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A REFERENCE MODEL FOR VIRTUAL ORGANIZATIONS PLANNING AND LAUNCHING

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DEDICATORIA

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SUMMARY

Nowadays, enterprises faces a lot of new challenges due to globalization, enterprise should be enough competitive in order to maintain or increase their market share, all these factors have lead to the generation of new organizational forms. One of these new forms is the Virtual Organization. The advanced developed in ICT tools during the last decade have reduced the impact of the distance factor in business. For these reasons the planning and launching of Virtual Organizations have been a key issue in nowadays scientific community. The presented research describes a reference model for planning and launching of Virtual Organizations. The reference model has three main elements: the first element of the reference model are (1) six modules which define the guidelines for VO planning and launching, The modules are: (1.1) Collaboration Opportunity analysis, (1.2) Partners selection, (1.3) Preliminary VO planning, (1.4) Detailed VO planning, (1.5) VO set up and (1.6) Scheduling; The second elements is a (2) mechanism for knowledge capturing and sharing during VO planning and launching and (3) a multidimensional modelling approach. The main results obtained were: a 1) a methodology for VO planning and launching that support a systematic approach during VO planning and launching, 2) a basic structure for knowledge capturing and sharing in inter-enterprise environments and 3) A reference model for VO planning and launching which enable rapid creation of VO by providing a modular approach that allow the integration of different methods, models and tools. The major conclusions this research are: a) it was possible to achieve a systematic approach during VO planning and launching stages and b) It was shown that through reference model it is possible to develop a particular planning and launching approach for VO specific characteristics. As a result, the use of systematic approach during the creation of Virtual Organizations will be the key to develop competitive Virtual Organizations.

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LIST OF TERMS

VO.- Virtual Organization

VBE..- Virtual Breeding Environment

CNO.- Collaborative Networked Organization

UML.- Unified Modelling Language

ICT.- Information and Communication Technology

KM.- Knowledge Management

GERAM.- Generic Enterprise Architecture and Methodology

PERA.- Purdue Enterprise Reference Architecture

KM.- Knowledge Management

PDM.- Product Data Management

Chapter 1. - Introduction

1.1 Context

21st century companies are faced with the increasing demands from the market. These demands are among other things derived from technological innovations and the corresponding development towards a global marketplace.

Due to globalization, heightened competition and pressure on firms to be adaptive and innovative; several new emerging paradigms have emerged in recent year as an answer to the fast changing environmental challenges, paradigms such as virtual manufacturing, lean enterprise, agile manufacturing, fractal company, and holonic manufacturing. Introduction of these concepts have made them face successive "waves of restructuring" during the last decade (Camarinha-Matos et al, 2005)

The increasing significance of the so-called 'New economy´, also referred to as the digital and knowledge economy push towards further concentration on corporate competencies while exploiting and developing these competencies in inter-organizational networks facilitates by advanced information and communication technologies (ICTs).

The introduction of new information and communication technologies (specially World Wide Web) offer the possibilities of finding new ways of working and learning, new products and services, and even entire new enterprises. Also, the socio-economical, political and technological developments of the last two decades have drastically changed the way business is conducted at national, as well as international level. The distance factor has been eliminated while custom restrictions and market protectionism have attempted to persist (Camarinha-Matos and Afsarmanesh, 2004).

Emergence of the Virtual Organization paradigm falls in the natural sequence of the evolution processes developed during the last decade. The need to remain competitive in the open market forces companies to seek "world class" status and therefore, to concentrate on their core competencies while searching for alliances when additional resources are needed to fulfil business opportunities (Camarinha-Matos et al, 2005).

The idea of Virtual Organization (VO) was not developed by a single researcher; rather it is concept that has matured through a long evolution process. Some of the early references first introducing the terms like virtual company, virtual enterprise, or virtual corporation go back to the early 1990's. However, concepts and definition related to the VO paradigm are evolving and the terminology is not yet fixed. There is not even a common definition for the VO concept that is agreed by the researchers in this area (Camarinha-Matos et al, 2005). In this work a definition developed

The research work reported in this thesis contributes to the area of Virtual Organizations theoretical foundation by the creation of a mechanism for VO planning and launching. The mechanism is a reference model composed by three main elements, a modular structure which defined the guidelines for planning and launching in an inter-enterprise environment, a modelling approach and special emphasis have been placed in investigating a suitable knowledge structure which enable knowledge capture and sharing in a Virtual Organization.

1.2 Aims and Objectives

The aim of this research work is to create a reference model to provide an integrative and systematic approach during VO planning and launching stages.

In achieving this aim, the major objectives of the research are:

1. To create a reference model that supports VO planning and launching
2. To identify methods and tools that supports VO planning and launching.
3. To describe the reference model according to GERAM elements
4. To demonstrate the use of the reference model in particular VO's

1.3 Scope

This research is made in the context of VO planning and launching. This research explores how VO planning and launching can be systematized using reference models.

VO planning and launching is very wide and this research thesis is developed at a general level of VO planning and launching stages. Hence Manufacturing Virtual Enterprises have been targeted as Virtual Organizations with strong emphasis on Aerospace Products Manufacturing and Engineering. It is important that Aerospace Products Manufacture and Analysis is only been used to show how the components of the reference models helps during VO planning and launching. However, the approach can be extended beyond Aerospace Products Manufacturing and Engineering.

There are different tools to support VO planning and launching; a majority of them are ICT tools focused on project planning and knowledge management, in this work a manual assisted approach is used to show reference model implementation, this work is focused in the conceptual level of VO planning and launching.

1.4 Research Environment

This section of the research work presents the environment in which this work was developed and provides a description of the tools used to develop and validate the concepts of the research work.

The research presented on this thesis is a part of ECOLEAD[1] project. ECOLEAD project is expected to significantly impact industrial competitiveness and social structures mechanisms, by providing means to effectively exploit opportunities deriving from the deployment of Virtual Organizations, and by designing and enabling new professional work paradigms, capable of enacting the Knowledge-based Society (ECOLEAD, 2004).

[1] ECOLEAD: European COllaboraitive Networked Organizations LEADership Initiative

ECOLEAD vision:

"In ten years, in response to fast changing market conditions, most enterprises and specially the SMEs will be part of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations."

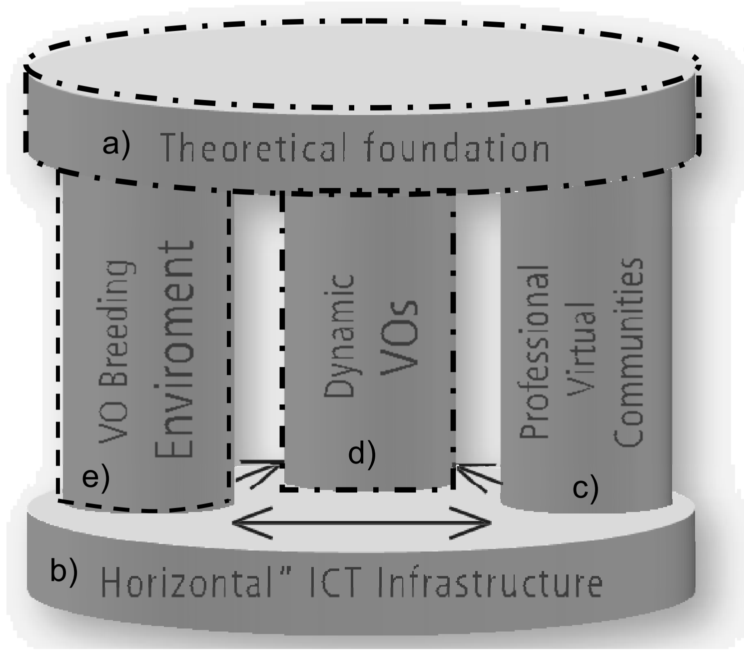

Figure 1. ECOLEAD pillars (Ecolead, 2004)

Figure 1 depicts the pillars of Ecolead; these pillars are the main research lines of Ecolead. The three vertical pillars represent the most fundamental and inter-related focus areas that are the basis for dynamic and sustainable networked organizations: Breeding Environments, Dynamic Virtual Organizations, and Professional Virtual Communities. These areas are support by two horizontal structures: (1) the Theoretical Foundation for collaborative networks and the (2) ICT Infrastructure that support and affect the three vertical pillars. The research presented in this thesis is focused in developing the theoretical foundation (*horizontal structure a)*) for VOs planning and launching (*pillar d) & e)*).

1.5 The structure of the thesis

The structure of the thesis is organized into five chapters. Chapters 1 provides the introduction to the research work outlining aims, objectives, scope of the research and a description of the research environment in which the work was developed.

Chapter 2 presents a literature review of the relevant areas related with Virtual Organization, Knowledge Management and Reference Architectures. It starts defining VO general concepts and relevant areas to VO planning and launching are analyzed, Knowledge management concepts are presented and finally reference architectures issues are presented.

Chapter 3 presents the proposed reference model for Virtual Organization Planning and Launching. In this chapter the elements of the reference model are described and finally the use of the reference model is described.

Chapter 4 shows a formalization of the reference model according to GERAM elements. The formalization describes how GERAM elements were instantiated into VO Frame.

Chapter 5 describes the implementation of the reference model in two study cases developed. It starts describing how the reference model was implemented within a VBE[2] context in the first study case and finally a second study case developed outside a VBE is presented.

Chapter 6 summarizes the results and conclusions obtained of the experiences in using the reference model for VO planning and launching in two study cases.

Finally at the end of this thesis a group of appendixes is included.

[2] VBE: VO Breeding Environment (VBE): A VBE represents an association (also known as a cluster) or pool of organizations and their related supporting institutions that have both the potential and the will to cooperate with each other through the establishment of a "base" long-term cooperation agreement and interoperable infrastructure. When a business opportunity is identified by one member (acting as a broker), a subset of these organization can be selected and thus forming a VO (Camarinha-matos et al, 2004)

Chapter 2. - Literature Review

2.1 Introduction

In this chapter a literature review of the themes involved in the process of planning and launching of Virtual Organizations is presented, the first part presents a general overview of the main concepts related with Virtual Organizations, research made within virtual organization main themes and international projects where Virtual Organizations have been the main research theme. The second part provides a general view of knowledge management general concepts, differences between data, information and knowledge and knowledge models developed till today. The third part presents a review of the concepts related with enterprise reference architectures is presented, in last stage action research is presented as research methodology, all this review is made in order to integrate these concepts in a reference model within the Virtual Organizations environment.

2.2 Virtual organizations

2.2.1 The Concept of Virtual Organization

In an era where rapid changes have been guided by trends such as mass customization, agility, globalization of markets, supply sources and increasing demand for extended products and services are shifting the competitive focus of organizations, based on this, organizations are beginning to co-operate in many different ways (Saabeel et al, 2002).

Virtual organization is one of this new organization schemes. VO is a term being used to describe how different organizations come together to explore business opportunities, and collaborating on a temporary basis (Katzy and Obozinky, 1999). Several definitions have been developed for Virtual Organization, Mainly, the definitions are in line with the other, but the emphasis may vary (Camarinha-matos, 2003). The following are examples of these definitions:

“A Virtual Organisation is a combination of various parties (persons and/or organisations) located over wide geographical areas which are committed to achieving a collective goal by pooling their core competencies and resources. The partners in a Virtual Organisation are dependent upon electronic connections (ICT infrastructure) for the co-ordination of their activities.” (Bultje, 1998).

"VO's (virtual organizations), refers to a new organizational form characterized by a temporary or permanent collection of geographically dispersed individuals, groups or organization departments not belonging to the same organization – or entire organizations, that are dependent on electronic communication for carrying out their production process." (Travica, 1997)

“A stable network of enterprises whose purpose is to set up Virtual Enterprises (VE) in which the partners are connected to each other through their core competencies and market strategies. VE’s are supported by Information Technology” (Bremer et al, 2001)

The definition before mentioned show that there is not defined a standard definition for VO, in this research work the definition used was the following:

“Temporary alliances of organizations that come temporary alliances of organizations that come together to share skills or core competencies and resources in order to better respond to business opportunities and produce value-added services and products, and whose cooperation is supported by computer networks (ECOLEAD, 2004)”.

Virtual Organizations have been under study for more than a decade, during this time several generic characteristics have been defined, table 2 shows these characteristics and the authors related with the definitions of these characteristics:

Characteristics	Traditional organisation	"Virtual" organisation
Structure	Hierarchical	Networks
Scope	Internal/closed	External/open
Resource focus	Capital	Knowledge, relationship, technology management
State	Static, stable	Dynamic, changing
HRM	Management	Specialists
Direction	Management directives	Empowerment/intrapreneurship
Basis for action	Control	Empowerment
Motivation	Meet corporate management directives	Achieve team goals
Learning	Specific skills	Broader competencies
Compensation	Position/seniority	Achievement
Relationships	Competitive	Cooperative/collaborative
Information communications among partners	"Need to know" basis	Open and transparent

Table 1 Traditional Business Structures versus Virtual Organization structure (Walters, 2000)

2.2.2 VO Characteristics

Virtual organizations have the following characteristics (Jagers et al, 1998):

- **Boundary crossing**

The products can only be produced through the co-operation of multiple specialists. Small organizations must (eventually) realize that only through co-operation does the possibility exist of living up to this market demand. Co-operation between independent branches of the organization shall take place in the form of a network type of virtual organization. This collaboration can take place through the pooling of core competencies and/or the combination of working methods utilized by the participating parties. Those participating in a virtual organization are entirely dependent upon each other during this collaboration.

- **Complementary core competencies / the sharing of resources**

Market difficulties and demands which confront individual organizations can no longer be solved or met by the solitary organization. The participants in a virtual organization complement each other, making it possible to deliver a product or complete a project collaboratively. The objective from the individual participant's standpoint is to procure non critical core competencies or activities (from the other participants) with which to achieve greater results than would be possible for the solitary party.

- **Geographic dispersion**

Because communication between participants is taken care-of by ICT, the work location is no longer significant. It is possible to communicate within seconds on a world-wide scale.

- **Changing participants**

The virtual organization can be composed differently each day. On one day a certain organization may be part of the network, forming the virtual organization along with other networks. The following day the virtual organization could be composed of other organizations.

- **Partner equality**

Increased dependence in virtual organizations leads to a greater equality in participant relations. Each partner in this collaborative effort plays his own role, contributes to the improvement of the end product and forms a link, regardless of location, in the functional process of the virtual organization.

- **Electronic communication**

The essence of the virtual organization is to break up the unity of time, location and trade. The often changing and geographically dispersed collaborations that have come into existence are based on information and communication technology (ICT) applications. This is an essential prerequisite for the proper functioning of virtual organizations and is largely recognized as being a 'conditio sine qua non'. The possibilities of the virtual organization grow ever larger as a direct result of ICT.

- **Temporariness**

Opinions are divided regarding whether a temporary nature is a specific characteristic of the virtual organization. Some authors postulate the temporary nature of the virtual organization. On the other hand, virtual organizations can be of a temporary nature but can also be functional without the perspective of being finite.

One example in which one can speak of the temporariness of the virtual organization, is in the event of project completion. The virtual organization could also have an undetermined duration; the organization will remain functional for as long as customer demand exists and/or the participants find their collaboration to be beneficial.

