2. Standards in Enterprise Inter- and Intra-Organisational Integration

Kurt Kosanke
CIMOSA Association
kosanke@t-online.de

World-wide collaboration and co-operation of enterprises of all sizes increases the need for standards supporting operational interoperability in the global environment. Such standards are concerned with the communication aspects of information and communication technology (ICT), like communication protocols as well as the syntax and semantics of the communication content. Communicating parties have to have the same understanding of the meaning of the exchanged information and trust both the communication itself and the validity of its content. Focus of the paper is on business process modelling and its standardisation in the area of enterprise inter- and intra-organisational integration. Relations to the subject of interoperability are discussed.

Keywords: business process modelling, enterprise integration, enterprise engineering, standardisation.

1. INTRODUCTION

Business in today's global environment requires the exchange of physical products and parts and even more importantly the exchange of the related business information between co-operating organisations. The latter is true for such an operation itself, but to an even larger extent for the decision making processes during the establishment of the cooperating enterprise with market opportunity exploration and co-operation planning and implementation. The need for a knowledge base to be used for organisational interoperation and decision support on all levels of the enterprise operation is recognised as an urgent need in both business and academia (Kosanke *et al* 2002).

Building and maintaining the enterprise knowledge base and enabling its efficient exploitation for decision support are major tasks of enterprise engineering. Enterprise models are capable of capturing all the information and knowledge relevant for the enterprise operation (Vernadat 1996). Business processes and their activities identify the required and produced information as inputs and outputs. Since business processes may be defined for any type of enterprise operation, including management-oriented activities, their models will identify and capture all relevant enterprise planning knowledge as well and thereby complementing the operational knowledge of the enterprise. Process-oriented and model-based enterprise engineering and integration will be a significant contributor to the needed support for enterprise interoperation, provided it can become an easy to use and commonly accepted decision-support tool for the organisation.

Today's challenges concern the identification of relevant information, easy access across organisational boundaries and its intelligent use. To assure interoperation between organisations and their people the exchanged items have to be commonly understood by both people and the supporting ICT and have to be useable by the receiving parties without extensive needs for costly and time consuming preprocessing and adaptation. Therefore, we have to distinguish between two types of interoperability issues: the understanding by people and by the ICT environment.

To achieve common understanding does not mean to establish an Esperanto like all-encompassing business language, but to provide a commonly agreed language base onto which the different professional dialects can be mapped.

The other major interoperability problem encountered in the area of information exchange is due to the use of ICT systems with incompatible representation of information syntax and semantics. Many solutions have been proposed to improve interoperability using both unifying and federating approaches (Petrie, 1992). However, ICT unification is again not to be understood as a semantically unified universe. Only the universe of discourse of the interchange between participating enterprise models and their corresponding processes has to be founded on a common base. A common semantic modelling base will be sufficient to reduce the needs for unification for only those items or objects which have to be exchanged – the inputs and outputs of co-operating models and business processes, respectively.

Standards-based business process modelling will play an important role in creating this needed ease of use and common acceptance of the technology (Clement 1997, Kosanke, 1997). Only with a common representation of process models and its global industry acceptance will the exchange of models and their interoperability become common practice, and only then will decision support for creation, operation and discontinuation for the new types of enterprise organisation become reality.

Focussing on semantic unification, the European ESPRIT project AMICE developed CIMOSA[1], an enterprise modelling framework including an explicit modelling language (AMICE 1993). The European standards organisation developed standards on enterprise modelling based mainly on the AMICE work (CEN/CENELEC 1991, CEN 1995).

These standards have been further developed by CEN jointly with ISO leading to revisions of the original standards (CEN/ISO 2002, 2003). The revisions have been guided by GERAM (GERAM 2000), the work of the IFAC/IFIP Task Force (Bernus, *et al* 1996), which in turn has been the base for the ISO standard IS 15704 on requirements for enterprise architectures (ISO 2000).

In the following the key features and the expected use of the two CEN/ISO standards supporting enterprise integration are presented. The basic principles of GERAM and ISO 15704 are introduced as well.

