broca 75005 Paris France
Fax : 33 - 1 53 55 27 01
Email: ijudith@ula.ve ; nurcan@univ-paris1.fr

The correspondence should be sent to:

Selmin Nurcan
(+) *IAE de Paris (Business School)*
Université Paris 1 - Panthéon - Sorbonne
21, rue Broca 75005 Paris France
Fax : 33 - 1 53 55 27 01
nurcan@univ-paris1.fr

Keywords: Enterprise Information Systems, Model Driven Architectures, Business Models

Model Driven Architectures for Enterprise Information Systems

Keywords: *Enterprise Information Systems, Model Driven Architectures, Business Models, Organisational Change.*

Abstract: *Over the past decade, continuous challenges have been made to traditional business practices. Rapid market changes such as electronic commerce, deregulation, globalisation, and increased competition have led to a business environment that is constantly changing. At the same time, organisations have also experienced the effects of the integration and evolution of information and communication technology (ICT). Consequently, the Enterprise Information Systems (EIS) have a new strategic support role as enabler of automation, monitoring, analysis and co-ordination of whole business functioning, a central role in the evolution of today organisations. These rapid changing situations originate a critical need for realistic representations -called business models- of what are the current or future business situations or what should be changed as well as its potential organisational impacts. This paper characterises the strong relationship existing between Business Models and EIS Architectures in a changing environment. Our main contribution is a set of roadmaps, which highlight the relationships between business process models and the requirements of EIS. These roadmaps provide guidance during the business modelling and the information system modelling processes.*

1 INTRODUCTION

The last twenty years, the evolution of Information and Communication Technologies (ICT), along with the search for management strategies that could take advantage of them, are pushing organisations into a very competitive and changing environment. Rapid market changes such as electronic commerce, deregulation, globalisation and increased competition have led to a business environment that is constantly evolving. Companies change to better satisfy customer requirements, address increasingly tough competition, improve internal processes and modify the range of products and services they offer (Jacobson et al., 1994). At the same time, organisations also experience the effects of the integration and evolution of information technology. While information systems continue to serve traditional business needs such as co-ordination of production and enhancements of services offered, a new and important role has emerged for them. Specifically, such systems have the potential to adopting a supervisory or strategic support role. Information and Communication Technologies (ICT) are thus positioned as a strategic resource that enables automation, monitoring, analysis and co-ordination to support the transformation of business processes (Grover *et al.*, 1994).

In that sort of environment, only those organisations, which can react quickly to environment demands, are the ones that survive. Obviously, that capacity of quick reaction is due to their capacity of handling ICT in favour of organisations' adapting demands. Thus, ICT and management go hand by hand in the way of reacting, adapting and implanting new ways of doing business in today dynamic environments. Organisational transformation supported by ICT became a major issue for today managers. Information systems are thus not just supporting businesses; they are an integral part of them.

All these ICT and management changes have imposed serious challenges, which have been made to traditional business practices. For instance, in a competitive and evolving environment, quality became a fundamental key to obtain and to keep market share (Dumas and Charbonnel, 1990). The *Total Quality Management* (TQM) was defined as a management method, which aims towards long-range success. It is based on collective participation of each member in the improvement of processes, products, services and organisation of the company. Another important wave in the evolution of management strategies was the *Business Process Reengineering* (BPR) (Hammer and Champy, 1993), which consists of a radical remodelling of the organisation around its processes[1]. In all these management challenges, the ICT and the Enterprise Information Systems (EIS) are becoming a critical aspect of their reacting strategies. The IS should be continuously adapted to changing business practices and needs. The ICT act as facilitators of business changes implementation and standardisation. According to (Davenport and Short, 1990), the *new industrial engineering* has two statements: "*thinking about IT should be in terms of how it supports new or redesigned business processes; and business processes and process improvements should be considered in terms of the capabilities that IT can provide*".

[1] a set of activities which produces, from one or several inputs, an output valuable for the customer

In the field of Information Systems, the notion of *"Enterprise modelling"* refers to a collection of conceptual modelling techniques for describing different facets of the *organisational domain* including operational (information systems), organisational (business processes, actors, roles, flow of information etc), and teleological (purposes) considerations (Bubenko, 1994). Existing enterprise modelling frameworks (Dobson *et al.*, 1994), (van Lamsweerde *et al.*, 1995), (Yu and Mylopoulos, 1996), (Loucopoulos *et al.*, 1998), (Nurcan *et al.*, 1998), (Rolland *et al.*, 1998b), (Loucopoulos and Kavakli, 1995), (Bubenko et al., 2001) stress the necessity to represent and structure enterprise knowledge taking into account all these facets in order to develop information systems and IT architectures that enterprises need.

As worded in (Erikson and Penker, 2000), "*the owner of the business sets the goals and allocates resources to make the business run; the business modeller* –helped by the appropriate resource persons- *creates the structure, designs the business processes, and allocates resources in order to achieve the goals; and the system developer adapts, designs and develops appropriate information systems that support running of the business*". In order to take business through a well managed change process, the organisation needs to strike a balance between the technical and the social organisational levels; i.e. there must a consolidation of the diversity of perspectives and positions that stakeholders, managers, and IS engineers have about the

The work presented in this paper concerns principally with the third issue which expresses the need of methods providing guidance while the transformation process takes place. Nevertheless, it implicitly considers the two others issues. In this paper, we present an extension of the EKD-CMM[2] method previously presented in (Nurcan et al., 1999), (Loucopoulos et al., 1997), (Rolland et al., 1998b), (Bubenko and Stirna, 1997), (Rolland et al., 1999), (Nurcan and Rolland, 2003), and (Nurcan and Barrios, 2003). This extension provides a clear and complete picture of what are the main activities related with the definition of IS architectures in a dynamic and evolving environment. Considering that our approach is requirements driven, we describe the way of moving from business processes to EIS architecture and from ICT requirements to business process redesign.