2.2.3 VO Topologies

Most of VO types can be described in a topology; a topology thus describes the top-level structure of the network architecture. For VO's there are three types of topologies (Voster project 2001, Ahuja and Carley 1999). The topologies are described in figure 2.

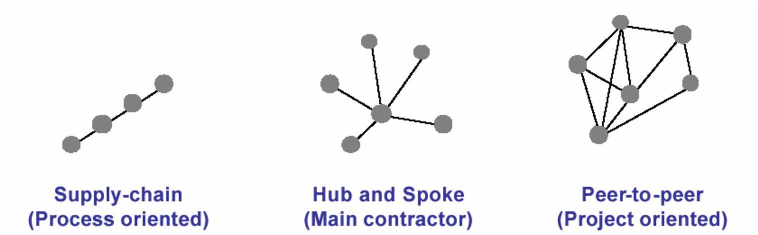

Figure 2 Topologies for VO's

In a supply chain topology, the partners' interaction pattern mainly follows a chain. In a star topology all partners interact with one central hub or strategic centre. In the third topology, partners show high peer-to-peer interaction between all nodes (Voster project 2001).

Comparing projects revealed that supply chain topology projects assume the existence of very long-term partnership networks amongst the partner firms, while projects that assume star topology networks allow for a more rapid reconfiguration of the partner network. Projects with peer-to-peer network topologies are different again; relying on personal networks and social relationships to a much higher degree than the other two network types, which primarily work at the level of the firm.

2.2.4 Support Infrastructure.

According to Camarinha-Matos and Afsarmanesh (2003), the VO infrastructure shall play the role of an enabler of the interoperation and integration among the various participants, which can be considered at various levels:

Level 1 – Basic communications and information exchange, including safety, business Transactions and technical information transactions.
Level 2 – Application integration, supporting the interoperability among enterprise application tools running at different enterprises.
Level 3 – Business integration, including support for distributed business process coordination.
Level 4 – Teams integration, including facilities to support collaboration among professional teams composed of members from different enterprises / organizations.

2.2.5 Emerging support technologies.

Last years have been quite fertile in terms of a fast proliferation of new ICT tools and standards aimed at facilitating different aspects of collaborative networks. The emergence of a large and growing number of standards and technologies represent potential enabling factors, such as for instance (Camarinha-Matos and Afsarmanesh, 2003, Camarinha et al, 2004):

- Open interoperable underlying network protocols (TCP/IP, CORBA-IIOP, HTTP, RMI, SOAP)
- Open distributed object oriented middleware services (J2EE Framework, CORBA Framework, ActiveX Framework),
- Information / object exchange mechanisms and tools (XML, ebXML, WSDL), Standardized modelling of business components, processes and objects (EJBs, AG and OMGs Business Objects and Components)
- Business Process Modelling Tools and Languages (UML, UEML, WfMC XML-based Business Language, PSL)

- Open and standard business process automation and Workflow Management Systems (WfMC, OMG-JointFlow, XML-WfMC standards, many commercial products)
- Standard interfacing to federated multi-databases (ODBC, JDBC)
- Intelligent Mobile Agents (FIPA, OMG-MASIF, Mobile Objects)
- Open and standard distributed messaging middleware systems (JMS, MS-Message Server, MQSeries, FIPA-ACC),
- XML-Based E-Commerce Protocols (BizTalk, CBL, OASIS, ICE, RosettaNET, OBI, WIDL)
- Web Integration Technologies (Servlets, JSP, MS-ASP, XSL)

Information and Communication Technologies progress fast, suggesting new opportunities for development and broad adoption of new collaborative networked organizations. But as a consequence of this fast evolution, technologies and products have very short life-time, what represents a major obstacle for SMEs (Camarinha et al, 2004).

2.2.5 VO Related work

Virtual Organizations have been under study for most than a decade, during this decade several themes were identified in order to support the Virtual Organization foundation, the table 2 shows these main themes as columns and the work made by several authors as rows, and this table show how this topics have been studied by academics along these years

AUTHORS	Risk Management	Brokering	Coordination and collaboration	Partners search and selection	Negotiation	Contracting	VO structure and topology	Knowledge management	VO planning	VO partnership forms	ICT support tools	VO launching	Trust building	VO performance measure
Augusta et al, 2001			X											
Avila et al, 2002		X												
Belak et al, 2003														X
Bernus et al, 2002											X			
Bonini et al, 2002											X			
Burgwinkel 2002						X								
Buzon et al, 2004								X						
Camarinha-matos and Abreu, 2004			X											
Camarinha-matos, 2003							X				X			
Eisentraut et al, 2001													X	
Fischer and Rehm, 2004								X						
Gerber et al, 2004	X													
Grabowsky and Roberts, 1999												X	X	
Hieber et al, 2002														X
Holton, 2001													X	
Horts et al, 2004			X											
Ignatiadis and Tarabanis, 2004						X							X	
Katzy and Dissel, 2001											X			
Kazi and Hannus, 2003								X						
Lackenby and Seddighi, 2002									X					
Laurikkala and Tanskanen, 2002					X	X								
Mejia et al, 2002		X												
Mejia et al, 2004											X			
Mezgar, 2004											X			
Noran 2004									X					
Preece, 2001								X						
Presley et al, 2001									X			X	X	
Prikladnicki R., 2004	X													
Rabelo et al, 2004			X											
Ren et al, 2004						X								
Rittembruch et al, 1998			X								X			
Scherle et al, 2004	X													
Seifert and Eschenbaecher, 2004														X
Tolle M. 2004				X	X	X			X			X		
Valikangas and Puttonen, 2003								X						
Valikangas et al, 2000								X						
Weib and Trunko, 2002														X
Zhou et al, 2003		X									X			

Table 2 VO main related research work made the last years

As is showed in table 2, most of the works oriented to provide VO theoretical foundation has been developed in specific topics, few works has been made in order to integrate the topics related with VO planning and launching, the most representative work made in the integration of these topics during the last years is a PhD dissertation (TØlle, 2004) from Denmark Technical University.

Based on the review presented in table 2, a lot of work has been made in particular topics included in VO planning. However, there is a research opportunity in the integration of these topics into reference models in order to provide an integral approach in VO planning and launching.

The research work presented in this thesis provides an integrative approach for the elements involved in VO planning. The integration is achieved through a reference model. The reference model differs from TØlle's (2004) work in the application level where the research work was developed. TØlle's (2004) work was developed for a specific type of VO (Virtual Enterprise); the work presented here is focused in all types of VO's. The work presented in this thesis integrates the work made from other researchers into a generic structure for VO planning and launching.

2.2.6 International projects related with VO's

Several attempts have been done in order to generate, systematize and consolidate the knowledge about Virtual Organizations. The THINKcreative project was one of the first initiatives to introduce the concept of Collaborative Networked Organization (CNOs) as a more general concept to encompass various collaborative forms such as virtual organization, virtual enterprise, professional virtual community, etc (Camarinha-matos, 2004). THINKcreative identified and briefly analyzed some potential theories and approaches developed in other disciplines that could form the basis for the desired theoretical foundation. THINKcreative also discussed the concept of emergence in complex self-organizing systems and briefly analyzed the potential contribution of areas such as theories of complexity, multi-agent systems, self-organizing systems and evolving networks, and holistic approaches.

An attempt to organize and categorize reference models for VOs can be found in TØlle, Bernus, and Vesterager (2002), and Zwegers, TØlle and Vesterager (2003) as a result of the GLOBEMEN project.

A contemporary initiative, the VOmap roadmapping project, also pointed out the importance of a theoretical foundation for advanced virtual organizations (Camarinha-Matos and Afsarmanesh, 2003, Camarinha-Matos and Afsarmanesh, 2004). This project aimed at identifying and characterizing the key research challenges needed to fulfil the vision, required constituency, and the implementation model for a comprehensive European initiative on dynamic collaborative virtual organizations.

One example of effort to systematize and consolidate the existing empiric knowledge on virtual organizations, mainly based on the achievements of a large number of European projects, was carried out by the VOSTER project. Some other projects developed in the VE/VO field are shown in table 3:

Esprit, INCO programs

CE-NET
CHAMAN
COBIP
COWORK
DELPHI
ELSEwise
EVENT
FREE
GLOBEMAN 21
ICAS
LogSME
MARVEL OUS
MASSYVE
PLENT
PRODNET II
SCM+
SPARS
VEGA
VENTO
VIRTEC
X-CITTIC
...

IST Program

Virtual Organizations

BIDSAVER
Business Architect
ECAMP
JASMINE
STARFISH
eLEGAL
VIVA
SOSS
E-ARBITRATION-T
ENTER
AESOP
B-MAN
MARKET MAKER
OBELIX
PLEXUS
GLOBEMEN

Accompanying Measures

THINKcreative
VOSTER
CE-NET II
ALIVE
VOSTER
UEML
VOmap

Collaboration

EXTERNAL
ECOLNET
E-COLLEG
DYCONET
WHALES
SCOOP
LENSIS
LINK3D

Supply Chain Management

ADRENALIN
APM
CHAINFEED
DAMASCOS
CO-OPERATE
SMARTISAN

Others

SMART
SMARTCAST
PATTERNS
SOL-EU-NET
DISRUPT IT

... & more

TeleCARE
FETISH-ETF
VOmap
...

Table 3 Examples of European Project in VE/VO (Camarinha-Matos and Afsarmanesh, 2003)

2.3 Knowledge Management.

Nowadays, Knowledge Management (KM) is currently receiving a lot of attention from practitioners and academics, and is being addressed by a broad range of academics literature and popular press (Kakabadse et al, 2003). However, while the literature is revealing in particular aspects of KM models, a better understanding of the multidisciplinary characteristics of KM Models have been identified (Guerra, 2004).

During the last century, researchers began to explore KM, first were economist (Hayek, F.A, 1989, Marshall 1997), organizational theory (March and Simon, 1958) and philosophy (Polanyi, 1966). There are many definitions and models of KM, each adding new insights to a crucial, but nebulously defined field (Kakabadse et al, 2003).

Several authors have tried to define KM, definitions presented KM as a systematic and explicit management of knowledge related activities, practices, programs and policies within the enterprise the enterprise (Wiig, 2000), For others, KM is a 'conscious strategy of getting the right knowledge to the right people at the right time and helping people share and put information into action in ways that strive to improve organizational performance' (O'Dell and Jackson, 1998). From a general perspective KM can be described as a set of activities oriented to provide the knowledge required to people involved in a decision making process.

According to Pentland (1995), KM consists of four sets of knowledge processes: (1) knowledge creation, (2) knowledge organization and storage/retrieval, (3) knowledge transfer, and (4) knowledge application. In this research work, only the first two processes are considered, further activities should be focused in improving the integration of these four processes within VO life cycle.

Based in a survey study Mason and Pauleen (2003) defined three main drivers of KM, these drivers have subcategories, the figure 3 shows the before mentioned structure:

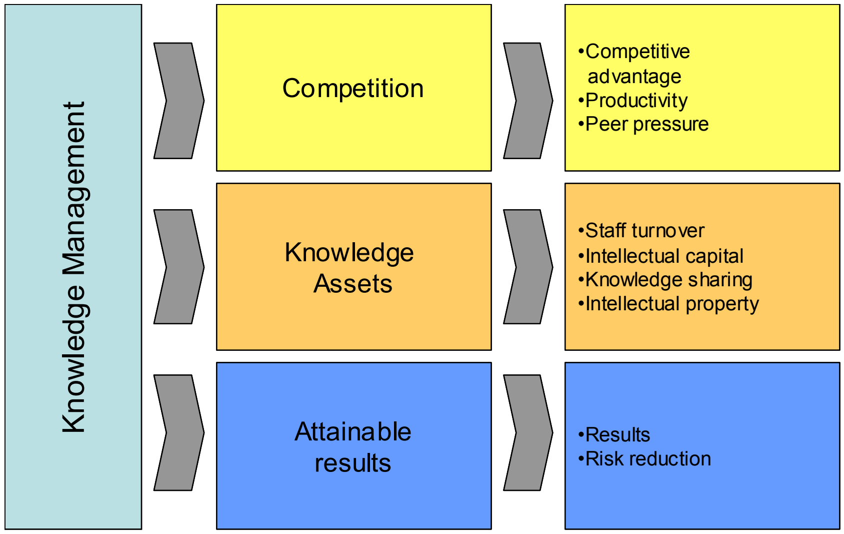

Figure 3 Knowledge drivers (adapted from Mason and Pauleen, 2003)

2.3.1 The concept of Knowledge

During the last decade, knowledge was conceptualized in different manners, for some authors knowledge was 'economic ideas' (Wiig, 1995) or 'intellectual capital' (Stewart, 1997). In the last year some authors have explored the knowledge concept in order to obtain more understanding about this concept (Guerra, 2004).

The terms knowledge, information and data are concepts that are commonly used in KM literature, is important to clearly identify the differences between these three concepts. Based on the definitions developed by several authors it is possible to identify the differences between knowledge, information and data. Data represents observations of facts out of the context that are, therefore, not directly meaningful (Zack, 1999). Information results from placing data within some meaningful content often form of a message (Zack, 1999). Knowledge, as a 'justified true belief', is that which people believe and value on the basis of the meaningful and organized accumulation of information through experience, communication or inference (Dretske, 1981; Lave, 1988; Blacker, 1995).

2.3.2 Knowledge types

According to Leonard and Sensiper (1998) knowledge types can be represented in a knowledge spectrum (See figure 4), "at one extreme it is almost completely tacit, that is, semiconscious and unconscious knowledge held in peoples' heads and bodies. At the other end of the spectrum, knowledge is almost completely explicit, or codified, structured, and accessible to people other than the individuals originating it. Most knowledge, of course, exists in between the extremes".

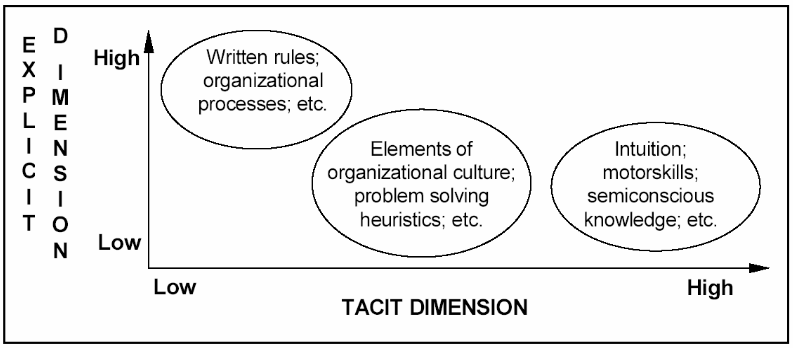

Figure 4 Knowledge spectrum (Leonard and Sensiper, 1998)

Nowadays, tacit and explicit knowledge are the types of knowledge that more have been explored by researchers, however a third type of knowledge called implicit knowledge is under study, according to Guerra (2004), implicit provides a link between tacit and explicit knowledge, this mean that implicit knowledge is the type of knowledge that can be articulated but has not.