2. GERAM AND ISO 15704

The IFAC/IFIP Task Force developed GERAM (Generalised Enterprise Reference Architecture and Methodologies), which is the result of the consolidation of three initiatives: CIMOSA, GRAI-GIM[2] and PERA[3]. GERAM provides a framework for

[1] CIMOSA = Computer Integrated Manufacturing – Open System Architecture
[2] GRAI/GIM = Graphes de Résultats et Activités Interalliés/ GRAI-IDEF0-Merise
[3] PERA = Purdue Reference Architecture

enterprise integration which identifies a set of relevant components and their relations to each other. These components group specific concepts selected from the three initiatives underlying GERAM. The most important concepts are: life cycle and life history, enterprise entities, modelling language and an integrated enterprise model with user oriented model views.

GERAM has been the base for the standard ISO 15704 Requirements for enterprise reference architectures and methodologies. This standard defines several key principles: applicability to any enterprise, need for enterprise mission/objectives definition, separation of mission fulfilment and control, focus on business processes, and modular enterprise design. Based on GERAM, the standard places the concepts used in methodologies and reference architectures such as ARIS[4], CIMOSA, GRAI/GIM, IEM[5], PERA and ENV 40003 within an encompassing conceptual framework. It states the concepts and components that shall be identified in enterprise reference architectures, which are to support both enterprise design and enterprise operation. Included are the framework for enterprise modelling and modelling languages supporting model-based methodologies a concept and a component further defined in the two standards CEN/ISO 19439 and 19440 described below.

3. CEN/ISO 19439

This standard on Enterprise Integration – Framework for Enterprise Modelling describes the modelling framework that fulfils the requirements stated in ISO 15704. The work is based on the Generalised Enterprise Reference Architecture (GERAM) proposed by the IFAC/IFIP Task Force and recognises earlier work in ENV 40003 (CEN/CENELEC 1991). The framework is described as a three dimensional structure consisting of a life cycle dimension with seven life cycle phases, a view dimension with a minimum set of four model views and a genericity dimension with three levels of genericity (Figure 1).

4. MODEL LIFE CYCLE

The phases of the life cycle dimension identify the main activities to be carried out in an enterprise modelling task, but they do not imply a particular sequence to be followed during the modelling process. Especially the life cycle phases may be applicable with different work sequences (top-down, bot-tom-up) for modelling tasks like business process re-engineering or business process improvement.

The domain identification phase allows to identify the enterprise domain to be modelled – either a part or all of an enterprise – and its relations to the environment; especially the sources and sinks of its inputs and outputs. Relevant domain concepts like domain mission, strategies, operational concepts will be defined in the following phase. Operational requirements, the succeeding system design and its implementation are subject of the next three phases. The released model will be used in the operational phase to support the operation in model-based decision processes and in model-based operation monitoring and control. Any needed end-of-life

[4] ARIS = ARchitecture for integrated Information Systems.
[5] IEM = Integrated Enterprise Modelling

activities like recycling of material, retraining of personnel or reselling of equipment may be described in the final life cycle phase.