This paper is organised as follows. In Section 2, we present the concepts associated to our representation of an enterprise model through the EKD-CMM method. We made special emphasis on the relationships between business processes and information systems. Section 3 presents in detail the set of concepts associated to the information systems architecture of an organisation. We highlight those elements that are more vulnerable to environment changes. This section presents also the modelling needs for those who define the IS architecture of an organisation. The guidance offering a methodological response to these needs are expressed by roadmaps that show a set of alternative ways of moving from business processes to information systems architecture. Section 4 illustrates an example of path for the specification of an information system model through the conceptualisation of the enterprise process model. Finally, section 5 concludes the paper.

2 BUSINESS MODELLING THROUGH EKD-CMM

As introduced before, the recent transformations in economical and ICT environments have imposed radical changes in the way business is driven nowadays. There is an increasing need for ICT support in achieving competitive business goals. Examples of this are the Enterprise Application Integration (EAI) approach, the Enterprise Resources Planning (ERP), and the e-Business (Canfora et al., 2003), among the most known.

Analysing these innovative approaches, we found that they are based on a common business driver: "the urgency of adapting business to the dynamical environment demands". This adaptation must be made by taking into account not only the internal processes and ICT exigencies, but considering the reasons that caused the change process. For example, if the change is caused by a modification in business goals because of a predefined surviving strategy, then the change problem must be analysed in a top-down manner. In this case, the ICT technologies must act as a support for the decision making process and also as a solution for implementing and consolidating change in the organisation. The

[2] The term EKD-CMM stands for Enterprise Knowledge Development-Change Management Method

perspective for analysing the change process is different if the origin of change is at the IS layer, i.e. if the change process is caused by the introduction or modification of some I&C technologies. Let us assume that a new ICT may improve the current way of working in the organisation. In that case, the change situation must be analysed in a bottom-up manner so the advantages for the whole business can be elicited. In this case, the ICT is a cause of the business change, thus its impacts must analysed from many perspectives. For instance, the Information Systems Architecture, as well as the way business processes are organised and executed, may change.

These two complementary examples of the ICT role in a business transformation process aim to help us to state that the relationships between business processes and information systems are the nucleus of a successful organisational change process. In other words, it does not matter what causes the change process. What it is relevant is how well the relationships between business functioning and ICT are characterised and implemented. This characterisation will allow business managers to visualise, analyse and implement business changes without neglecting the crucial effects that ICT have over business functioning and vice versa. Moreover, models facilitate understanding and communicating about the business and its support systems only if the objective of the model is well understood. For instance, if the objective is to understand the business well enough to specify supporting systems, it is not useful to model the entire business in detail. Contrary, if the aim is to innovate the business, it is necessary to provide more effort to define and/or redefine the entire business and to find improved ways of conducting it (Nurcan and Rolland, 2003), (Nurcan et al., 1999).

The purpose of the work presented in this paper is to characterise the relationships between business processes and IS architecture in an evolving environment.

2.1. A survey of EKD-CMM method

EKD-CMM is a method to documenting an enterprise, its objectives, business processes and support systems, helping enterprises to consciously develop schemes for implementing changes. EKD-CMM satisfies two requirements: (i) assisting enterprise knowledge modelling and (ii) guiding the enterprise modelling and the organisational transformation processes.

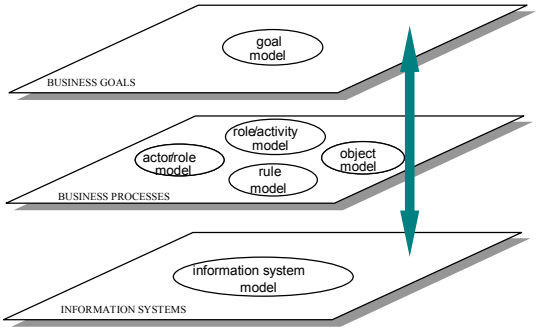

Figure 1. EKD-CMM enterprise representation layers

The EKD-CMM *enterprise knowledge modelling* component (Nurcan *et al.*, 1999), (Loucopoulos *et al.*, 1997), (Rolland *et al.*, 1998c), (Bubenko and Stirna, 1997), (Nurcan and Rolland, 2003) recognises that it is advantageous to examine an enterprise from multiple and inter-connected perspectives. Thus, EKD-CMM models describing an enterprise are structured in three layers of concern (see Figure 1): *Enterprise Goal Model*, *Enterprise Process Model* and *Enterprise Information System Model*. The first two layers focus on intentional and organisational aspects of the enterprise, i.e. the organisational objectives and how these are achieved through the co-operation of enterprise actors manipulating such enterprise objects. The third layer is useful when the EKD-CMM approach is applied to define the requirements for the information systems supporting the enterprise.

The result of applying EKD-CMM method is an *enterprise model*, which represents a set of operational (information systems), organisational (business processes) and intentional (business objectives) models describing several views of the organisation.

From the point of view of method engineering, an enterprise model is a product (Odell, 1996), (Brinkemper, 1996). In fact, the product is the desired output of the design process, whereas the process keeps track of how the product has been constructed in a descriptive manner. A *Product Model* defines the set of concepts and their relationships that can be used to build a product, i.e., in our case, to build a model representing a given enterprise. The *Process Model* defines how to use the concepts defined within a Product Model. A *Process Model* and its related *Product Model* [3] are specific to a *method*. The EKD-CMM Product and Process models, according to method engineering principles, have been previously presented in (Barrios, 2001), (Nurcan *et al.*, 2002), (Barrios and Nurcan, 2002), (Nurcan and Rolland, 2003) and (Nurcan and Barrios, 2003).

The intention oriented modelling used in EKD-CMM provides a basis for understanding and supporting the enterprise modelling, and the managing the organisational changes. At the same time, it helps to define the supporting information systems. Process guidance provided by EKD-CMM is based on the map formalism (Rolland *et al.*, 1999c), which is a navigational structure in the sense that it allows the modellers to specify paths from *Start* intention to *Stop* intention. The approach suggests a dynamic construction of the most appropriate path by navigating in the map. Thus, EKD-CMM proposes several ways of working, and in this sense, it is a multi-method. In fact, using the EKD-CMM framework, one can start at any enterprise representation layer and move on to other layers, depending on the modelling and organisational situations.