2.3.6 Knowledge Management Models description

Literature and praxis reveal that there are many KM models as there are practitioners and theorist alike – from specialized functional or packaged KM models of business functions to diffused KM, such as in terms of different grouping (Kakabadse et al, 2003). The main models are the philosophy model, Cognitive model, Network model, Community Model and Quantum Model, the Table 4 shows provides a summary of each model:

	Philosophy-based model	Cognitive model	Network model	Community model	Quantum model
Treatment of knowledge	Knowledge is "justified true belief"	Knowledge is objectively defined and codified as concepts and facts	Knowledge is external to the adopter in explicit and implicit forms	Knowledge is constructed socially and based on experience	System of possibilities
Dominant metaphor	Epistemology	Memory	Network	Community	Paradox
Focus	Ways of knowing	Knowledge capture and storage	Knowledge acquisition	Knowledge creation and application	Solving paradox and complex issues
Primary aim	Emancipation	To codify and capture explicit knowledge and information – knowledge exploitation	Competitive advantage	Promote knowledge sharing	Learning systems
Critical lever	Questioning, reflecting and debating	Technology	Boundary spanning	Commitment and trust	Technology
Primary outcomes	New knowledge	Standardization, routinization and recycling of knowledge	Awareness of external development	Application of new knowledge	Creation of multi-reality
Role of IT based tools	Almost irrelevant	Critical integrative mechanism	Complimentary interactive mechanism	Supporting integrative mechanism	Critical-Knowledge centric

Table 4 Knowledge Management perspectives (Kakabadse et al, 2003)

2.4 Enterprise reference architectures

2.4.1 General Concepts

This research work is developed in the context of Architectures, Reference model Methodologies and Models. It is important to differentiate these concepts within Enterprise Integration Engineering context.

Enterprise Integration cannot be bought (Bernus et al, 1996); it must be tailored to the specific needs of each company. The integration of a company is not only a technological matter about integrating applications and equipment. Therefore companies need a guideline to or methodology to succeed in this task.

Architecture refers to an organized set of elements with clear relationships to one another, which together form a whole defined by its finality (Vernadat, 1996). Reference Architectures are intellectual paradigms which facilitate analysis and accurate discussion and specification of a given area of discourse, they provide a way of viewing, conceiving and talking about an issue. Most representative reference architectures are: PERA, CIMOSA and GERAM.

A framework refers to a collection of elements put together for some purpose (Vernadat, 1996). A methodology is a set of methods, models and tools to be used in a structured way to solve a problem (Vernadat, 1996) and a model is a representation of description of an entity or a system, describing only the aspects considered to be relevant in the context of its purpose (International Standard Organization, 1997).

According to Williams (1994) to be valuable an Enterprise Reference Architecture should be able to supply answers or solutions to all or most of the following requirements:

1. Show the evolution of an enterprise development program through its life cycle.
2. Guide all the parties in the different areas of the enterprise for a diverse type of industries.
3. Incorporate different views to describe the entire enterprise.
4. Describe the place of the human in the organization.
5. The architecture should be independent of the technology employed.
6. Present a method for the breakdown of all system functions into their inherent generic functions.
7. Provide a common structure to be used by individual enterprise as a particular architecture.
8. Provide guidelines for the development of new standards.

During the years many reference architectures have been developed by private, governmental and standards organizations, these last years the focus on the development of this architectures have been in generic architectures for all kind of device, system or enterprise. The following section presents the most important Reference Architectures.

2.4.2 Review of reference architecture: CIMOSA, PERA, GERAM and VERAM

2.4.2.1 CIMOSA

CIMOSA (Open Systems Architecture for CIM) has been developed by AMICE as part of ESPRIT projects jointly financed by the European Commission and 30 project partners since 1986. "The goal of CIMOSA is to help companies to manage change and integrate their facilities and operations to face worldwide competition and to compete in price, quality, and delivery time" (Vernadat, 1996).
CIMOSA provides three interrelated concepts (Bernus et al, 1996):

- Modelling framework
- System life cycle and environments
- Integrating infrastructure

CIMOSA recognizes previous efforts in enterprise integration especially in the manufacturing industry and draws from the experience already gained in enterprise modelling and computer systems integration.

"CIMOSA provides a reference architecture in its modelling framework for the specific description of a particular enterprise. CIMOSA facilitates a system life cycle which guides the user through model engineering and model execution. Model engineering and model execution is supported by the CIMOSA integrating infrastructure" (ESPRIT Consortium AMICE, 1993). The figure 5 shows the CIMOSA framework.

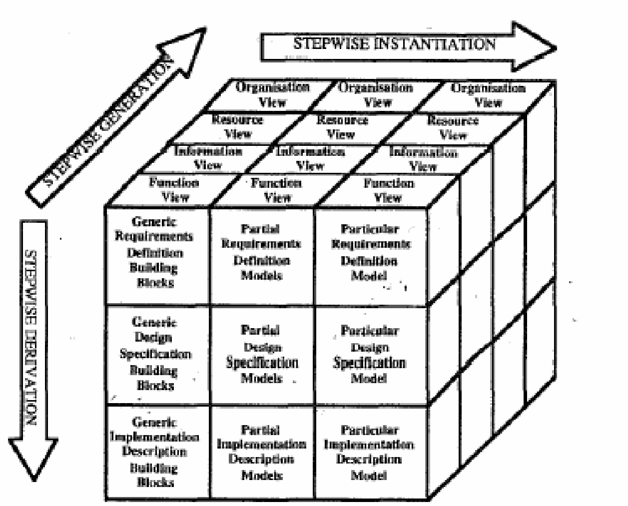

Figure 5 CIMOSA Modelling Framework (ESPRIT Consortium, 1993)

CIMOSA have been validated in many ESPRIT projects (Kosanke et al., 1999) with substantial benefits some of the industries in which have been applied are: FIAT (Automotive), Magneti Marelli Ricambi (Automotive), Koehler (Paper production), Traub (Machine tools) and Elval (Aluminium casting).

2.4.2.2 PERA

PERA (Perdue Enterprise Reference Architecture) and its related methodology work stated in 1989 in Purdue University (Williams, 1992). PERA is characterized by its layering structure. It has been created to cover the full enterprise life cycle from inception and mission definition down to its operational level and final plant obsolescence. Each layer describes a task phase. Each phase is informally described by a technical document as a set of procedures for user's applications group through all the phases of the enterprise development program (Vernadat, 1996). Figure 6 presents the different layers description among the system life cycle.

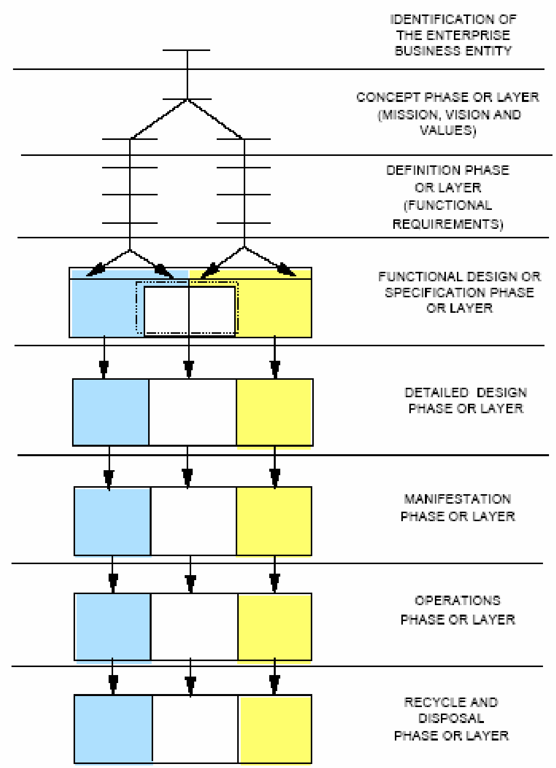

Figure 6 Different layers of PERA (Williams, 1992)

PERA most important concept is the life cycle, the life cycle starts with the identification of the business entity that is the object that it is going to be analyzed. Then in the concept phase, the architecture describes mission, vision and values of the entity. The definition phase defines basic requirements for manufacturing personnel and information policies on one side, and product and manufacturing units on the other side. Next, the functional design layer defines functional requirements, instrumentation and control diagrams, management and union mandated requirements, and plant layout. The Detailed design layer is concerned with detailed physical design. The manifestation layer corresponds to plant installation. The operational layer corresponds to day-to-day exploitation of the plant and continuing process development and maintenance layout (Vernadat, 1996) PERA has been used in industrial applications. The most famous example, The Flour Daniel Company used PERA in their project work. They have used PERA to present a framework around which much of their current work practices can be organized (Williams, 1995).

2.4.2.3 GERAM

In 1990 the IFAC/IFIP Task force on architecture on Enterprise Integration was formed. The objective of this task force was to select the best architecture from the existing ones to be used ad a single universally accepted architecture in the field of Enterprise Integration, the principal architectures that analyzed by the task force were CIMOSA, PERA and GRAI-GIM

During the analysis of this architecture, the following conclusions were defined:

- There are many architectures or frameworks for Enterprise Integration
- Many of them have similar concepts presented in different types of graphical models.
- None of the architectures cover completely all the aspects required by the Task Force
- The Task Force did not pick a single methodology, because each one has unique characteristics.
- The Task Force decided to create a new model formed with the sum of the useful characteristics of each architecture.

Based on this, the Task Force developed GERAM (Generic Enterprise Reference Architecture and Methodology), "The purpose of GERAM is to serve as a reference for the whole community concerned with the area of enterprise integration providing definitions of the terminology, a consistent modelling environment, a detailed methodology, promoting good engineering practice for building reusable, tested, and standard models, and providing a unifying perspective for products, processes, management, enterprise development, and strategic management" (Vernadat, 1996). During year 2000 GERAM was accepted as an annex to ISO 15704: 2004 which is a standard that establish the requirements for enterprise reference architectures and methodologies.

GERAM includes the most important elements of the architectures before mentioned, in the case of GERAM; the reference architecture has three major elements that must be considered. Firstly, the life cycle establishes the stages of the enterprise development program, secondly the views used to represent the entity dynamics and finally is the instantiation process; figure 7 shows these three elements:

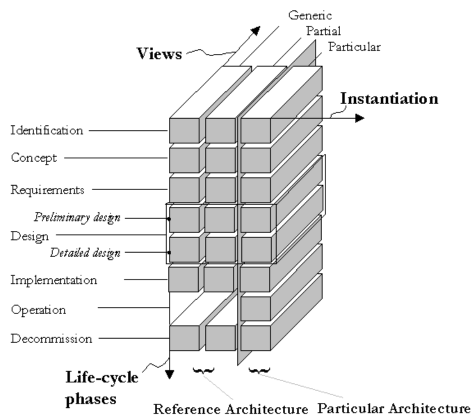

Figure 7 Description of GERAM Reference Architecture (GERAM, 1998)

GERAM provides a description of all the elements recommended in enterprise integration engineering and thereby sets the standard for the collection of tools and methods from which any enterprise would benefit to more successful initial integration design, and the change processes which may occur during the enterprise operational lifetime. It does not impose any particular set of tools or methods, but defines the criteria to be satisfied by any set of selected tools and methods (GERAM, 1999). Figure 8 shows the major tools and methods needed for GERAM:

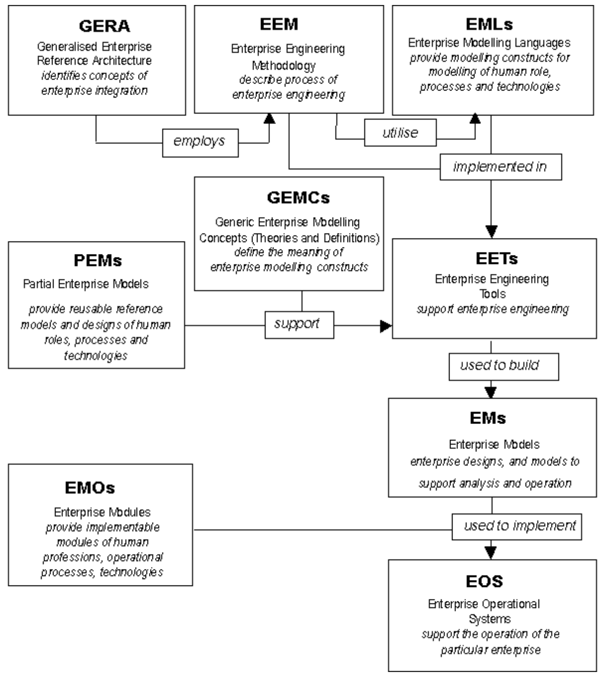

Figure 8 GERAM Framework Components (GERAM, 1998)

Due the differences founded in the operation of particular organizations, has been identified that enterprise modelling is not only applicable for one particular organization, enterprise modelling concepts can be used to describe operations of EE's (Extended Enterprises) and VE (Virtual Enterprises) as well (Kosanke et al, 1999). Based on this, the design of this type of organization may need personalized versions of Enterprise Engineering Methodologies (EEM), Enterprise Modelling Languages (EML) and Enterprise Engineering Tools (EET).

It is important to mention that the architectures analyzed previously are not suitable for the creation, launching and maintenance of a VO. For this reason they do not address the needs of a VO like cluster formation, partners search and information exchange between partners.

2.4.2.4 VERAM

VERAM (Virtual Enterprise Reference Architecture and Methodology) have been created in the IMS GLOBEMEN Project. VERAM organizes all the knowledge about the formation and operation of Virtual Enterprise (Zwegers et al, 2003) and this is a specialization of GERAM (ISO 15704:2000). VERAM was created using GERAM as basis, but VERAM in developed within a VE context.

VERAM structure the elements that support modelling formation/setup, management and ICT support of VE's, such as reference models, and supporting tools and infrastructures.

Regarding to VERAM, this architecture includes the same way the GERAM concepts related with *entity life cycle* and *life history,* and *recursiveness*. As regards to the views concepts of GERAM, the *entity purpose* view has been systematically applied. In addition, the views concepts have been used as follows *Entity Model Contents Views* (Functional, information, resource and organization) by referencing when needed. The *Entity Implementation view* has not been used explicitly but is nevertheless dealt with through systematic application of a traditional Industrial Engineering Work preparation approach to the preparation of VE's. Lastly, the *Entity Physical Manifestation View* component "software" was dealt with due to the fact that all industrial demonstrators were software projects (Vesterager et al, 2000).

Figure 9 shows the main components of VERAM, this architecture has three layers, in figure 9 VERAM first layer is the only one that is shown. This layer includes VERAM component that are used during the application of the architecture in practice. It consist of those tools, applications, applications and models that can be used during the formation and operation of VE's (TØlle et al, 2002)

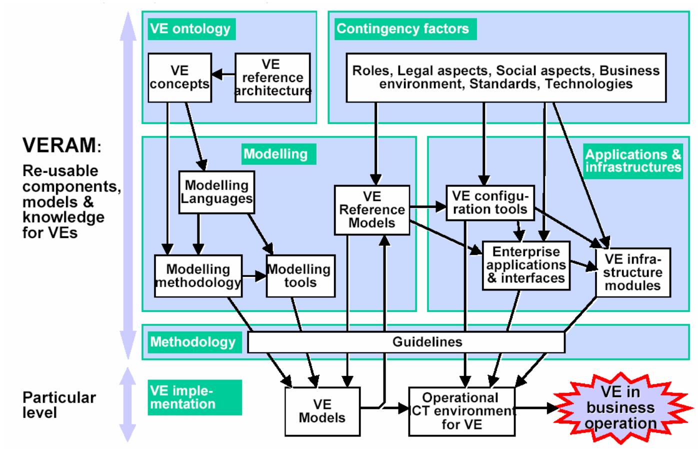

Figure 9 VERAM Components (Globemen, 2002)

The purpose of the architecture is to structure a knowledge body that support future work in the area of global engineering and manufacturing in enterprise networks. The architecture aims to solve the problems of VE formation, operation and maintenance. In addition to operate and set up a virtual enterprise from a dynamic enterprise network.