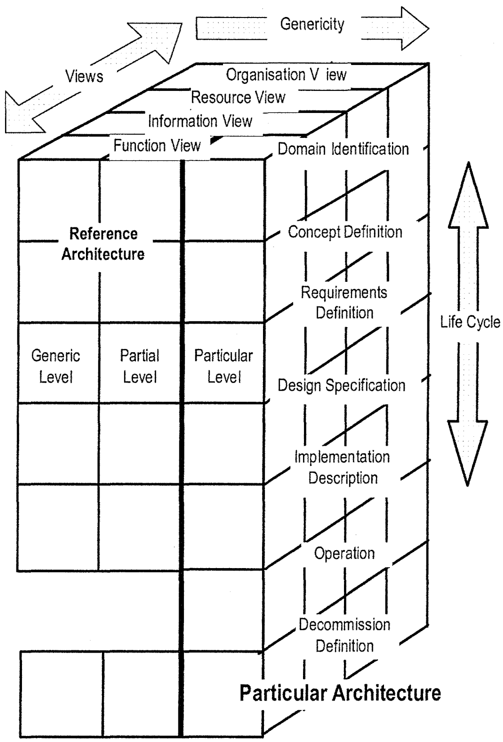

Figure 1: Enterprise Modelling Framework

5. MODEL VIEW

Enterprise models representing enterprise domains of any significance will become rather complex and not very easy to comprehend by both the modellers and the expected model users. Therefore, the framework provides the concept of model view enabling the representation of sub-models, which allow to show only those parts of the model that are relevant for the particular decision making, monitoring or control task. The model view concept is applicable throughout the life cycle.

The four model views identified in the standard are: function view, information view, resource view and organisation view. Other model views e.g. product view or economic view may be derived from the model by providing the appropriate filtering functionality in the modelling tools.

The function view allows to represent the business processes of the domain and the corresponding enterprise activities. All necessary domain, process and activity inputs and outputs as well as the process control flow (the process dynamic behaviour) will be defined in this view. Inputs and outputs for processes will be mainly material and products, whereas activity inputs and outputs define resources, constraints and related messages as well. However, the representation of the function view may be reduced to process structures (static representation or activity modelling) or activity nets (dynamic representation or behavioural modelling) both with or without selected inputs and outputs.

Enterprise objects and their relations will be represented in the information view. This information model holds all the information needed (inputs) and created (outputs) by business processes and enterprise activities during model execution. Enterprise Objects may be any object identified in the enterprise, e.g. products, raw material, resources, organization entities. To reduce complexity enterprise object of types resource and organization will be presented in their own model views. The inputs and outputs usually use only some parts of the enterprise objects. These parts are named object views.

The two subsets of enterprise objects, enterprise resources and organisational entities are represented in the resource view and in the organisation view, respectively. All enterprise resources: people, equipment and software are represented in the resource view. The organisation view shows the enterprise organisation with their objects being people with their roles, departments, divisions, etc. This allows the modeller to identify the responsibilities for all the enterprise assets presented in the three other views – processes, information and resources. Again object views identify those particular parts of the enterprise objects in the resource and organisation view, which are used for the description of the resource and organisation inputs and outputs in the particular model.

6. MODEL GENERICITY

The third dimension of the framework represents the concept of genericity identifying three levels: generic, partial and particular where less generic levels are specialisations of the more generic ones. The generic level holds the generic modelling language constructs applicable in the different modelling phases. Reference, or partial, models, which have been created using the generic modelling language(s) identified in the generic level, are contained in the partial level. Both, modelling language constructs and partial models are used to create the particular model of the enterprise under consideration.

7. CEN/ISO 19440

The standard on *Language Constructs for Enterprise Modelling* fulfils the requirements for a modelling language also stated in ISO 15704 and supports the framework for enterprise modelling described in CEN/ISO 19439 with its life cycle phases, model views and genericity levels.

The standard is based on ENV 12204 (CEN 1995) and defines a set of fourteen language constructs for enterprise modelling (see Figure 2). Models generated using constructs in accordance with the modelling framework will be computer processable and ultimately enable the model-based operation of an enterprise.

The standard contains definitions and descriptions – the latter also in the form of templates – of the set of constructs for the modelling of enterprises. Figure 2 shows nine core constructs and four additional constructs, which are specialisations of one of the core constructs (enterprise object) or even specialisations of a specialisation

(Resource – Functional Entity). Also indicated in Figure 2 are the relations to the four model views, which are supported by the particular modelling language constructs.

8. FUNCTION VIEW

The operational processes and the associated activities are represented in the function view. Four core constructs are used to model the functional aspects of the enterprise.

Starting with the domain construct, which identifies the domain scope, its goals, missions and objectives as well as the relations to the environment with domain inputs and outputs and their sources and sinks.