The method may be used for both business engineering and information systems engineering purposes, permitting:

(a) *Business process reengineering*: from business processes layer to the business objectives for change (Rolland *et al.*, 1998b), (Nurcan *et al.*, 1999), (Nurcan and Rolland, 1999), (Rolland *et al.*, 1999b) and then to the business process architecture for the future;

(b) *Reverse engineering*: from legacy information systems at the information system layer to model the business processes layer (Kavakli and Loucopoulos, 1998), (Kardasis and Loucopoulos, 1998) ;

(c) *Forward engineering* or *information system design*: from business objectives to business process modelling and to the choice of the processes to be supported by the information and communication technologies (ICT) and than to the IS modelling (Nurcan and Barrios, 2003);

(d) *Business process improvement*: by modelling and analysing the business processes in order to enhance them by specific modifications such as role definition or activity flow;

(e) *Quality management*: by defining the business processes and quality procedures and by aligning them, ones with respect to others.

The EKD-CMM three layers framework and the associated Process Model allow us to understand, to analyse and finally to model the enterprise according to its multiple perspectives or views, i.e. its strategy, its structure and its IT strategy and support systems, in a global, interrelated and guided manner.

During our previous work, we were particularly interested in the definition and modelling of the organisational change processes. To this end, we focused our attention on business processes to understand the current way of working of the enterprise (second layer in Figure 1) and reasoned on the organisational change at the intentional level (Nurcan *et al.*, 1999), (Nurcan and Rolland, 1999), (Rolland *et al.*, 1999b). The EKD–CMM approach has been thus successfully applied in an ESPRIT Project (ELEKTRA) aiming to discover generic knowledge about change management in the electricity supply sector for reusing it in similar settings. Two end-user applications have been considered within the project. The common theme underpinning their requirements was their need to deal with change in a controlled way, which would lead to an evaluation of alternative options of possible means to meet the objectives for change.

[3] We use capitalised initials in order to differentiate the method specific Models from the application specific models (for instance a business model) that compose the product.

Our current work focus on the two lower layers shown in Figure 1, namely business processes and information systems in order to highlight the relationships between the enterprise process models and the specifications of the ICT systems.

2.2. EKD-CMM Product Models

A business model can act as the basis for modelling and designing the supporting software systems in an enterprise. Typically, business modelling and software modelling use different languages and concepts making integration of the two models difficult (Erikson and Penker, 2000). The set EKD-CMM Product Models aims to ease this integration by providing methodological tools to use a *business model* (enterprise goal model and enterprise process models) to define the supporting information systems' architecture.

From the EKD-CMM perspective and experience, an important conclusion about *business models* use, is that it has a twofold goal: first, a model helps organisational members to understand what they are, what they want to be as an organisation, and how they can achieve an identified set of business goals by reorganising or (re)defining the business processes. Second, a model aims to design the information systems architecture that best fits organisational needs already expressed by the business goals and their corresponding business processes.

The instantiation of the Product Model's concepts allows business modellers to build specific *business models*, which represent particular business situations. Let us suppose that the future business has been modelled from different perspectives (see (Nurcan and Rolland, 2003) and (Nurcan *et al.*, 2002) for details), i.e. by modelling the business goals, the actors that are responsible for the execution of the underlying business processes and the set of activities that are under the responsibility of those actors, as well as the resources involved in the execution of those activities. The resulting *business models* are instances of the Goal Model, the Actor/Role Model, the Role/Activity Model and the Business Object Model with their relationships as depicted in Figures 1 and 2.

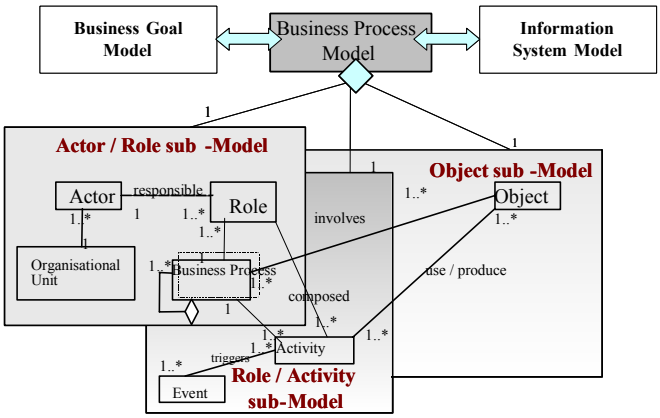

Figure 2. The Integrated Business Process Model

2.3. EKD-CMM Process Model

A map (Rolland *et al.*, 1999c) is a Process Model in which a non-deterministic ordering of intentions and strategies has been included. It is a labelled directed graph with intentions as nodes and strategies as edges between intentions. A map consists of a number of *sections* each of which is a triplet < source intention I_i, target intention I_j, strategy S_{ij}>. The map is a navigational structure that supports the dynamic selection of the intention to be achieved next and the appropriate strategy to achieve it whereas the associated guidelines help in the achievement of the selected intention.

The EKD-CMM high-level map, shown in Figure 3, contains a finite number of paths; each of them is a *EKD-CMM Process Model*. Therefore the EKD-CMM map is a *multi-model*. None of the finite set of models included in the map is recommended 'a priori'. Instead the approach suggests a dynamic construction of the actual path by navigating in the map. In this sense the approach is sensitive to the specific situations as they arise in the modelling process. The EKD-CMM multi-model allows us to

express all modelling strategies that can be followed to build an enterprise model (a business model and an information system model). The formalisation used to define the EKD-CMM Process Model is intention oriented, i.e. the business owners', the business modellers' and the systems developers' modelling intentions are directly expressed by maps. This is carefully described in (Barrios, 2001) and (Nurcan *et al.*, 2002).

The EKD-CMM Process Model is shown in Figure 3 as a roadmap. Guidelines help users to choose between two alternative sections between a source process intention and a target process intention (strategy selection guidelines) or to choose between possible target intentions when moving from a source intention (intention selection guidelines). This will be described in Section 4. The execution of each map section is also *supported by* a guideline.