2.5 Literature Review Discussion

Based on the performed review about Virtual Organization, The author has noticed:

- The concept of Virtual Organizations have been under studied during several years, this provides a good conceptual, it is important to mention that concepts has knowledge exchange, negotiation and contracting must need further years of research in order to provide a good conceptual foundation to the VO.

- During the last years complex ICT support tools are been developed, based on this tools the VO concept achieved a more agile concept. Although these tools help the improve VO dynamic, this tools do not achieve the entire life cycle of a VO.
- Researches on knowledge management are focused on the development of the technologies that will support knowledge sharing process among the Virtual Organization.

- Few researchers have explored how reference architectures should provide a basis for Virtual Organization creation and launching.
- A remaining open issue is to cover the legal issues related to VO; this is made in order to provide a strong basis for topics such as intellectual property, responsibilities and agreements.
- Another remaining issue in VO's is related to the establishment of appropriate performance metrics and partners selection methods for VO's.

Nowadays VO faces the challenge of establish the theoretical and technological infrastructure that provide enough support to achieve well structured methods for planning and launching of Virtual Organization. Virtual organizations (VO) have been rapidly growing within collaborative business environment. VOs seem to have a lack of integration among all the topics that this concept comprises, and this in an important issue to be tackled. There are just a few works where an integrated approach of VO creation and launching is considered. Based on this, there is need to develop work related to VO planning and launching. Due to the dynamic nature of Virtual Organizations a reference model which involves all types of these organizations is needed. Thus, a good opportunity is the creation of a novel approach that enables an integrative perspective during VO planning and launching.

As a result, this research work intends to tackle the major issues already mentioned in this analysis. The author of this thesis proposes a reference model for planning and launching of virtual organizations. The reference model looks to integrate important elements during VO planning and launching.

Chapter 3. - Virtual Organizations Planning and Launching Reference Model

The research work included in this chapter describes a reference model for VO planning and launching (VO Frame), within this reference model all the issues related with VO creation are proposed using a systematic approach. Most of this research work is based on the work made by TØlle (2004), Camarinha-Matos (2005) and experiences obtained from IECOS[3] operation.

As the reference model is deployed during Virtual Organizations lifecycle, a Systematic approach for VO planning and launching is achieved.

In the reference model are included all the mentioned themes in chapter 2 (Knowledge management, Enterprise reference architectures, Virtual Organizations) as major components of the reference model in order to provide a integrative tool that involves all major components that influence during VO planning and launching.

The chapter is structured as follows, the first section presents a brief description of the elements that support VO Frame; the following three sections provide a detailed description of the three element of VO Frame. Finally, a section were the integration and use of VO Frame elements is shown.

3.1 VO Frame elements.

3.1.1 VO Frame description

The reference model has a structure based on GERAM elements. Using GERAM is possible to develop a reference model with a robust theoretical foundation and to achieve an Enterprise Integration Engineering approach during VO planning and

[3] IECOS is brokering firms located in Monterrey, México, The competencies of the firm are: Constructions systems, Supply and Engineering services. IECOS looks to integrate the competencies of their network partners.

launching. Figure 10 shows how the reference model (VO Frame) is supported by three components. The first component is a set of six phases (CO analysis, Partners selection, Preliminary VO planning, Detailed VO planning, VO set up and Scheduling) that defines the guidelines for VO planning and launching based on methodological aspects defined in TØlle (2004) and ECOLEAD (2005), the second element is a multidimensional modelling approach composed by four modelling views, through the modelling approach it is possible to represent the interactions of all the elements involved in VO planning and launching stages, finally, the third element is a mechanism that allows knowledge capturing and sharing during VO planning and launching, throughout this element is possible to capture the knowledge created during the development of the activities required by the six phase included in VO frame first element.

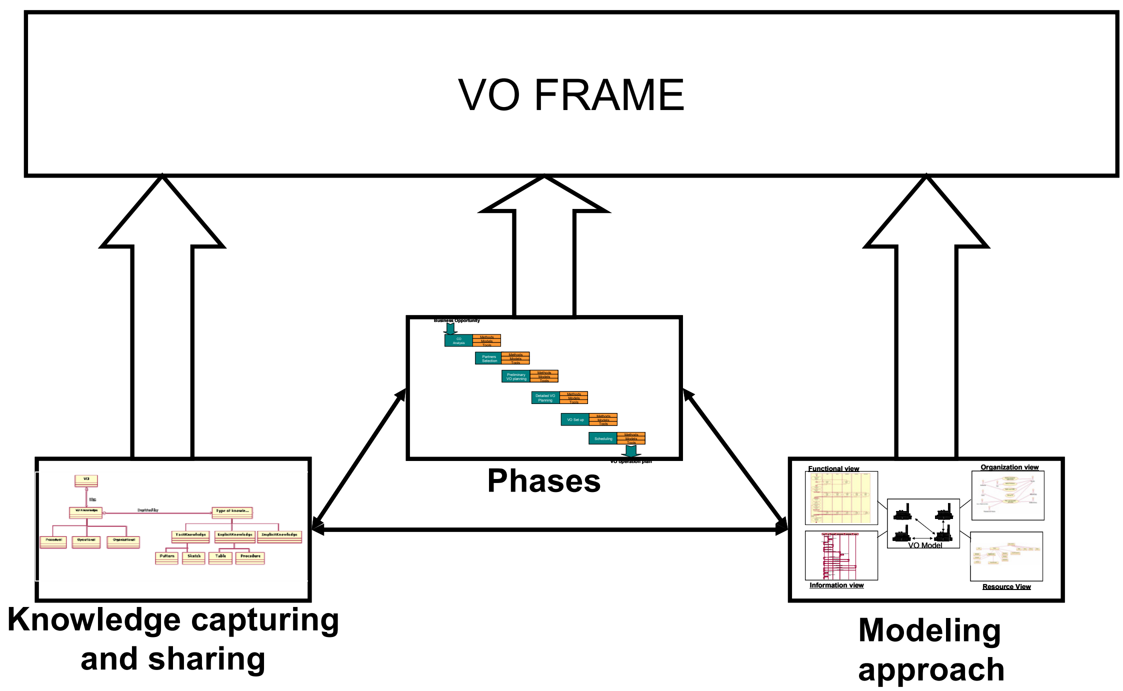

Figure 10 Elements that support VO Frame

In the following sections, a detailed description of VO Frame is presented. The description sequence is:

1. VO Frame: Phases
2. VO Frame: Modelling approach
3. VO Frame: Knowledge capturing and sharing mechanism.

3.1.2 VO Frame: Phases.

To provide a flexible methodological approach during VO planning and launching, VO frame has six phases: (1) Collaboration Opportunity analysis, (2) Partners selection, (3) Preliminary VO planning, (4) Detailed VO planning, (4) VO set up. The purpose of these phases is to establish the basic guidelines for VO planning and launching activities.

The phases included in VO frame can be customized according to specific VO requirements. Phase’s customization is based in three elements: (1) methods used in the phase, (2) tools that support the activities required in the phase and (3) models that represents the dynamics of the phase. Figure 11 describe the structure of VO Frame phase and how methods, tools and models are included in each VO Frame phase.

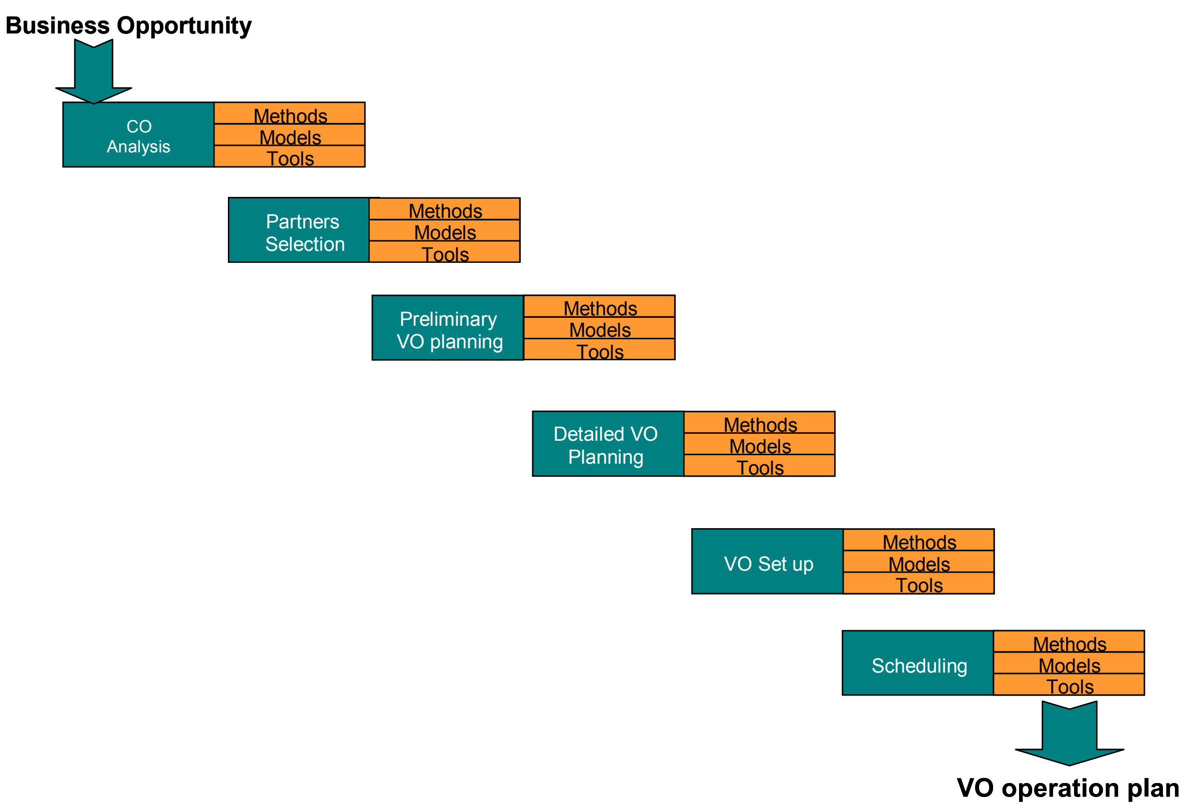

Figure 11 VO Frame phases

In VO Frame, two overall types of use of their six modules are being envisioned:

1) General use (Step-by-step):

Using the modules step-by-step from top to bottom can support the set up of more formalised VOs. This could either be an enterprise already operating in a sort of networked environment but where a need for further preparation and clarification is needed in order to be able to set up effective VOs efficiently, i.e. in a competitive manner with regards to e.g. time, cost and quality.

2) Selected use (pick relevant activities):

As an alternative to using the whole list step-by-step, selected activities can also be used to support within a certain sub-part. This could be the case if a more formal enterprise network has already been established. In this case the list in general can work as a kind of checklist and serve as inspiration for how the network could be configured or prepared in a different matter. If a need for reconfiguration is identified then the list could be used in more detail to support one or more of the described activities.

VO Frame modules define general guidelines for VO planning and launching, table 5 presents a detailed description of each VO frame module according to figure 13.

Phase	Description
Collaboration Opportunity (CO) analysis	Include all the activities required when a partner in confronted with a collaboration opportunity, this phase includes activities such as: network capabilities assessment, Scope definition, CO classification, CO representation and feasibility analysis.
Partners Search and Selection	Partners search and selection includes assessing if the partner possesses enough capabilities, i.e. have knowledge and experience to fulfil the type of works as well as have needed capacity at the request time. In this phase are included activities such as: Members capabilities assessment, definition of search mechanism, specification of preferences, etc.

	The more extensively the partners have been assessed in the network the less assessment needs to be done as a part of the VO and vice versa.
Preliminary VO Planning	This phase defines a rough VO plan in order to establish the basis for a more detailed VO planning; this rough plan can be used during partners search and selection to optimize the selection of partners. In this phase should developed activities such as identification of required competencies, preliminary VO modelling, Simulation, task decomposition, preliminary topology definition, etc.
Detailed VO planning	This phase uses the rough plan developed in the previous stage as basis. In this phase the activities must be developed in order to define the negotiation activities to be made, assign roles and responsibilities, definition of operating and contracting rules.
VO Set up	Set up of a VO highly depends on the type and level of work preparation already determined in VO planning stages. The more the VO planning has been developed , less work has to be made during VO set up and more it can be an instantiation of previously prepared VOs, the set up includes: • Set up VO infrastructure, e.g. a multitier (partner) project structure, define access rights and interfaces with partner's legacy systems. • Deploy VO rules, template to be used, Reference Models to instantiate in the specific situation, other tools, etc. • Contractual issues (Contracting process), e.g. contract

	reference models to use. • VO organization, e.g. standard roles or ad hoc, depending of the specific project.
Scheduling	Here two scheduling level should be considered, The first one is an Inter-Organizational scheduling, where the schedule generated should represent the VO activities sequence and the second level is a Intra-Organizational scheduling, here all the partners have to make more detailed description of the internal activities that must do in order to achieve the deliverable required.

Table 5 Description of VO Frame phases

Table 6 presents several methods and tools that can be used in VO frame phases according to specific VO characteristics. This feature provides high flexibility and adaptability to VO Frame by including customized tools into VO planning and launching stages.

VO Frame Modules	Methods	Tools
Collaboration Opportunity Analysis	Feasability analysis	Worksheets (Mejia and Molina, 2002)
Partners Selection	Service-Based Model, Mathematical models (Ivanov et al, 2003), Skill Matrices, Profile Based (Tsakopoulos et al, 2003), IMMPAC Methodology (Molina et al, 2003), Analytic Hierarchy Process (Khurrum and Faizul, 2002)	Match Making Engine (Field and Hoffner, 2002), Multi-Agent systems (Rabelo et al, 2003), UDDI (Camarinha-Matos, 2005, Kaletas et al, 2005)
Preliminary VO planning	Capability and capacity analysis (Mejia and Molina, 2002), Functional decomposition (PMI, 1996), Business plan techniques (Mejia and Molina, 2002)	Expert systems, worksheets (Mejia and Molina, 2002), Product decomposition, Visio
Detailed VO planning	Game theory (Kerr and Wu,2003), E-Negotiation (Cunha et al, 2002), PMBOK (Mejia and Molina, 2002)	Multi-Agent Simulation (Marik and Pechoucek, 2003), Contract Net Protocol (Kaihara and Fujii, 2002), Q-learning algorithm (Kaihara and Fujii, 2003), WBS (Tolle, 2004), Last Planner
VO Set up	e-contracting (Ren et al, 2004), Service Level Agreements (Duncombe, 1992, Ignatiadis and Tarabanis, 2004), Sensibility analysis	Multi-Agent Systems Simulation (Marik and Pechoucek , 2003), Multilevel supply chain simulation and optimization (Machado et al, 2003), WISE (Kasahara et al, 2003), VE cockpit (Rabelo et al, 2004)
Scheduling	CPM/PERT (Lewis, 1995), Evolutionary Techniques (Sarker et al, 2002) , Method123, FIFO (Askin and Standridge, 1992)	WFMS (Kaletas et al, 2005), Simulation (Kasahara et al, 2003), Gantt Charts, SUPREME (Nishioka et al, 2003), APS (Nishioka et al, 2003), MS Project, Activity-On Arrow (Lewis, 1995), Decision Tree Analysis (Lewis, 1995), Xplan

Table 6 Methods and tools that can be used in VO Frame

3.1.3 VO Frame: Modelling Approach

Modelling is one of the key activities in understanding, designing, implementing, and operating systems. Modelling is at the very heart of any scientific and engineering activity (Ecolead, 2005). VO frame has a modelling scheme based in GERAM; the modelling scheme includes four modelling views (Functional, Organizational, Resource and Information) that represent a specific perspective of the VO. The purpose of each modelling view is:

a) **Functional**: This view represents the behaviour of the entities involved in the processes developed in the life cycle.
b) **Information**: This view represents the information and knowledge structure among the entities involved in the Virtual Organization, and the exchange relationships among these entities
c) **Organization**: Represents the responsibilities, authorities and relationships of all the entities involved in the Virtual Organization.
d) **Resource**: This view represents all the resources (Human, Technological, etc.) employed by the processes developed by the Virtual Organization in order to achieve their objective.