From the relations between inputs and outputs the needed transformation function – the main *business processes* of the domain – can be identified. These processes can be further decomposed into lower level processes until the desired level of granularity for the intended use of the model is reached. Process dynamics will be described by behavioural rule sets, which are defined as part of the business process construct.

The lowest level of decomposition is the level of enterprise activities, which usually would be rep-resented as a network of activities linked by the control flow defined using the business process behavioural rule sets. Enterprise activities transform inputs into outputs according to activity control/constrains information and employ resources to carry out the activity. All needed and produced inputs and outputs are identified as object views and are defined for each of the activities participating in the particular process.

The business process dynamics is controlled by behavioural rules and events. The latter are generated either by the modelled environment or by enterprise activities in the course of processing. Events start identified business processes through their identified enterprise activities and may provide additional process information as well.

9. INFORMATION VIEW

Enterprise objects and their relations are represented in the information view in the form of an information model. Two core constructs are defined for modelling of the information.

The enterprise objects are organised as a set of high level objects, which in general have lower level sub-objects. Different enterprise objects and sub-objects have relations to other objects in the same or other views.

A special set of sub-objects are the enterprise activity inputs and outputs, which only used in the function view. These sub-objects are selected views on particular enterprise objects and are named object views. Object views are of temporal nature; they only exist during the model execution time.

Three different enterprise object specialisations are defined in the standard: product, order and resource. These language constructs provide means to identify specific aspects relating to these enterprise sub-objects.

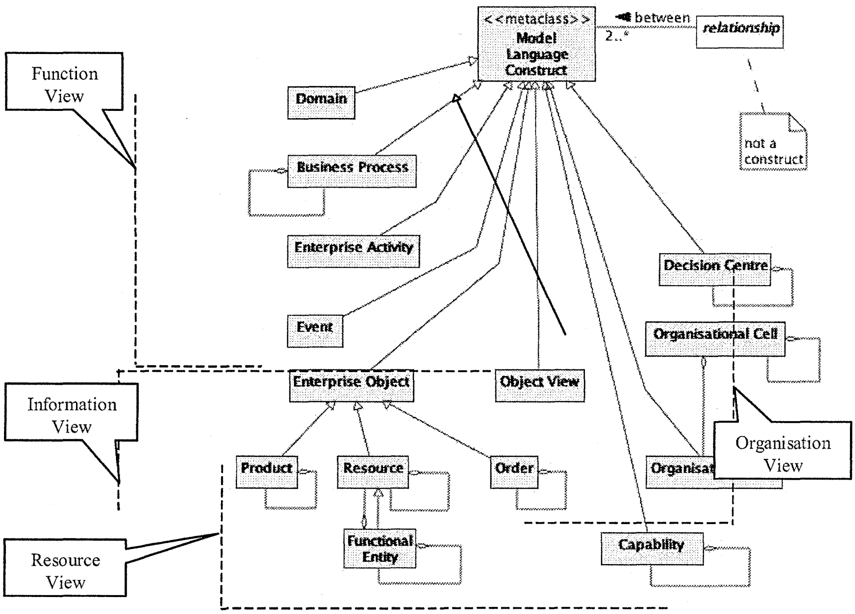

Figure 2: The set of enterprise modeling language constructs (EN/ISO 19440)

10. RESOURCE VIEW

The Resource View represents the enterprise resources, which can be organised into higher-level structures as well. These structures may represent the some of the organisational structure of the enterprise like shop floor, assembly line, etc.

In addition to the specialisations of the enterprise object – resource and functional entity – a core construct – capability – is provided as well. Whereas the resource construct (and its specialisation, functional entity) is used to describe general aspects of resources, the capability construct captures both the required (by the enterprise activity) and the provided (by the resource) capabilities. Functional entities are resources, which are capable of sending, receiving, processing and storing information.

11. ORGANISATION VIEW

The organisational entities of the enterprise and their relations are represented in the organisation view. It allows to identify authorisations and responsibilities for processes, information, resources and organisational entities.