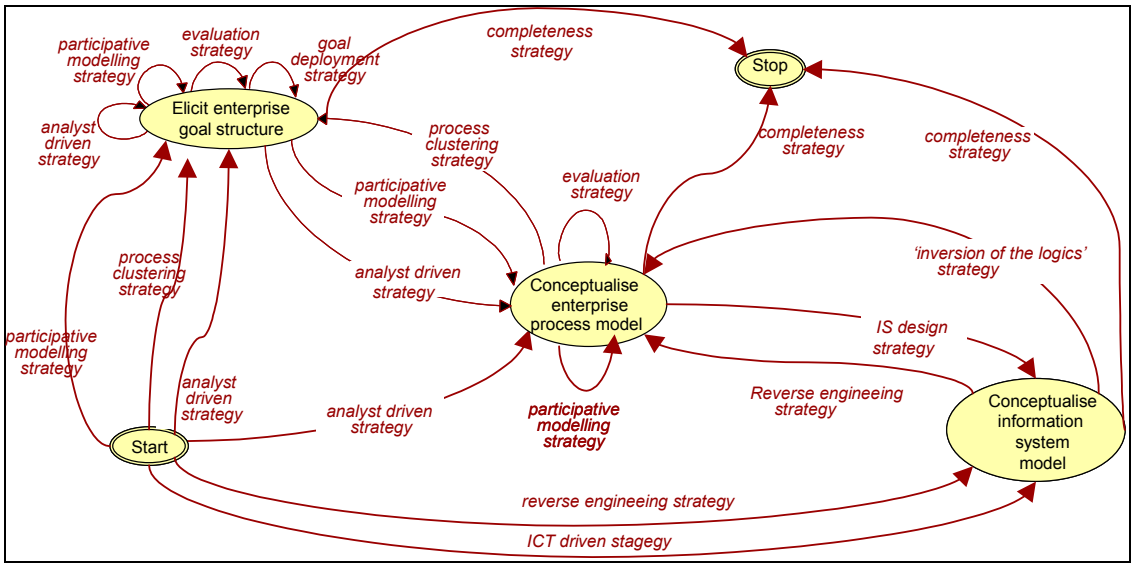

Figure 3. EKD-CMM Roadmap

Some map sections can be defined as maps in a lower level of abstraction. For instance, the global map section <*Start, Conceptualise enterprise process model*, Analyst Driven Strategy> is defined as a local map shown in Figure 4. This means that the method knowledge embodied in the guideline supporting the execution of this map section is too complex and too rich to be described in operational terms and requires an intermediary intentional description in a lower level of abstraction.

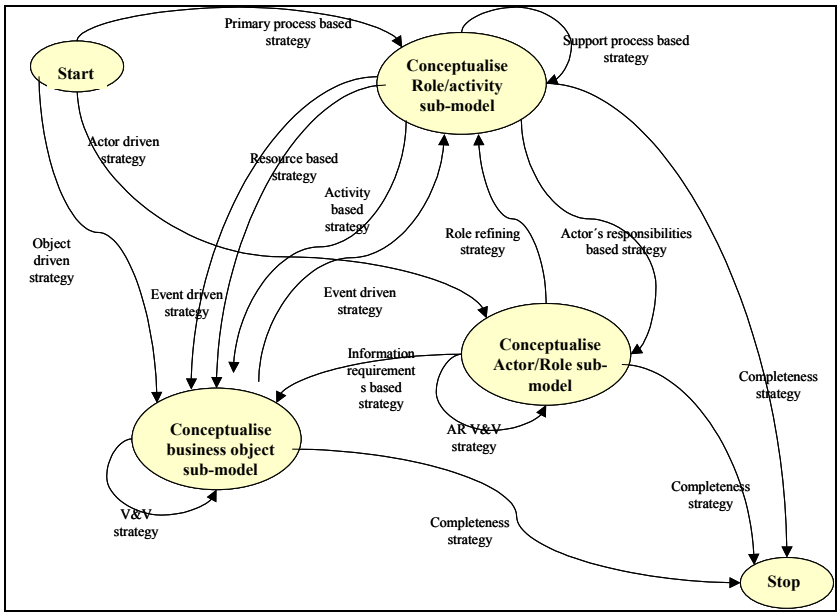

Figure 4. Roadmap for conceptualising a *business process model* from scratch

All guidelines corresponding to the sections between the process intentions *Elicit Enterprise Goal Structure* and *Conceptualise Enterprise Business Process Model* have been developed in (Nurcan and Rolland, 2003) and (Barrios, 2001). Our current work consists in identifying and developing the methodological guidelines associated to the map sections having the process intention *Conceptualise Information System Model* as source or as target. For instance, Figure 5 shows the local map defined to provide guidance to the global map section (see Figure 3) <*Conceptualise Enterprise Business Process Model, Conceptualise Information System Model,* IS design strategy>.

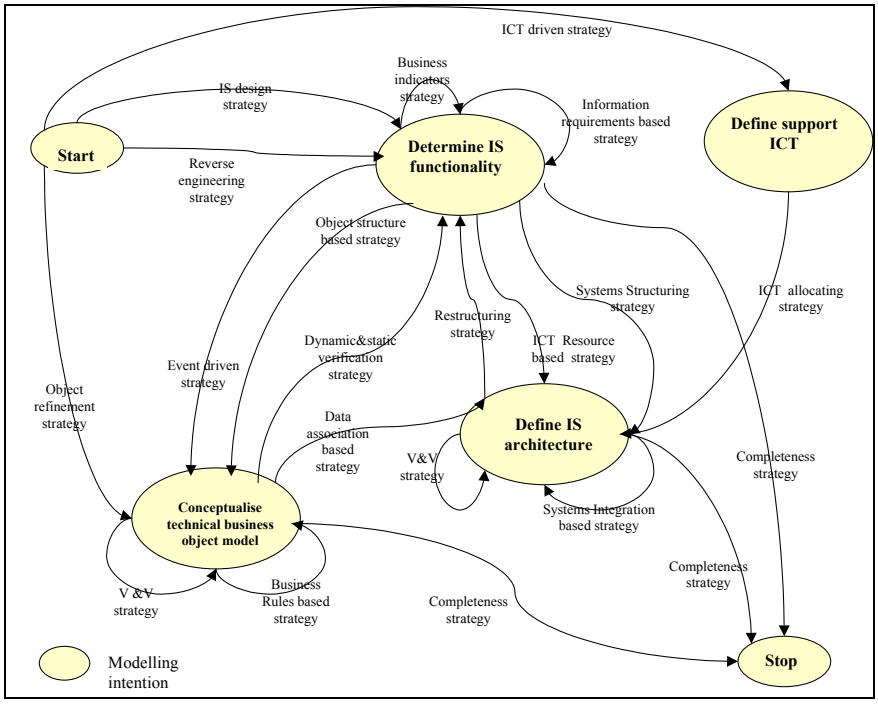

Figure 5. Roadmap for conceptualising IS model after the BP model being conceptualised

The next sections concentrate in developing guidance (using local maps) for passing from the Business Process layer to the Information Systems layer.