The four modelling views establish the basis for the creation of a model which integrates all modelling views.

Using the four modelling views an integrated model is built. This integrated model is called VO model. VO model (See figure 12) purpose is to provide a multidimensional perspective of VO behaviour through the integration of the four modelling views. VO model is composed by a set of diagrams focused in representing information, functional, organizational and resource views. These diagrams serve to represent the behaviour of VO entities during VO planning and launching.

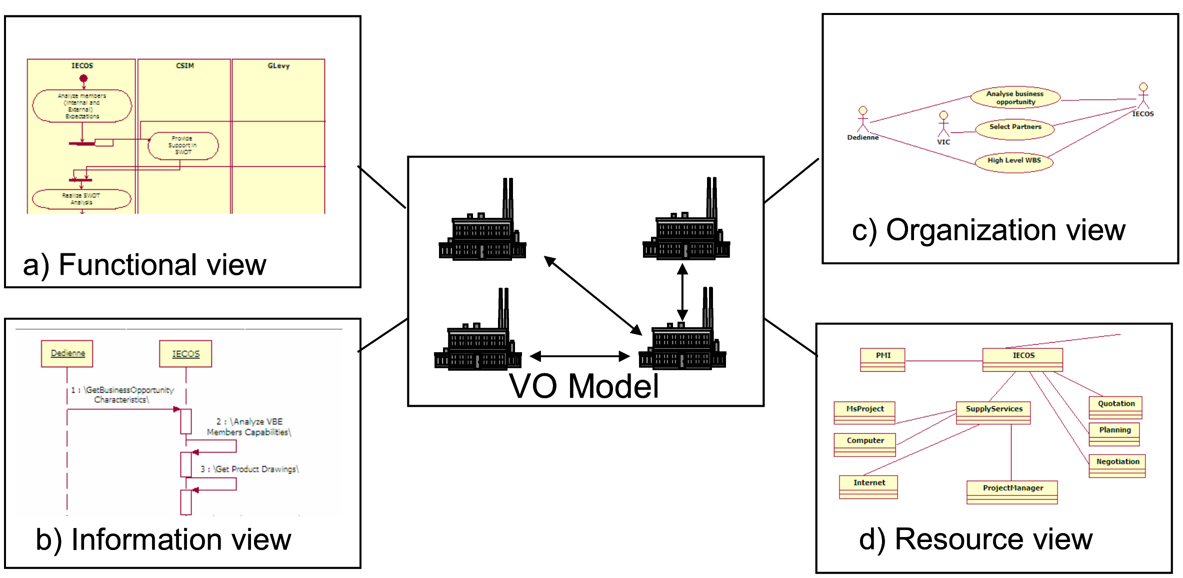

Figure 12 VO Model elements (Adapted from Molina, 2004)

An important element to create the VO model is the modelling language which support the modelling efforts needed to create the diagrams that support the VO model. In this research the modelling language used is UML (Unified Modelling Language). UML is a family of graphical notations backed by single meta-model that help in describing and designing systems, this language built these systems using an object oriented approach (Fowler, 2004).

The selection of the UML diagrams to be used in the modelling process depends mainly on the level of detail required in VO model to be created. Before selecting the diagrams, the members involved in the modelling process should define the detail level and scope of the VO model.

During the creation of the VO model an important element is the commitment degree and modelling capabilities of the VO partners. The VO members involved in VO planning and launching should clearly understand the detail level required to develop a VO model that accurate represents the behaviour of all the entities involved in VO planning and launching.

3.1.4 VO Frame: Knowledge capturing and sharing mechanism

During the development of this research work the need to establish mechanism for knowledge management in VO planning and launching was identified. Due to this, VO Frame provides a basic mechanism for knowledge capturing and sharing. This mechanism is composed by three knowledge domains. A knowledge domain is defined as a sphere of activity, concern of function where certain knowledge is related. The knowledge domains are:

- **Organizational Knowledge**.
  This domain includes all knowledge related with VO structure, members profile, roles, competencies, authorities and available resources.
- **Procedural Knowledge**
  This domain includes knowledge which represents the way that VO's work; this can be work procedures, member's responsibilities, business processes, etc.

> **<u>Operational Knowledge</u>**

This includes knowledge related with the status of the activities been developed within VO, can be Gantt Charts, Quotations, Quality Inspections Reports, etc.

The purpose of each knowledge domain is to serve as a filter for the knowledge generated during VO planning ad launching. Figure 13 describes the roles of the three knowledge domains within VO planning and launching. These domains serves a knowledge filters (See figure 13) for all the knowledge generated during VO planning and launching activities.

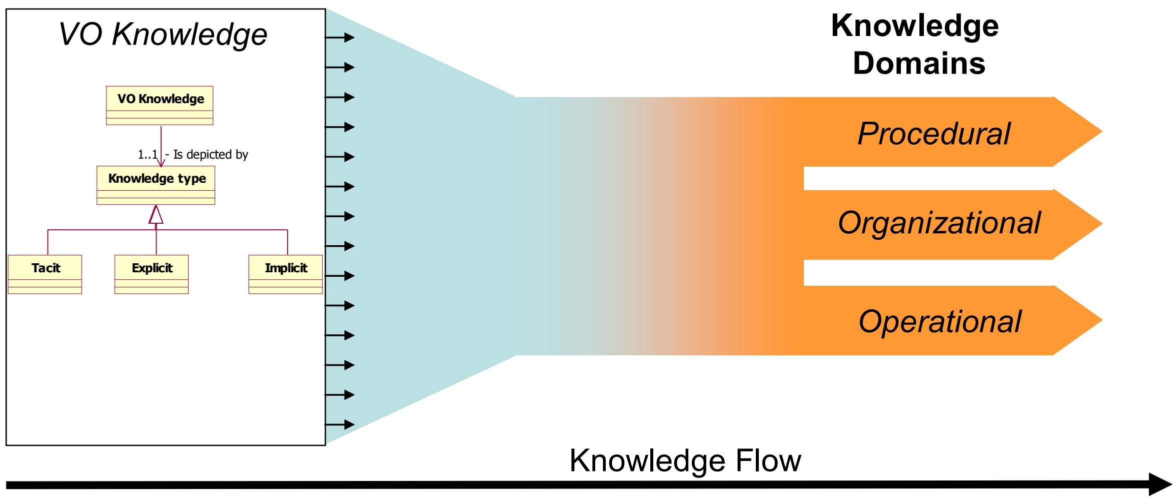

Figure 13 Knowledge Domains effect in VO knowledge

These three domains provide a structure that supports knowledge creation during VO planning and launching. Figure 14 shows how knowledge domains are related with the knowledge created during VO planning and launching stages, in this class diagram is shown that the VO has knowledge; VO knowledge can be of a specific type of knowledge (explicit, tacit or implicit); finally, VO knowledge is captured by a knowledge domain.

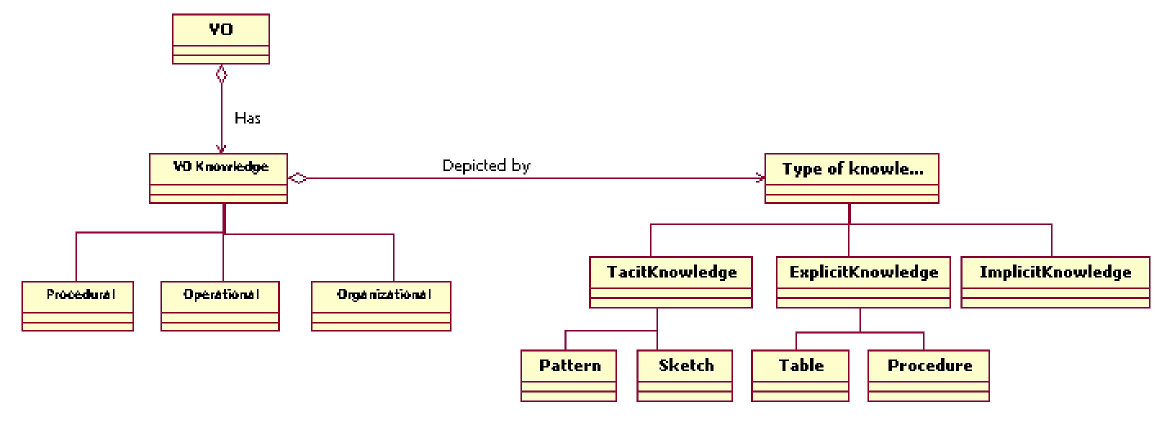

Figure 14 Knowledge domains structure (Adapted from Guerra, 2004)

In VO Frame, knowledge domains are the mechanism that enables knowledge capturing and sharing among VO members during VO planning and launching. However, these domains can be deployed through entire VO life cycle.

3.2 VO Frame elements integration.

To implemented VO Frame it is important to create understanding of the elements of the reference model as an integrated entity. Figure 15 describes how the three elements of VO Frame are integrated; VO Frame phases are the element that guides the integration of the other two VO Frame elements. For each phase, specific methods and tools should be selected according to particular characteristics of a VO; also, a model should be created in each phase to represent function, organization, information and resource view, through the creation of this model is possible to integrate two elements of VO Frame (VO Frame phases and modelling approach). Table 7 describes how modelling views are represented in VO Frame phases, each modelling view is supported by a model created used a set of diagrams that allow the creation of a descriptive representation of the elements involved in each VO planning and launching.

VO Frame Life cycle	Function	Resource	Information	Organization
Planning	-Description of the process to: -CO analysis -Partners search and selection -Preliminary VO planning	- Describe the human and technological resources needed to perform VO planning process. (Human resources: Managers, government workers, customers, members representatives, etc; Technological (Databases, WFMS, ICT, computer equipment, project management software)	-Representation of the data/information that will describe the need for the creation VO, this include, SME in a VBE, Degree of collaboration, VBE economic data Partners capabilities documentation	- Description of organizational entities that will be involved during the entire process, this include; members profiles, Universities, Professionals, Government Institutions
Launching	Describe the process to define: -Detailed VO planning -VO Set up -Scheduling	-Describe members resources needed to perform the activities required by the VO (VO Members) and technological resources required (WFMS, Email, Database, Telephone, etc.)-	- Representation of the information involved in VO launching, this includes (WBS charts, Organizational charts, Gantts, Members roles, information models, transactional models, etc.)	-Explanation of the organizational entities that will perform VO planning an launching process -For example: -Broker -Manager -Integrator

Table 7 VO Frame phases relationship with the four modeling views

Regarding to VO Frame knowledge capturing and sharing mechanism, this element interact with VO Frame phases as they are developed. Figure 15 shows how knowledge domains are integrated to VO Frame phases, to enable the use of VO Frame knowledge domains; firstly a manual or computer assisted knowledge repository should be created, once the repository was created, knowledge domains are mapped into VO Frame phases. Based on this the integration of knowledge domains with VO frame phases is made through a knowledge repository created based on the structure shown in figure 14.

During the use of VO Frame phases great amounts of knowledge is generated, however this knowledge is not structured; through VO Frame knowledge domains, the knowledge generated during VO Frame phases is captured and shared in a structured way in the knowledge repository created.

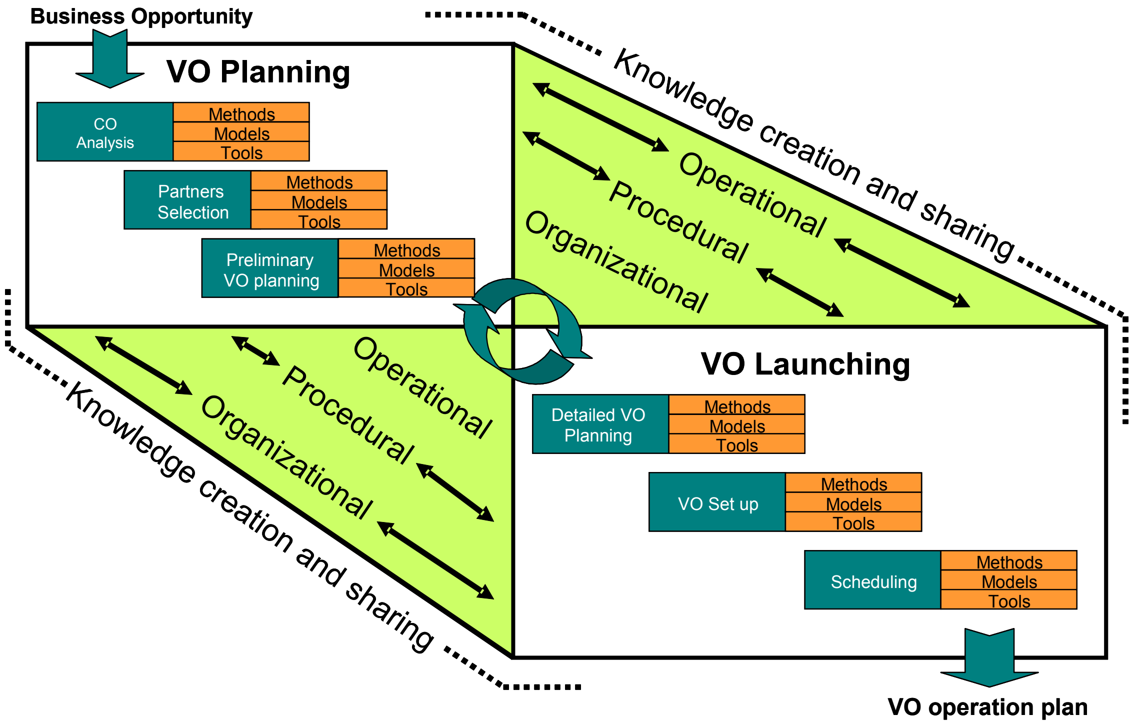

Figure 15 VO Frame structure.

In figure 15 is shown the integration of VO Frame elements, VO Frame knowledge capturing and sharing mechanism relation with VO Frame phases is presented as the knowledge structuring process among VO Frame phases according to knowledge domains presented in section 3.1.4. The models required in each VO frame phase represents the way that VO modelling approach is related with VO frame phases.