Three different core constructs are defined in the standard: organisation unit, organisation cell and decision centre. The first two allow to model the organisation, using the organisational unit construct to describe the organisation relevant aspects of people and the organisation cell for describing organisational groupings like departments, divisions, etc.

The third construct enables the representation of the enterprise decision making structure that identifies the relations between different decision makers. It identifies a set of decision making activities that are characterised by having the same time horizon and planning period, and belonging to the same kind of functional category.

Note: People play a dual role in the modelling concept as organisational entities in the organisation view and as human resources in the resource view.

12. THE MODEL VIEWS

Figures 3 and 4 show an illustrative example for the four views with their enterprise objects and sub-objects (object views are shown in Figure 4 only).

Figure 3 identifies main relations between the different enterprise objects within and between model views. Special relation are the events, which start the two business processes (Manufacturing and Administration). The first event, associated with the customer order, starts the administrative process which creates the two events associated with purchase and shop floor orders. The latter in turn starts the manufacturing process, which uses the information held by the enterprise object 'product' and its sub-objects and is executed by the relevant resources identified in the resource view. Responsibilities for planning, processes, information and resources are identified for the organisation view objects.

Additional information on these relations are provided in Figure 4, which shows the relations between the enterprise activity in the function view and the enterprise objects in the information view. Inputs and outputs of the enterprise activity 'assemble' are identified as object views, which are views on the enterprise object 'product' and its sub-object 'part', respectively.

Similar diagrams are shown in CEN/ISO 2002 for the relations between function view and resource view and the organisation view and all other views.

13. ISSUES

Terminology is still a major problem in standardisation. A particular issue in the two standards described in this paper is the view concept. This concept is used in the sense of filtering the contents or presentation of specific aspects of the particular model by means of enterprise model views as well as presenting sets of selected attributes of enterprise objects by means of enterprise object views. This means the same concept is used in a rather similar way in its two applications in the standards. However, using the term view without its different qualifiers leads to misunderstandings. But to find a meaningful new term for either one of the two uses of the term view seems to be rather difficult. Therefore, it is essential to understand the meaning of the two qualifiers to be able to have meaningful discussions about the model content with co-workers.

Definitions

- *View:* visual aspect or appearance (Collins Dictionary 1987) perspective, aspect (WordNet 1.7.1 2001)
- *Enterprise model view:* a selective perception or representation of an enterprise model that emphasizes some particular aspect and disregards others. (ISO/CEN 19439 2002)
- *Model view:* a shortened form of, and an alternative phrasing for, 'enterprise model view' (ISO/CEN 19440 2003)

- *Enterprise object view:* <construct> a construct that represents a collection of attributes of an Enterprise Object. The collection is defined by a selection of attributes and/or a constraint on these attributes (ISO/CEN 19440 2003)
- *Object view:* <construct> a shortened form of, and the usual alternative phrasing for, 'Enterprise Object View'.(ISO/CEN 19440 2003)

These definitions imply for the enterprise model views that they will reduce the complexity of the particular model for both the modeller and the model user. However, to do this in a useful way the model views have to retain their links to the underlying complex model and thereby allow model manipulations of the model contents via modifications of the individual views.

Similarly enterprise object views will help to reduce the amount of information to be identified in the particular enterprise model. Only those attributes, which are needed in the course of model execution will be selected from the relevant enterprise objects and will be used as enterprise object views to define the business process and enterprise activity inputs and outputs.