3 THE INFORMATION SYSTEMS ARCHITECTURE (ISA)

The Information System Model contains not only the representation of the set of information systems (IS), but also the definition of the local and shared databases, as well as the information requirements and management indicators that should be satisfied by the different applications or IS.

As we explained before, the main goal of the information system architecture (ISA) is to support business processes at the operational and strategic levels. The definition of *information requirements* and *management performance indicators* is directly associated to business processes through the *Business Objects Model* (BOM) shown in Figure 2.

As stated in (Papazouglou and van den Heuvel, 2000) business objects do not only provide a natural way to model the enterprise, but also guarantee a close link to the business applications. Considering that the BOM constitutes the central link between the business processes and the information systems that support them, special implementation requirements must be considered when designing and distributing the enterprise databases and the software components that handle them.

In order to complete the *business objects model* of the Business Process layer (BOM), the *business rules* must be linked to the *business objects model* built at the IS layer. We call this model the *technical business objects model* (TBOM). Business rules are useful for defining (i) the set of operations that should be performed over the business objects for satisfying information requirements; (ii) the conditions under which these operations should be performed. Business rules set up also what business objects attributes may change, and what are their domains of validity, when operations are performed.

Finally they can set the non-functional requirements (security, accuracy, etc). Consequently, the TBOM constitutes the heart of the Information System Architecture (ISA).

An ISA comprises the set of enterprise information systems, the connections and dependencies between them, and the Information and Communication Technology (ICT) required for their implementation. ICT includes hardware (PC, servers, nets, and storage, input/output devises, etc.), software (exploitation, support, development, and applications) and finally, methodological (project management, development, change control, maintenance, etc.) and technical (languages, modelling tools, etc.) artefacts. Considering the evolving environment where enterprises are immersed nowadays, the ISA may include all or part of these types of information systems: legacy systems, enterprise resource planning applications (ERP), and new specific developments. The data distribution and exploitation is directly associated to each IS functionality.

For completing the set of concepts associated to the enterprise IS layer, we include a set of strategic and operational plans which define what, when and how developing, maintaining, integrating, or purchasing the different systems contained in the IS architecture.

3.1. Technical business objects in the Information Systems layer

At the Information Systems layer of the EKD-CMM framework, the technical business objects model (TBOM) is defined as a refinement of the (preliminary) business object model (BOM), which is a sub-model of the Business Process layer (see Figures 1 and 2). This preliminary model must be refined and expressed according to the adopted software engineering techniques. Therefore, we determine two complementary ways or perspectives for defining the set of business objects of an enterprise. Each perspective is associated with an enterprise representation layer: (1) the preliminary business object model (BOM), built at the business process layer (BP), and (2) the technical business object model (TBOM) built at the information systems layer (IS).

Processes inputs and outputs, as well as business resources involved in actor's activities drive the business process perspective. Figure 6 shows the process map associated to the BOM definition at this layer. This local map provides guidance for the map section <*Start*, *Conceptualise business objects sub-model*, Object driven strategy> shown in Figure 4.

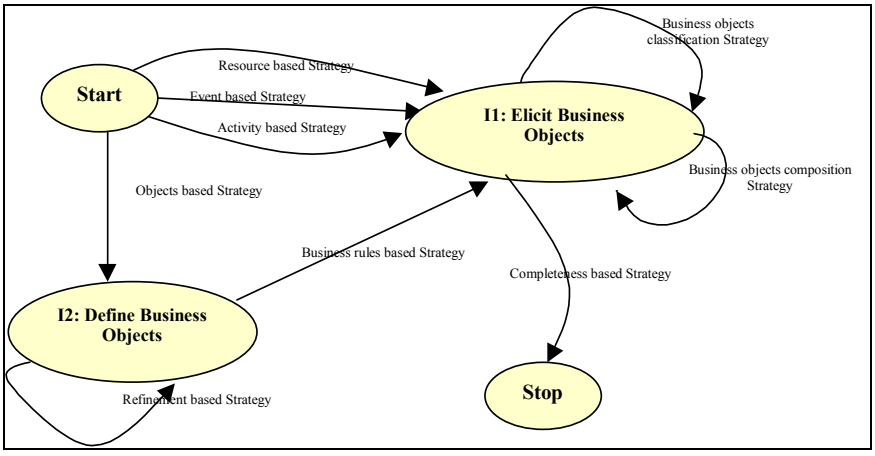

Figure 6. Conceptualising BOM using the object driven strategy at the BP layer

Observe that there are many ways of defining business objects involved in business process executions. There are two main intentions that can be achieved in a non-deterministic manner: *Define business objects* and *Elicit business objects*. Each intention has a set of achieving strategies that may be chosen according to specific modelling situations. For instance, there are three different ways of "eliciting business objects", the *resource based* strategy; the *input/output* strategy, and the *activity-based* strategy. Selecting the *activity based strategy* means that the business objects will be discovered by analysing low-level activities from each one of the business processes. Notice that, the selection of one of these strategies for achieving the *elicit business objects* intention does not eliminate the possibility of selecting the others (two strategies) for completing the knowledge associated to the business objects

already elicited. The BOM at the business process layer, is expressed in conceptual terms without technical considerations, thus managers and others enterprise members can easily understand it.

The IS perspective is technology driven; i.e. technical factors such as formal languages, and graphical notations controls the modelling process. Figure 7 shows the process map associated to technical business objects modelling at the Information Systems layer. This local map provides guidance for the map section <*Start*, *Conceptualise technical business objects model*, Object refinement strategy> shown in Figure 5. Observe that the intentions associated to TBOM construction are different from those depicted at Figure 6. The BOM obtained at the BP layer is here refined with respect to the software engineering and database concepts and techniques for obtaining first, the logical data model expressed according to the object oriented paradigm; and then, the object implementation model.