In this research work, a genericity dimension is achieved. A genericity dimension provides the controlled particularisation (instantiation) process from generic and partial to particular. Figure 16 shows how VO Frame is instantiated. During the instantiation process VO Frame is instantiated into IECOS particular model, finally IECOS is instantiated into particular VOs.

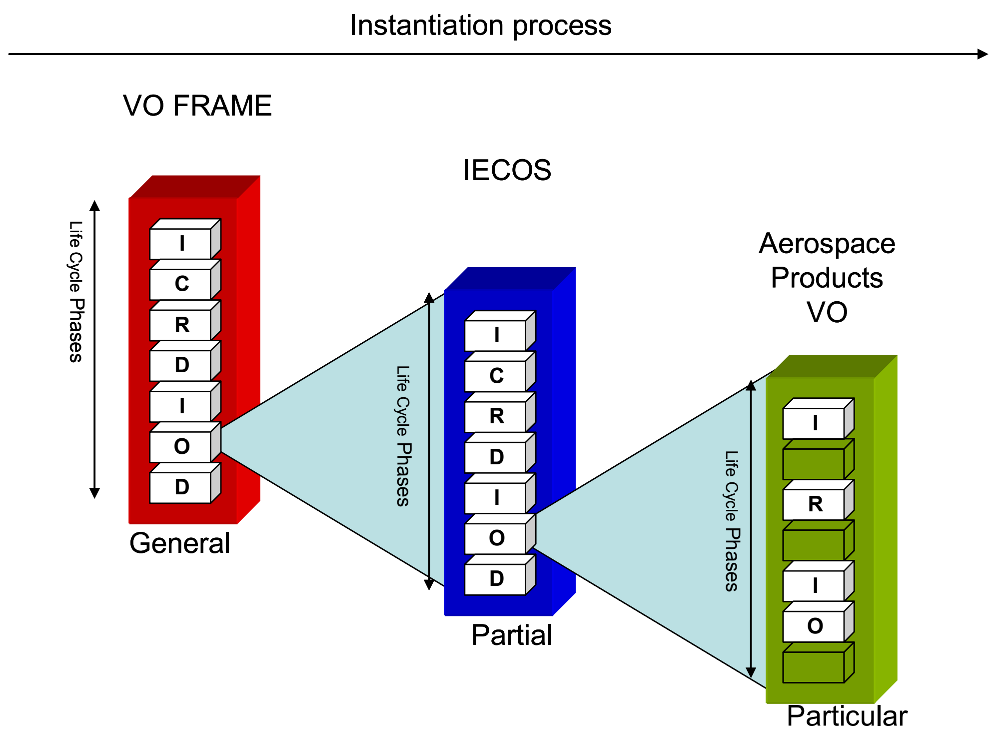

Figure 16 VO Frame Instantiation

VO Frame can be represented in several ways; figure 17 shows a model of VO frame. This model is UML (Unified Modelling Language) class diagram where all the elements of the reference model are included as classes. Four super classes define the structure of the model, the classes are: VO creation stages, VO modelling views and knowledge domain. Based on the concept of inheritance (Inheritance in the object model is a means of defining one class in terms of another) several sub classes are contained in each primary class. Figure 17 shows the relationships between the super classes and subclasses.

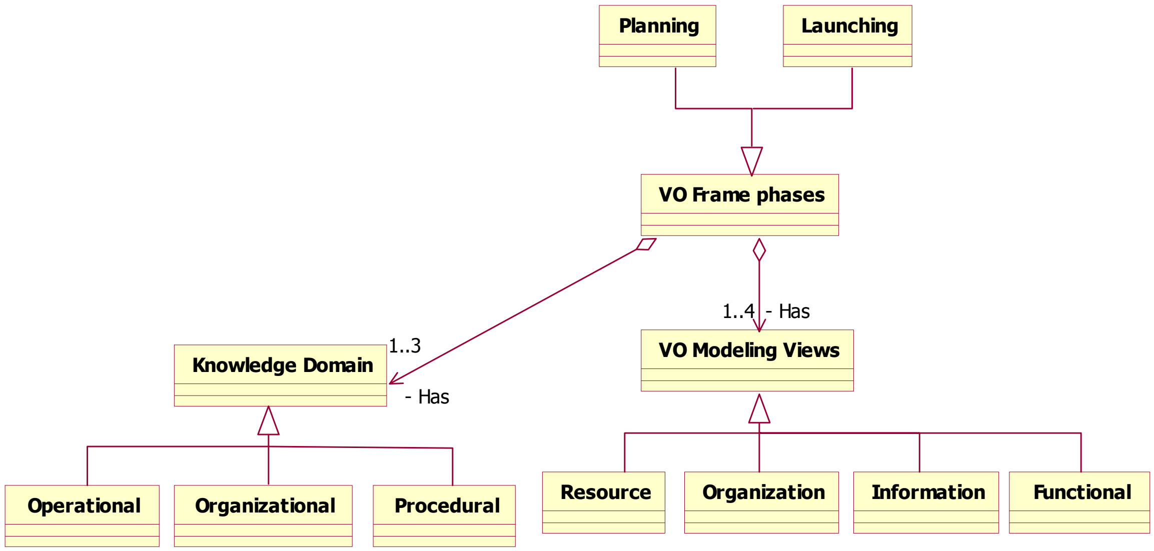

Figure 17 VO Frame model

VO creation stage super class, has two sub-classes (Planning and Launching), according to figure 13, Planning class has the following instances: (1) CO analysis, (2) Partners search and selection, (3) Preliminary VO planning. Launching class is instantiated into: (1) Detailed VO planning, (2) VO setup and (3) scheduling. All these classes correspond to VO Frame modules. VO modelling views super class has four sub classes (Resource, Organizational, Information and Functional); each class represents one of VO Frame modelling views. Knowledge domain class has three instances (Operational, Organizational and Procedural); these classes correspond to VO Frame knowledge domains.

Regarding to the relationship between knowledge domains and the modelling views, this two elements are involved as follows: a knowledge domains can be capture a specific type of knowledge, in this case the models for each modelling view will represent explicit knowledge, however this is a type of knowledge, each knowledge domains can capture this type of knowledge, but the criteria that defines in which knowledge domain the models of the modelling views will be capture is be based on the purpose of the knowledge domain. Based on this, models from organization and resource view will be capture in organizational knowledge domains, for the models from information and functional view will be capture in procedural knowledge domains. Finally, due to the models created in the four modelling view will not represent the status of the activities or process developed in the VO, this models cannot be captured in operational knowledge domain.

Chapter 4. - The use of GERAM to formalize VO planning and launching reference model

4.1 Using GERAM to formalize VO Frame.

4.1.1 Identification of GERAM components in VO Frame

The reference model (*VO Frame*) has a structure based in GERAM Components (see appendix 1). GERAM provides a consistent approach which serves as a basis for VO Frame structure in order to achieve an integrative approach during VO creation.

VO Frame uses seven GERAM Components to represent and modify the different entities that take part in the VO planning and launching stages. These components results from the standardization of architectures in the enterprise integration field, they have been specially created for the enterprise engineering field, based on these components it is possible to generate a reference model that will be a instance of an enterprise architecture. Figure 18 shows GERAM components identified in VO Frame.

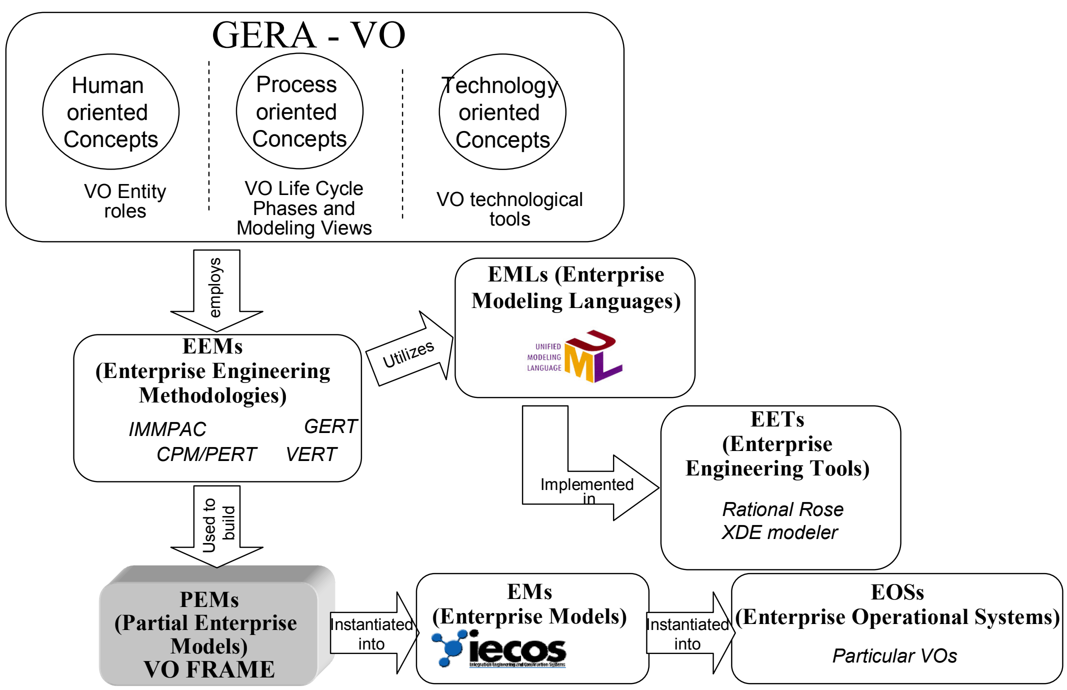

Figure 18 GERAM Components in VO Frame (Adapted from Carrasco, 2003)

Instantiation is an important element of GERAM; based on GERAM it was identified that VO Frame can be instantiated into particular cases, based on this the concepts of Virtual Organization are included in a partial level of the instantiation process. (See figure 19).

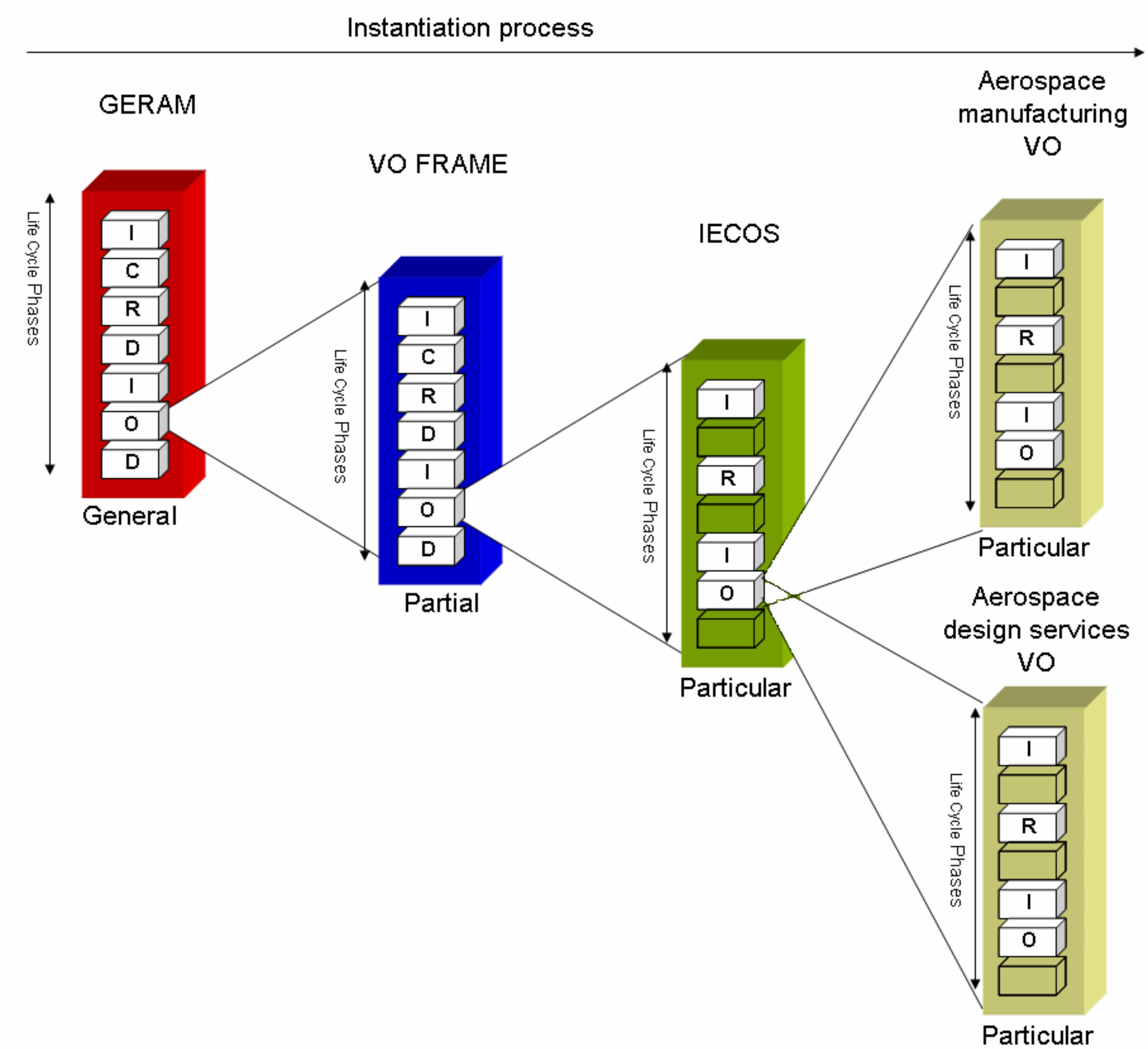

Figure 19 VO Frame interaction during GERAM instantiation process.

Life cycle is an important element of GERAM. Regarding to VO, a life cycle has been defined, the lifecycle has three stages: (1) Creation; (2) Operation; (3) Evolution/Dissolution. In VO Frame, creation stage is divided in two sub-stages: (1) Planning and (2) Launching. These two sub-stages are included in the reference model presented in this research work. Figure 20 shows the relationship between the VO life cycle and GERAM Life cycle, depicting how VO creation stage is divided in VO Frame stages.

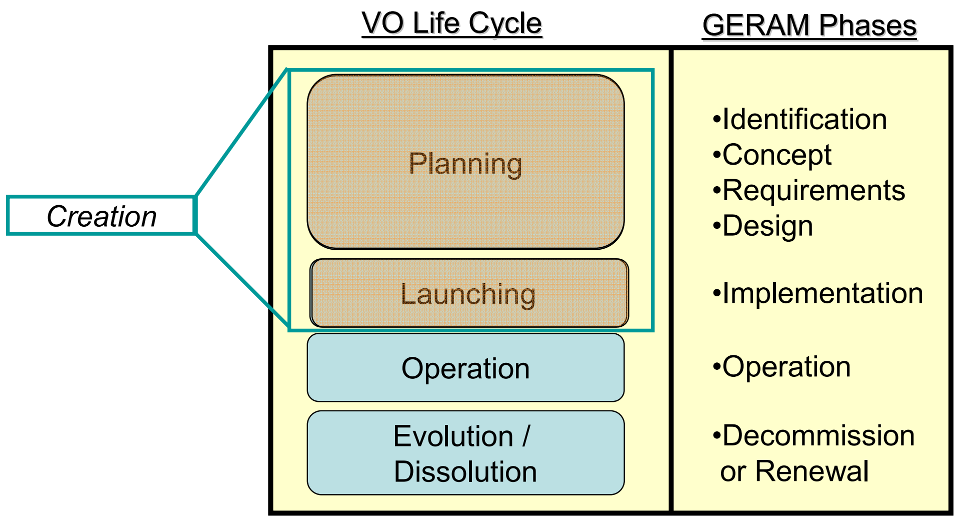

Figure 20 VO life cycle adapted to GERAM life cycle

The VO life cycle provides the basis for the main steps of VO Frame; during these steps, four views should be considered. The views considered (*see section 3.1.1*) in VO Frame are the same views (*Functional, Resource, Organization and Information*) included in GERAM. All these views are considered during the entire life cycle in order to support the modelling process of all the entities involved in the Virtual Organizations. Figure 21 depicts the modelling views in the VO creation stages.