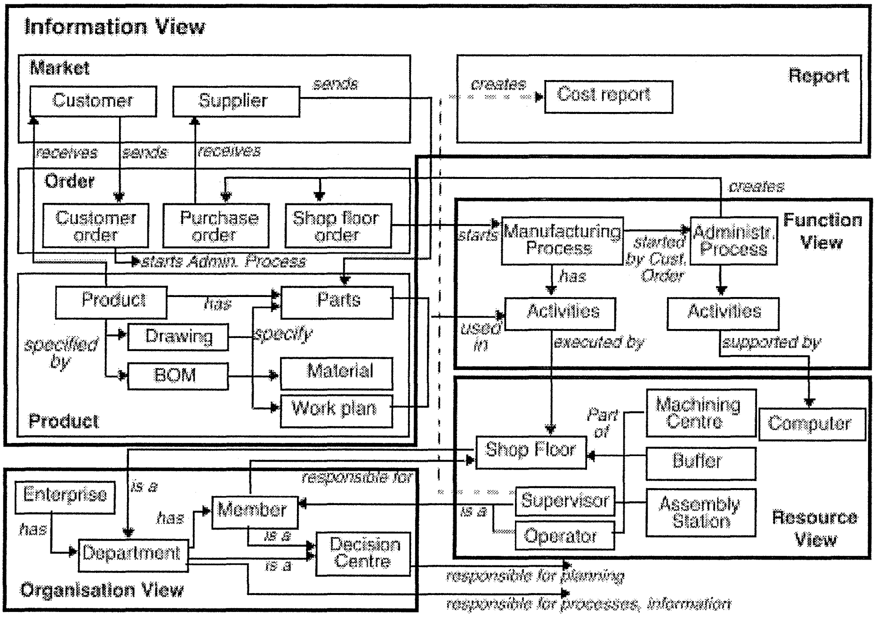

Figure 3: Model Views for Order Processing (illustrative example from CEN/ISO 2002)

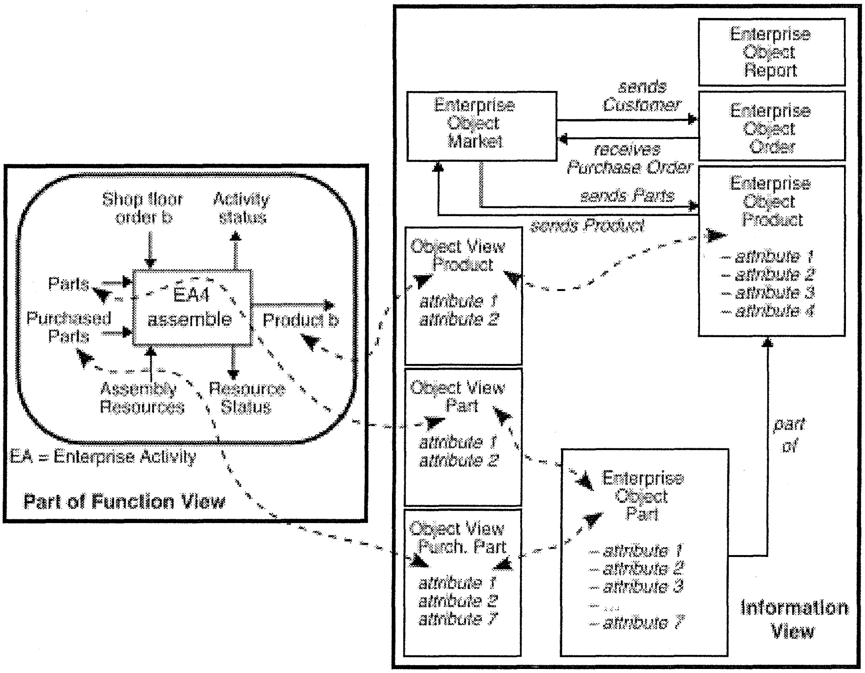

Figure 4. Information View for Order Processing ((illustrative example from CEN/ISO 2002))

14. SUMMARY AND CONCLUSIONS

Major issues of global collaboration and co-operation of enterprises are the interoperability between people and between different implemented ICTs. The two standards presented in this paper address enterprise and business process modelling, with their focus on semantic unification and orientation on end-user needs. Therefore, both standards intend to satisfy the requirement for common understanding by people. However, these standards can also improve ICT interoperability by providing a base for unifying the needed information exchange between the parties involved, may it be between operational processes during enterprise operation or between their models during decision support. Therefore, standard-based business process modelling will provide a common base for addressing both of the interoperability issues.