In order to assure the complete correspondence between the resulting data model and the business information requirements and rules, the data model must be validated against the business process model built at the BP layer. Thus, the possible inconsistencies on business object representations can be corrected assuring the correspondence between the two business object models.

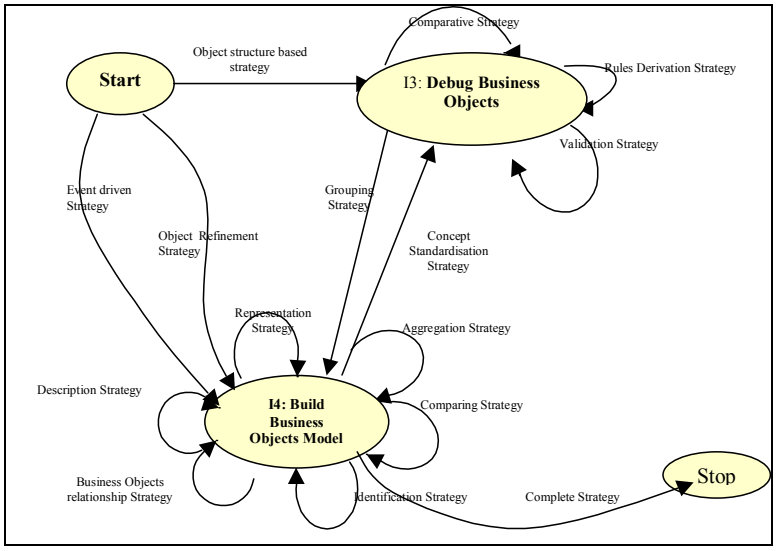

Figure 7. Conceptualising TBOM using the object refinement strategy at the IS layer

3.2. The ISA and the BP needs

It is not an easy activity to discover what is the information systems architecture, which is appropriate for a particular enterprise. There are many factors that must be considered while specifying business objects, information requirements, and business processes and activities. The way an activity or a set of activities (a business process) is performed, determines if one or several information systems are needed. This determines also if the business objects should be shared or not, and security, quality, access and visualisation restrictions that must be included in the IS functionalities.

Therefore, the relationship between the IS layer and the BP layer goes further than the simple business objects model definition (BOM and TBOM). The way a set of IS is structured, the definition and distribution of IS responsibilities, is a consequence of the way that business processes are performed. Besides, there are many other enterprise factors such as priorities, financial and technical issues, etc., that affect the decision of implanting a particular IS structure or another.

3.3. The BP and the IS issues more vulnerable to changes

In the context of the work still done, we just considered the technical factors associated to the technologies needed for business process execution and for supporting the exchange of information between business processes. Besides, we should consider the strategic perspective of an enterprise that wish to survive in an evolving environment, and then its requirement for a flexible ISA which must be

supported by adaptable and flexible ICT. That way, the changes can be analysed, defined and implanted easily and with minimal business and ICT impact.

From this perspective, the definition of the ISA for a business is based on:

- Business processes execution dependencies, such as inputs/outputs, support, and workflow coordination.
- Business objects owners and users, thus the set of permitted manipulations can be elicited and imposed.
- Legacy and acquired systems and their integration through an Enterprise Application (EAI) perspective.
- The kind of technology required for the execution of business processes, as well as the standardisation of some related procedures.
- The ICT available and required (restricted according to business financial possibilities) in the enterprise.

Almost all of these subjects concern with BP layer characterisation. Nevertheless, the responsibility of implementing an appropriate and flexible support for them belongs to the IS layer.

At the IS layer, the elements more vulnerable to changes are:

- Business objects definition (operations, structure, dependence degree, and owner).
- IS functionality (requirements, dependence degree, and support technology)
- ICT use (obsolescence, flexibility, versions, availability, security, growth capacity)
- IS implantation (purchase, ERP, integration, performance improvement).

At the BP layer, the elements more vulnerable to changes are:

- Process change (reengineering- new way of working, TQM)
- Standardisation requirements (business processes, procedures, methodologies, forms)
- Work technology (basic, new, improved)
- Business structure (new, restructured)
- Organisation (actors, roles, workflow).

For concluding this section, it is important to recall that any of these changes affects the two other enterprise representation layers (Figure 1) or it may comes from one of them. For instance, a reengineering process may be the consequence of a change in the organisational politics (goals layer). In that case, this change causes a redefinition of a set of business processes, and also a redefinition of the IS that support them.

4 HOW TO USE THE PROCESS MAPS

This section illustrates an example of path for the specification of an *information system model* through the conceptualisation of the *enterprise process model*. Our purpose is to explain how to use the process maps as methodological guidelines. In fact, those maps assist business owners, business modellers and IS modellers while specifying *business models* and *IS models*. The experience gained during our previous work shown that, during a particular enterprise modelling process, paths to be followed in the EKD-CMM global map, as well as in the local maps in their various levels of refinements, are situation-dependent. For instance, the selection of the bottom-up[4] path for one of the two end-users in the ELEKTRA project was influenced by the uncertainty regarding both the current Electricity Distribution Business Unit situation and its possible re-organisation alternatives.

[4] so called because this path suggests first to conceptualise the current enterprise process model, then to elicit the current enterprise goal structure

Enterprise modelling using EKD-CMM is an intention driven process that resolves repeatedly two issues, namely, (1) how to fulfil the modelling intention according to a strategy and (2) how to select the right map section to progress. Because the next intention and strategy to achieve it are selected dynamically, *guidelines* that make available all choices open to handle a given situation are of great importance. Maps have associated guidelines, namely one *'Intention Selection Guideline'* per node I_i, except for *Stop*, one *'Strategy Selection Guideline'* per node pair $<I_i,I_j>$ and one *'Intention Achievement Guideline'* per section $<I_i,I_j, S_{ij}>$. In (Rolland *et al.*, 1999c) they are referred as IAG, ISG and SSG respectively. Given an intention I_i, an *Intention Selection Guideline* (ISG), identifies the set of intentions $\{I_j\}$ that can be achieved in the next step. Given two intentions I_i, I_j and a set of possible strategies S_{ij1}, S_{ij2}, ..S_{ijn} applicable to achieve I_j, the role of the *Strategy Selection Guideline (SSG)* is to guide the selection of one S_{ijk}. Finally, the execution of each map section is *supported by* an IAG that provides an operational or an intentional means to fulfil a modelling intention. For the former, the IAG provides process knowledge specified by the means of operational models. For the latter, the IAG is defined as a map in a lower level of abstraction.