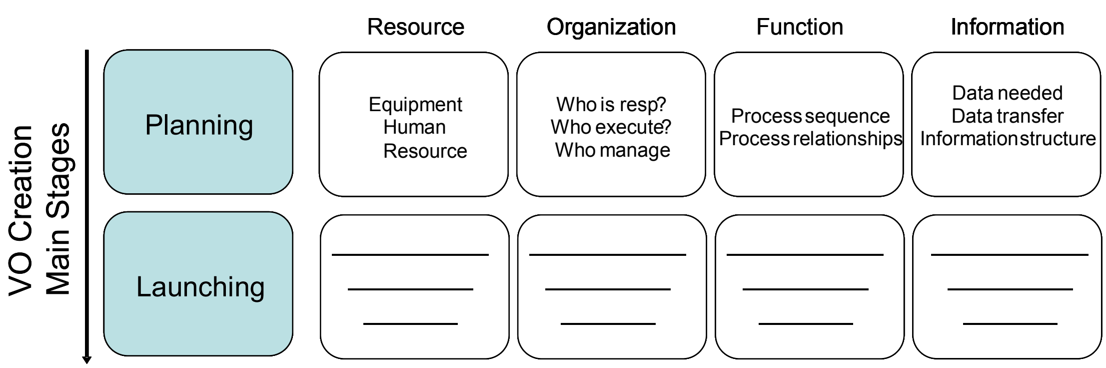

Figure 21 Modeling views in the VO Creation stages

4.2.2 Description of GERAM components used in VO Frame

Based on the figure 18, GERAM elements included in VO Frame are described:

4.2.2.1 GERA (Generic Enterprise Reference Architecture).

GERA is the most important component of GERAM, VO Frame has a architecture that fulfil GERA requirements, as an example, VO Frame has six roles which are included as GERA Human related concepts; figure 22 depicts VO Frame roles:

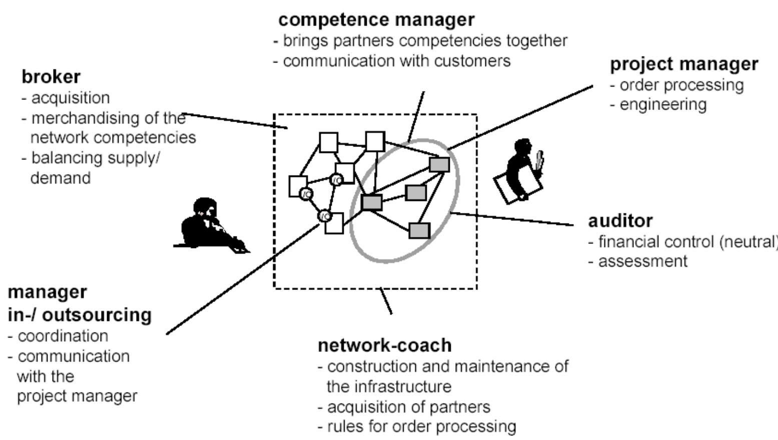

Figure 22 Roles in the Virtual Organization (Katzy and Schuh, 1997)

The broker is responsible for the marketing of the network and for the sale of the competencies of potential virtual organizations. Thus, the broker acts as a facilitator between customers and production.

The competence manager provides the engineering knowledge about available technologies and competencies in the network and supports the application engineering with the customers.

The project manager supervises the operations of the Virtual Organization according to the planned activities. She or he provides project management to keep time and budget restrictions and is able to re-engineer processes.

The in/outsourcing manager of each network partner provides a dedicated interface towards the network and interacts with Virtual Organization Technologies. She or he offers technological know how, resources and the technology of his or her enterprise towards the network.

The auditor serves the network as a neutral financial auditor providing financial solidity towards the business environment through his or her independent status.

The network-coach is not related to a business opportunity but constantly serves as a coach to the network.

Regarding to process oriented concepts, VO Frame provides the capability to analyze several different types of entities (enterprise, product and services); the entities analyzed in VO Frame have a life cycle, this means that there is a beginning and end; in the case of a VO the lifecycle is composed by Creation, Operation and Evolution of Dissolution. Finally, VO Frame can represent the interactions between the activities, inputs, outputs, actors and technology involved in VO planning and launching, this is achieved through VO frame modelling views.

With respect to technology oriented concepts, Table 6 provides a description of the types of tools (technology) involved in both the enterprise operation and the enterprise engineering efforts.

4.2.2.2 EEM's (Enterprise Engineering Methodologies)

An enterprise engineering methodology will help the user in the process of the enterprise engineering of integration projects whether the overall integration of a new of revitalised enterprise or in management of on-going change. Different methodologies may exist that will cover different aspects of the enterprise engineering process (Bernus et al, 2003).

VO Frame is characterized to be adaptable to several types enterprise engineering methodologies (See table 6). In VO Frame Enterprise engineering methodologies will guide the user in the engineering tasks required during VO planning and launching. For example, in VO Frame enterprise engineering methodologies should be focused in:

- Partners Search and Selection
- Knowledge management
- Scheduling
- Enterprise Modelling
- Project Management
- Contracting and legal issues

Based on figure 18, EEM's can utilize Enterprise Modelling Languages in order to describe how the EEM's will be developed from different perspectives.

4.2.2.3 EML's (Enterprise Modeling Languages)

The engineering of an enterprise is a highly sophisticated, multidisciplinary management, design and implementation exercise during which various forms of descriptions and models of the target enterprise will be created (Bernus et al, 2003).

In VO Frame this models are created using UML (Unified Modelling Language), UML represents the unification of three main modelling language methods (Booch, Rumbaugh and Jacobson). Through a set of UML diagrams it is possible to represent VO Frame modelling views. To represent VO Frame modelling views a combination of UML diagrams is required.

4.2.2.4 EET's (Enterprise Engineering Tools)

Enterprise Engineering tools will deploy enterprise modelling languages in support of enterprise engineering methodologies, specifically must support the creation, use, and management of enterprise models.

Depending on the enterprise entity in question these engineering tools of the enterprise may display a great variety. If the object of design is a project or an enterprise then the tools will be supporting the creation of the design of such project or enterprise, including its business processes, resources, organization, etc. If the enterprise in question is a product, or product type, then the tools will be supporting the design of the product, such a functionality, geometry, control systems, operator procedures, and so forth (Bernus et al, 2003)

To develop the activities included in VO Frame phases, several engineering tools must be used to instantiated the reference model into particular entities, some examples of those engineering tools (see appendix 2 and table 6) are: project management tools (WBS, Gantt charts, CPM diagrams), modelling tools (Rational XDE Modeller), and workflows (Smarteam Workflow).

4.2.2.5 PEM's (Partial Enterprise Models)

Partial enterprise models are models that capture concepts common to many enterprises. In the enterprise engineering process these partial models can be used as tested components for building particular enterprise models (EMs). In this research work, VO Frame is a partial enterprise model created to support the VO planning and launching activities. Figure 19 shows how VO Frame is instantiated into a particular enterprise model called IECOS, in this case IECOS is a broker assisted VO. Finally, IECOS model is instantiated into more particular models that represents two aerospace products fabrication and design virtual organizations.

4.2.2.6 EM's (Enterprise Models)

EMs represents the particular enterprise. Enterprise models can be expressed using enterprise modelling languages. EMs includes various designs, models prepared for analysis, executable models to support the operation of the enterprise, etc. They may consist of several models describing various aspects (or views) of the enterprise.

In this research work, VO Frame is instantiated into an IECOS enterprise model. IECOS model describes the operation of a broker assisted VO, IECOS model will serve as guide to the implementation of the operational system of the enterprise. In chapter 5 is shown how IECOS enterprise model through the enterprise engineering process was instantiated into two particular cases.

4.2.2.7 EOS's (Enterprise Operational Systems)

EOS support the operation of a particular enterprise, their implementation is guided by the particular enterprise model which provides the system specifications and identifies the enterprise modules used in the implementations of the particular enterprise system. In this research work EOS are represented by the particular VOs generated from IECOS model. The particular VO's created based on IECOS model were aerospace maintenance tooling equipment fabrication VO and Aerospace maintenance tooling embodiments design VO, these particular cases are presented in chapter 5.

4.2.2.8 GERAM elements not included in VO Frame

Regarding GERAM Elements not included in the reference model, firstly GEMC (Generic Enterprise Modeling Concepts) were not included due to there are not defined and formalized the most generic concepts of enterprise modeling within a VO context. Finally, Enterprise Modules (EMO) are not considered because there are not defined common resources for enterprise engineering and enterprise integration efforts.

Chapter 5. - Study Cases

5. 1 Introduction

In this chapter, the experiences in planning and launching Virtual Organizations using VO Frame will be described. Firstly, IECOS Enterprise Model elements are described, and finally, IECOS model is instantiated into two particular cases (Aerospace maintenance tooling equipment fabrication and Aerospace maintenance tooling embodiments design). These cases will lead to understand and demonstrate the use of VO Frame in different types of Virtual Organizations based on IECOS model.

5. 2 IECOS Model description

Based on the concepts included on GERAM, IECOS model is expressed using enterprise modeling languages; in this case UML is the enterprise modeling language used. IECOS model consist of several models describing various aspects describing various aspects (or views) of the enterprise. In this study case four UML diagrams were selected according to VO frame four modeling views required to create the VO model. Table 8 shows the diagrams selected to create each sub-model required to create IECOS model.

Modeling view / *VO Frame stage*	*Resource view*	*Information view*	*Organizational view*	*Functional view*
Planning	Classes diagram	Sequence Diagram	Use case diagram	Activity diagram
Launching				

Table 8 UML diagrams selected for IECOS model

An important element in order to represent information and functional view are the IECOS business processes, In this case, IECOS business processes were aligned to VO frame phases (See figure 23).

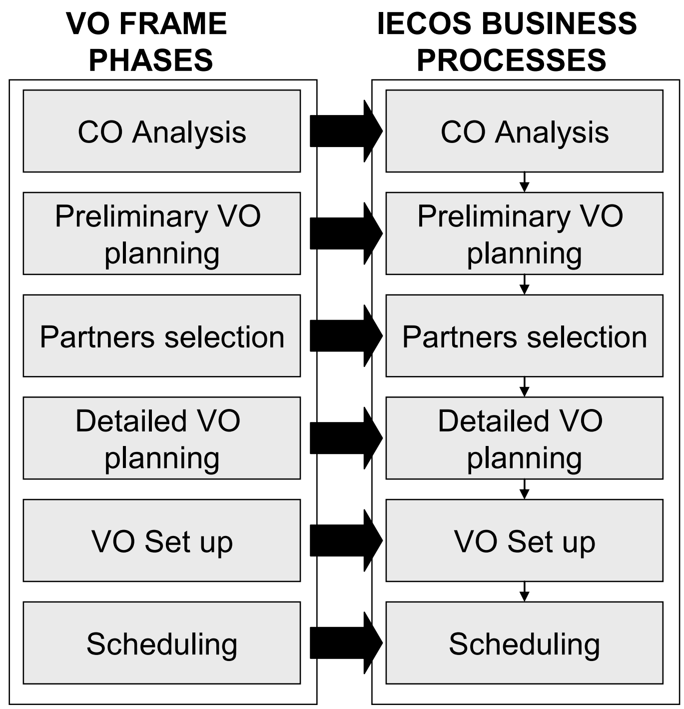

Figure 23 IECOS models business processes according to VO Frame

To represent IECOS information view a sequence diagram was selected in order to show information exchange within IECOS business processes, in this study case only the phase of scheduling was represented, figure 24 shows the model created to represent scheduling process according to IECOS information view. In this model, is shown the information and data exchange during scheduling process between broker (IECOS) and its partners. The model shows how the broker sends the Work breakdown structure (See appendix 2) to its partners and then a schedule is created using a Gantt chart.

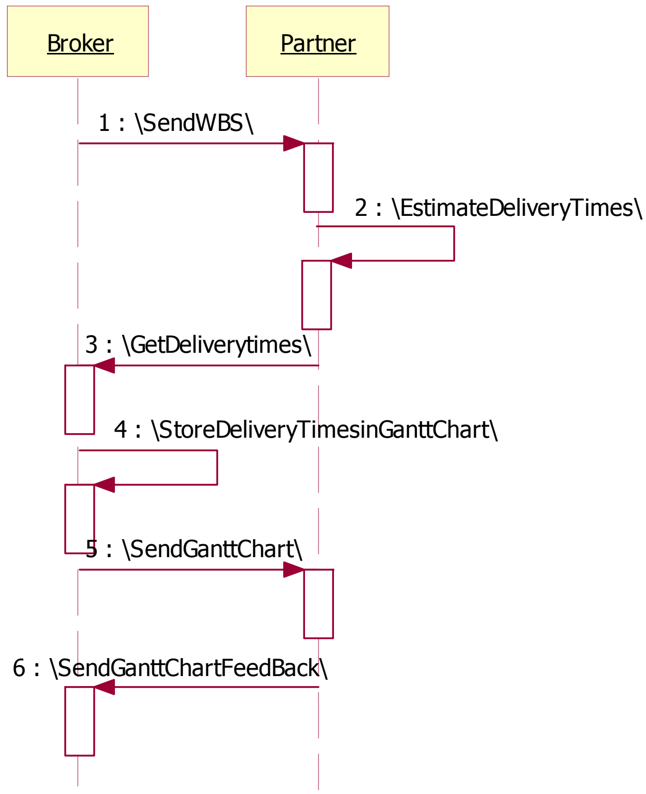

Figure 24 IECOS scheduling process information view model

Regarding to functional view, an activity diagram was selected in order to represent the functionalities and the behavior of IECOS business processes. Figure 25 presents the model created to represent scheduling process behavior (Flow of control). In IECOS functional model are shown he activities required to schedule VO activities, the main activities developed by the broker are focused in developing inter-enterprise schedule, broker partners are involved in the creation of intra-enterprise schedule.