In ISO and CEN the work is progressing in joint projects that will lead to additional international standards for business process modelling and its application in enterprises. More work is still required especially on the human-related aspects like model representation to the user, representation of human roles, skills and their organisational authorities and responsibilities. In addition standardisation is required in the area of business co-operations as well.

Standardisation for enterprise integration is considered an important subject. However, the current state of standardisation is not yet sufficient to allow easy implementation at the operational level. Many of the standards are still on the conceptional level and more detail is required to make them truly useable in the operation. Work is required in areas of languages and supporting modules, especially for the business process model creation and execution. To enable cross-organisational decision support especially the subject of 'common' semantics has to be addressed. ISO/CEN 19439 modelling constructs are defined using a meta-model and accompanying text (sufficient to define an intuitive semantics as well as to define a model repository database). However, the capture of finer points of these meanings requires even more detailed formal semantics. Ontologies will play an important role in this area as well as in the area of semantic unification (Akkermans 2003).

REFERENCES

Akkermans, H. Ontologies and their Role in Knowledge Management and EBusiness Modelling, in K. Kosanke *et al* (Eds.) Enterprise Engineering and Integration: Building International Consensus; Proc. ICEIMT'02 (Intern. Conference on Enterprise Integration and Modelling Technology), Kluwer Academic Publishers, pp 71-82.

AMICE (1993), ESPRIT Consortium (Eds.), CIMOSA: Open Systems Architecture, 2nd revised and extended edition, Springer-Verlag.

Bernus, P. Nemes, L. Williams, T.J. (1996), Architectures for Enterprise Integration, Chapman & Hall.

CEN/CENELEC (1991), ENV 40003 Computer Integrated Manufacturing - Systems Architecture - Framework for Enterprise Modelling.

CEN, (1995), ENV 12204 Advanced Manufacturing Technology - Systems Architecture - Constructs for Enterprise Modelling, CEN TC 310/WG1.

CEN-ISO (2002), DIS 19439 Framework for Enterprise Modelling, CEN TC 310/WG1 and ISO TC 184/SC5/WG1.

CEN-ISO (2003), CD 19440 Constructs for Enterprise Modelling, CEN TC 310/WG1 and ISO TC 184/SC5/WG1.

Clement, P. (1997), A Framework for Standards which support the Virtual Enterprise, in Kosanke, K. & Nell, J.G. (Eds.) Enterprise Engineering and Integration: Building International Consensus Pro-ceedings of ICEIMT'97 (Intern. Conference on Enterprise Integration and Modelling Technology), Springer-Verlag, pp 603-612.

Collins Dictionary (1987), The Collins Dictionary and Thesaurus, William Collins and Sons & Co Ltd. Glasgow and London.

GERAM (2000), GERAM 1.6.3: Generalised Enterprise Reference Architecture and Methodology, in ISO 15704

ISO (2000), IS 15704 Requirements for Enterprise Reference Architecture and Methodologies, TC 184/SC5/WG1.

Kosanke, K. (1997), Enterprise Integration and Standardisation, in Kosanke, K. & Nell, J.G. (Eds.). Enterprise Engineering and Integration: Building International Consensus Proceedings of ICEIMT'97 (Intern. Conference on Enterprise Integration and Modelling Technology), Springer-Verlag, pp 613-623.

Kosanke, K. Jochem, R. Nell, J.G. & Ortiz Bas, A. (Eds.) (2002). Enterprise Engineering and Integra-tion: Building International Consensus; Proceedings of

ICEIMT'02 (Intern. Conference on Enter-prise Integration and Modelling Technology), Kluwer Academic Publisher.
Petrie, C.J. (Ed.) (1992). Enterprise Integration Modelling Proceedings of the First International Con-ference, The MIT Press.
Vernadat, F.B. (1996), Enterprise Modelling and Integration, Principles and Applications; Chapman and Hall.
WordNet 1.7.1 (2001) WordNet Browser, Princeton University Cognitive Science Lab