All ISGs and SSGs and also the IAGs providing a methodological knowledge described in an operational level are specified according to the contextual formalism developed within the ESPRIT project NATURE (Rolland *et al*, 1995). We just recall here that a *context* is defined as a pair <(*situation*), intention>. The kind of EKD-CMM guidelines specified above are organised into hierarchies of contexts of three types, namely *choice* (refinement of contexts), *plan* (composition of contexts) or *executable*. For more details about EKD-CMM guidelines, see (Nurcan et al., 1999), (Barrios, 2001) and (Nurcan et al., 2002).

Let us suppose now that we are performing an enterprise modelling process in the following situation: the organisational maturity of modelling and the participative involvement are low and there is no available documentation of the business process models. The ISG associated to the intention *Start* in the EKD-CMM map shown in Figure 3 suggests us to choice *Conceptualise enterprise process model* as next intention and to apply the IAG associated to the unique map section between these two intentions. This IAG is defined as a map, shown in Figure 4, in a lower level of abstraction.

The ISG associated to the intention *Start* in the EKD-CMM local map shown in Figure 4 provides us a choice between three intentions. Let us suppose that the modelling team has a great experience with object modelling -and less with activity modelling- and a partial documentation of the legacy systems is available. Than the ISG associated to the intention *Start* suggests us to choice *Conceptualise business objects sub-model* as next intention and to apply the IAG associated to the unique map section between these two intentions. This IAG is again defined as a map shown in Figure 6.

Let us suppose that the modelling team has a great experience with event-based object modelling techniques, for instance Remora. The ISG associated to the intention *Start* in the EKD-CMM local map of Figure 6 suggests then to choice *Elicit business objects* as next intention, and the SSG associated to the couple <*Start, Elicit business objects*> suggests to select the *Event based strategy* and to apply the IAG associated the section supporting this strategy. To make short, let us suppose that navigation is terminated in the map of Figure 6 and the other sub-models of the BP layer are specified successively leading thus to end the navigation in the map of Figure 4. The specification of the *business process model* being completed, the global map of Figure 3 suggests us to *Conceptualise information system model* using *IS design strategy*. The IAG associated to this map section is again defined intentionally as shown in Figure 5. The map section <*Start, Conceptualise technical business objects model*, Object refinements strategy> is, in its turn, defined intentionally as shown in Figure 7. When the navigation is terminated in the map of Figure 7, modellers go back on the upper intentional level to navigate in the map of Figure 5, and finally in the map of Figure 3.

5 CONCLUSIONS AND FUTURE WORK

This paper reports on the use of an intentional framework for modelling enterprise knowledge using *business models* and *IS models*. A major advantage of the proposed approach is the systematic way of dealing with enterprise modelling and organisational transformation in terms of *knowledge modelling* used with a *process guidance* framework. The experience gained during our previous work has

substantiated the view that paths of the EKD-CMM maps to be followed in a particular enterprise modelling project is very much dependent on the enactment context of the enterprise project and a number of situational factors including degree of formal hierarchy (few vs. many formal levels), decision structure (authoritative vs. management by objectives), company culture (collectivistic vs. individualistic), degree of distance of power (short vs. long), type of market (deregulated vs. regulated), etc. Thus, the *EKD-CMM framework* provides a systematic, nevertheless flexible, way to organise and to guide the enterprise modelling processes.

The EKD-CMM modelling framework characterises an enterprise from interrelated perspectives using a three layers model. It integrates enterprise objectives, processes and systems in a single modelling framework. The more relevant feature of our framework is that it makes explicit the link between these three modelling layers. The way the three layers model has been structured assures that business processes are at the origin of the technical business objects as well as the definitions of information requirements and management performance indicators. In consequence, they will be taken into account for the design and distribution of the software components.

The EKD-CMM requires the domain knowledge to fully understand the organisation from its multiple perspectives. Rather than trying to gain huge amounts of knowledge, a better solution seems to involve several key persons of the enterprise in the modelling process. These persons will provide organisational knowledge or will know where it may be found. Simultaneously they will become an important resource by gaining knowledge of EKD-CMM, which will be useful if the organisation desires to continue work with enterprise analysis and modelling.

Our framework contributes to define accurate and precise decision making processes inside modern organisations, which are highly dependent of ICT. It reinforces also the ability of companies, which apply it to adopt a policy of knowledge management.

Our future work will consist to integrate in the EKD-CMM modelling framework, the ability to handle the issues listed in Section 3.3.

References

Barrios, J. (2001) Une méthode pour la définition de l'impact organisationnel du changement. *Thèse de Doctorat de l'Université de Paris 1*.

Barrios, J. and Nurcan, S. (2002) MeDIC: A Method Engineering Proposal for the Analysis and Representation of the Organisational Impact of Change. The 2002 International Conference on Software Engineering Research and Practice, SERP'02 - June 24-27, Las Vegas, USA.

Brinkemper, J. (1996) Method Engineering: Engineering of Information Systems, Methods and Tools. *Information and Software Technology*, 38, 275-280.

Bubenko, J. (1994) Enterprise Modelling. *Ingénierie des Systems d' Information*, Vol. 2, N° 6.

Bubenko J.A., jr., Persson, A. and Stirna, J. (2001) http://www.dsv.su.se/~js/ekd_user_guide.html

Bubenko, J., and Stirna, J. (1997). EKD User Guide. ELEKTRA project, Research report, February 1997.

Canfora, G., Rollo, F., and Venturi, G. (2003). Business Change in Systems Integration. Proceedings of the International Conference on Enterprise Information systems. ICEIS 2003. April 2003. Angers, France.

Davenport, T.H. and Short, J.E. (1990)The new industrial engineering: Information technology and business process redesign, *Sloan Management Review* 34(4) (1990) 1-27.

Dobson, J.S., Blyth, A.J.C., Chudge, J. and Strens, R. (1994) The ORDIT Approach to Organisational Requirements, *in 'Requirements Engineering: Social and Technical Issues'*, Academic Press, London, 87-106.

Dumas P. and Charbonnel G. (1990). *La méthode OSSAD-Pour maîtriser les technologies de l'information - Tome 1:Principes.* Les Editions d'Organisation, Paris.

Eriksson, H.-E. and Penker, M. (2000), *Business modeling with UML- Business patterns at work*, J. Wiley.

Grover, V., Fiedler, K.D. and Teng, J.T.C. (1994). Exploring the success of information technology enabled business process reengineering. *IEEE Transactions on Engineering Management*, 41:3 (August), 276-283.

Hammer M. and Champy J. (1993) *Reengineering the Corporation: a Manifesto for Business Revolution,* Harper Collins Publishers, Inc., New York.

Jacobson I., Ericsson M. and Jacobson A. (1994) *The object advantage - Business Process Reengineering with object technology*, Addison-Wesley.

Kardasis, P. and Loucopoulos, P. (1998) Aligning Legacy Information Systems to Business Processes. 10th Int. Conf. on Advanced Information Systems Engineering (CAiSE'98), B. Pernici (ed.), Springer-Verlag, Pisa, Italy, 25-39.

Kavakli, V. and Loucopoulos, P. (1998) Goal-Driven Business Process Analysis: Application in Electricity Deregulation. 10th Int. Conf. on Advanced Information Systems Engineering, B. Pernici (ed.), Springer-Verlag, Pisa, Italy, 305-324.

Loucopoulos, P., and Kavakli, V. (1995) Enterprise modeling and teleological approach to requirements engineering. *International Journal of Intelligent and Cooperative Information Systems*, Vol. 4, N° 1, 44-79.

Loucopoulos, P., Kavakli, V., Prekas, N., Rolland, C., Grosz, G. and Nurcan, S. Using the EKD approach: the modeling component. *ELEKTRA project*, Athena Deliverable (March 1997).

Loucopoulos, P., Kavakli, V., Prekas, N., Dimitromanolaki, I. Yilmazturk, N., Rolland, C., Grosz, G., Nurcan, S., Beis, D., and Vgontzas, G. (1998) The ELEKTRA project: Enterprise Knowledge Modeling for change in the distribution unit of Public Power Corporation. 2nd IMACS International Conference on Circuits, Systems and Computers (IMACS-CSC'98), Athens, Greece, 352-357.

Nurcan, S., Grosz, G. and Souveyet, C. (1998) Describing business processes with a guided use case approach. 10th International Conference on Advanced Information Systems Engineering (CAiSE'98), B. Pernici (ed.), Springer-Verlag, Pisa, Italy, 339-361.

Nurcan, S. and Rolland. C. (1999) Using EKD-CMM electronic guide book for managing change in organisations. 9th European-Japanese Conference on Information Modelling and Knowledge Bases, ECIS'99, Iwate, Japan, May 24-28, 105-123.

Nurcan, S., Barrios, J., Grosz, G. and Rolland, C. (1999) Change process modelling using the EKD - Change Management Method. 7th European Conference on Information Systems, ECIS'99, Copenhagen, Denmark, June 23-25, 513-529.

Nurcan, S., Barrios, J. and Rolland, C. (2002) Une méthode pour la définition de l'impact organisationnel du changement. *Numéro Spécial de la Revue Ingénierie des Systèmes d'Information "Connaissances Métier dans l'Ingénierie des SI*, 7:4, Hermès.

Nurcan, S. and Rolland, C. (2003). A multi-method for defining the organisational change. *Journal of Information and Software Technology*, Elsevier. 45:2, 61-82.

Nurcan, S. and Barrios, J. (2003). Enterprise Knowledge and Information System Modelling in an Evolving Environment. The EMSISE workshop in the OOIS Conference, Geneva, Switzerland, September 2003.

Odell, J. (1996) A primer to Method Engineering. *INFOSYS. The Electronic Newsletter for Information Systems.* 3:19, Massey University, New Zealand.

Papazoglou, M.P., van den Heuvel W.-J. (2000) Configurable business objects for building evolving enterprise models and applications, in *Business Process Management – Models Techniques and Empirical Studies*, Springer, 2000.

Rolland, C., Souveyet, C., Moreno, M. (1995) An approach for defining ways-of-working, *Information System Journal* 20(4), pp. 337-359.

Rolland, C., Loucopoulos, P., Grosz and G., Nurcan, S. (1998b) A framework for generic patterns dedicated to the management of change in the electricity supply industry. 9th International DEXA Conference and Workshop on Database and Expert Systems Applications (August 24-28), 907-911.

Rolland, C., Grosz, G., Nurcan, S., Yue, W. and Gnaho, C. (1998c) An electronic handbook for accessing domain specific generic patterns, *IFIP WG 8.1 Working Conference: Information Systems in the WWW environment*, July 15-17, Beijing, Chine, 89-111.

Rolland, C., Nurcan, S. and Grosz, G. (1999) Enterprise knowledge development: the process view. *Information and Management*, 36:3, September 1999.

Rolland, C., Loucopoulos, P., Kavakli, V. and Nurcan S. (1999b) Intention based modelling of organisational change: an experience report. Fourth CAISE/IFIP 8.1 International Workshop on Evaluation of Modeling Methods in Systems Analysis and Design (EMMSAD'99), Heidelberg, Germany, June 14-15.

Rolland, C., Prakash, N. and Benjamen A. (1999c) A Multi-Model View of Process Modelling, *Requirements Engineering Journal*, 4:4, 169-187.

Van Lamsweerde, A., Darimont, R. and Massonet, P. (1995) Goal-Directed Elaboration of Requirements for a Meeting Scheduler: Problems and Lessons Learnt, RE'95, IEEE Computer Society Press, 194-203.

Yu, E.S.K. and Mylopoulos, J. (1996) Using Goals, Rules and Methods to Support Reasoning in Business Process Reengineering, *Intelligent Systems in Accounting, Finance and Management*, Vol. 5, 1-13.