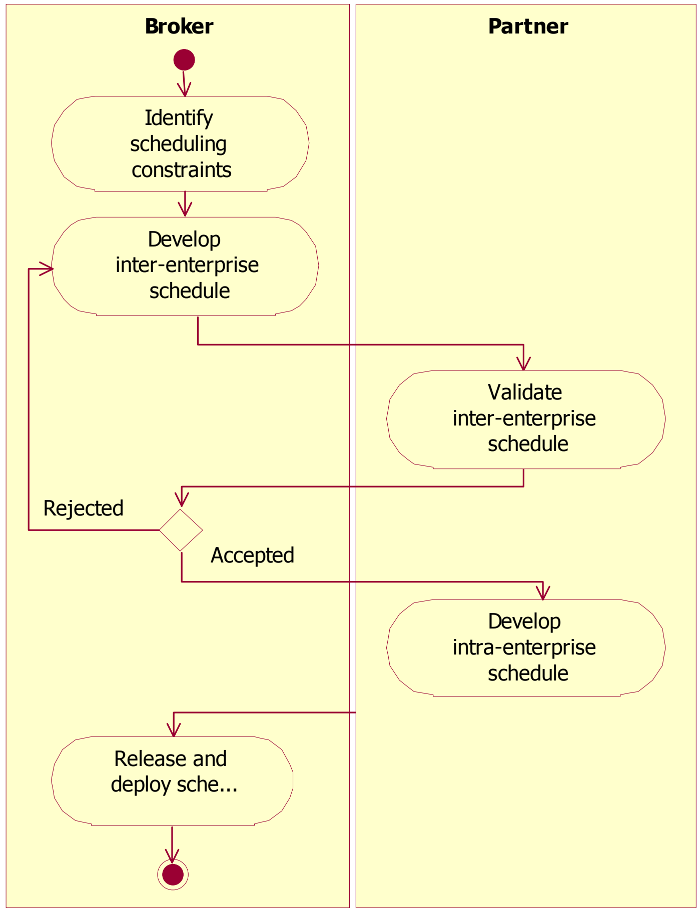

Figure 25 IECOS scheduling process functional view

For Organizational view a use case diagram was selected to describe the relationship of the entities with the business processes developed within a IECOS based VO; Figure 26 show how the actors involved with IECOS are related with its business process.

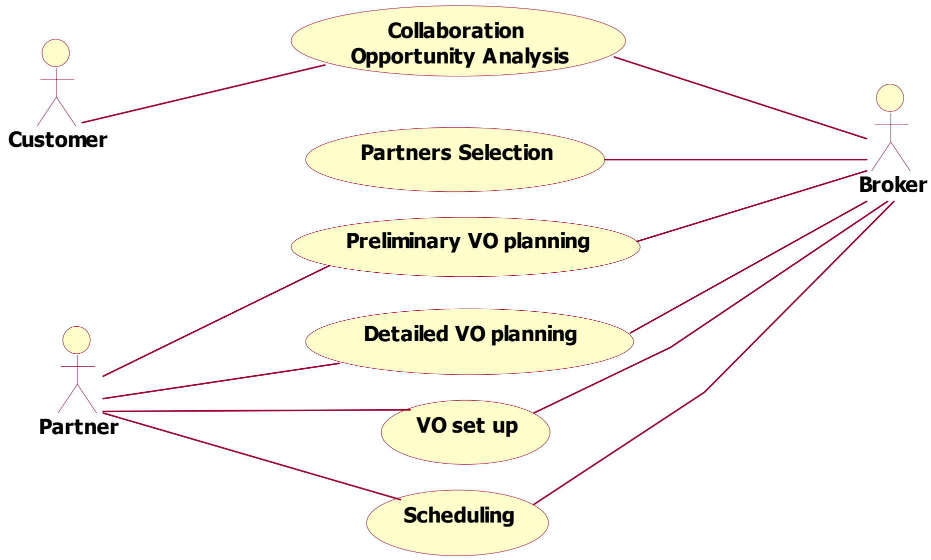

Figure 26 IECOS Organizational view model

In IECOS resources view an UML class diagram was used to represent the resources involved within IECOS. Figure 27 shows the structure of the class diagram created to represent IECOS resource view, this diagram will serve as guide for IECOS particular cases, the structure of the diagram is composed by one super class which describe the specific VO, a sub-class called partner serves to describe IECOS partners (in this case IECOS is considered a partner), partner class has three sub-classes, the first sub-class is Department which describe the area or departments of the enterprise, the second sub-class is process which describe the IECOS processes (IECOS is a partner) and the third sub-class is practice which represent the practices that support IECOS operation. Finally, any of these three sub-classes can be inherited into two sub-classes (HumanResource and TechnologicalResource) that represent the resources of the partner.

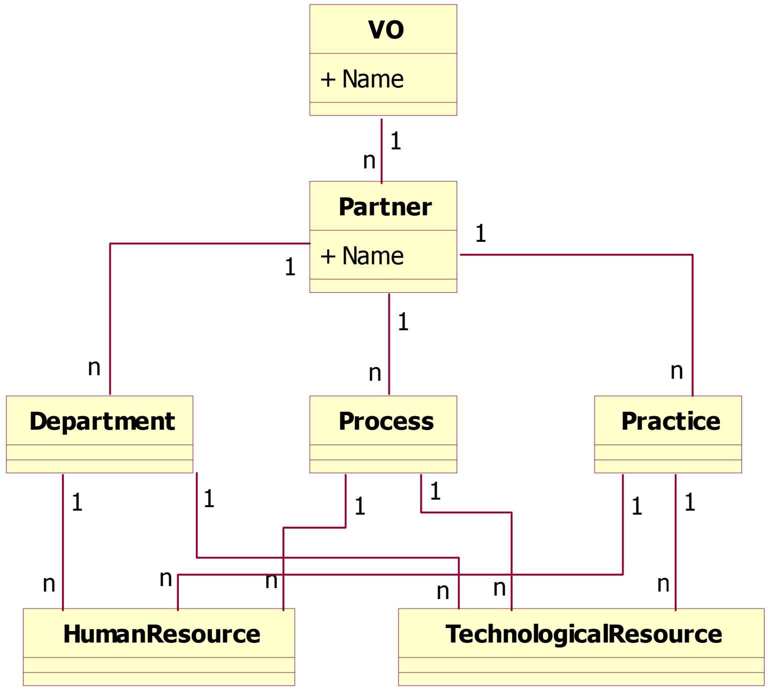

Figure 27 IECOS Resource view model

Regarding to the knowledge capturing and sharing mechanism presented in section 3.1.4. it was explored the implementation of the knowledge structure depicted in figure 14. However, the efforts made in this research work were not enough to validate and demonstrate how knowledge capturing and sharing mechanism can be used to support VO planning and launching knowledge management. Appendix 3 describes the efforts made in order to validate the concept presented in section 3.1.4.

In IECOS model an enterprise engineering tool called Rational XDE modeler (See appendix 2) was used to instantiated IECOS model into two particular cases. Other tools that support IECOS model were focused in developing collaborative project planning activities, this include basic tools such as Microsoft Project^{TM}, and SMARTEAM Workflow^{TM}.

In the following sections is shown how IECOS model was instantiated into two particular cases, the first case study is a Broker-assisted VO focused in aerospace maintenance tooling fabrication, finally, the second case study is oriented to Aerospace maintenance tooling equipment embodiment design.

5. 3 Study Case: Aerospace Maintenance Tooling Fabrication.

5.3.1 Description

In this study case, the VO planning and launching stages are triggered by a business opportunity related to Aerospace Maintenance Tooling fabrication, this product is required by a foreign customer who requires low cost production, high quality and accurate delivery time. In this study case, VO frame phases are used as a General Use (Step-by-Step), other VO Frame elements also are included during the implementation. The following section describes the implementation of VO Frame modules according to figure 13. For this study case the phases of VO frame were developed according to figure 28. Each phase was composed of specific activities developed with particular methods and tools.

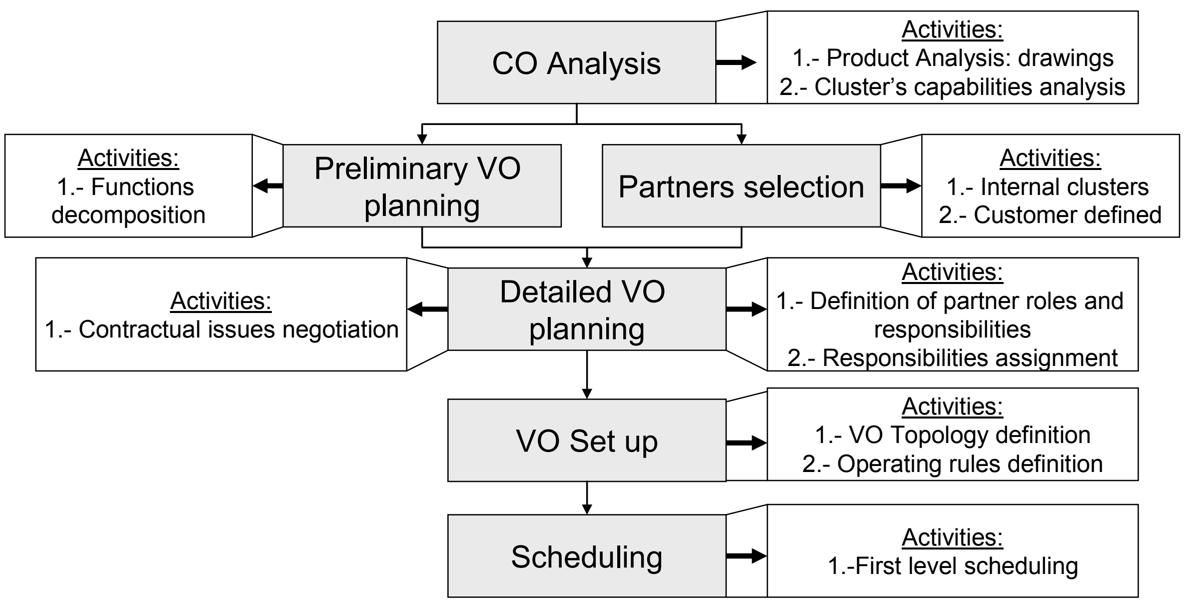

Figure 28 VO Frame phases development scheme

5.3.2 Collaboration Opportunity Analysis

Is important to mention that the collaboration opportunity was identified by IECOS (broker). In this phase all the activities were developed by the broker, the first activity was to analyze product characteristics, this include analyzing product drawings to understand its main requirements, figure 29 shows a graphical description of the product fabricated.

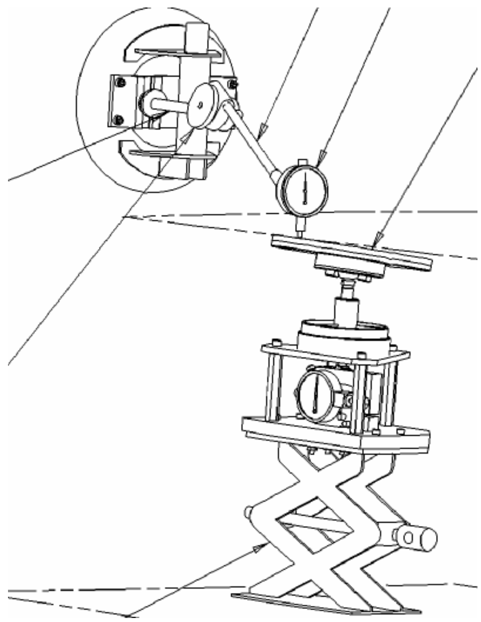

Figure 29 Aerospace Maintenance Equipment

After the product was analyzed, cluster capabilities were analyzed by the broker, for this study case only two of seven clusters were analyzed. The clusters analyzed were virplas and metalworking. Once the clusters were analyzed was defined if it was feasible to develop the project in order to satisfy the business opportunity.

After this phase, preliminary VO planning and partners selection were simultaneously developed. In the following section, preliminary VO planning is described first and subsequently partner's selection is described.

5.3.3 Preliminary VO planning

In this phase, the product was decomposed using a functional approach, the main functions identified were (1) quotation and negotiation, (2) procurement, (3) machining, (4) injection moulding, (5) inspection, (6) assembly and (7) delivery. Once these activities were defined; the elements required to develop the functions were identified, this include manufacturing process and other requirements needed to develop the functions. The elements identified were linked with physical components of the product. Table 9 shows how the product was decomposed according to functions identified.

Project Name	Aerospace Maintenance Tooling fabrication			
Functions	Activities required			
Quotation and Negotiation	Quotation and negotiation of internal parts	Quotation and negotiation of customer defined suppliers parts		
Procurement	Procurement activities for Pillar with mechanism	Procurement activities for Scarret Ind.	Procurement activities for gage with mechanism	Procurement activities for scissors jack
Machining	Screw	Nut	Washer	Hex Rod
Injection Moulding	7" x 0.25" Neophrene ring			
Inspection	Components inspection	Quality validation		
Assembly	Sub-Assembly Operation	Complete assembly operations		
Delivery	Product delivery			

Table 9 Function based product decomposition

5.3.4 Partners Selection

Partners search and selection was based on the cluster analysis made in the previous stage (Collaboration Opportunity Analysis). IECOS method and tools were used to find and select partners, the first step was to find the partners required using the product requirements as reference. Two approaches were developed in order to find the partners; first approach was to look for partners inside the cluster; with this approach the partners required to develop machining and injection moulding activities were found. Second approach was oriented to find customer defined components and suppliers, using this approach three partners were found. The two approaches were simultaneously developed in order to enhance partner's selection process. Figure 30 depicts the structure of the process of partners search and selection.

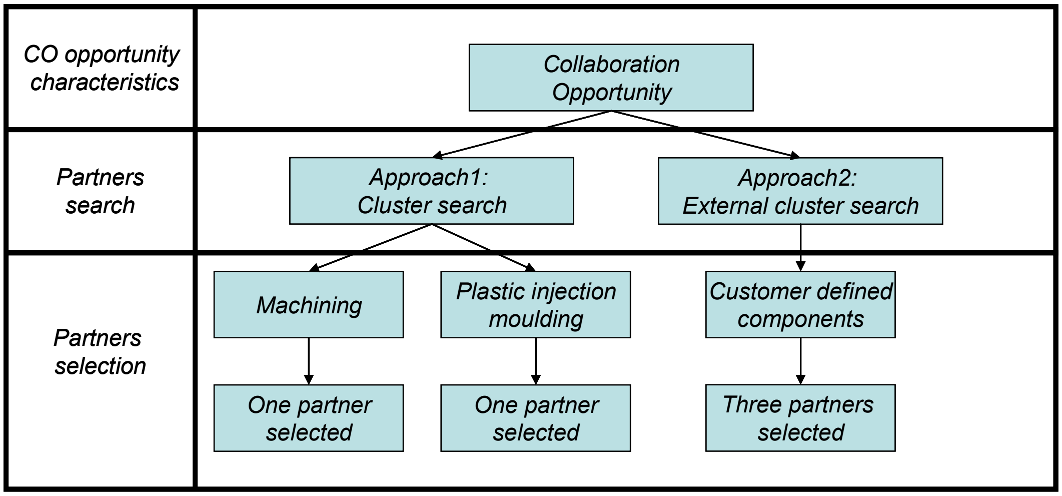

Figure 30 Partners search and selection structure

Once the partners were found, the selection process was executed. Partner's selection was developed using the same approaches described in the previous section. The first approach was to select partners included inside the clusters, from this approach two partners were selected, one to develop machining operations and other to make plastic injection moulding operations. The second approach was to select the required partner to provide customer defined product elements. The objective of the partners selected using this approach was to provide a specific physical element of the product. Using the second approach the partners selected were three external VBE entities; the purpose of these partners was to provide the following components:

1. Hand cup
2. Scissors Jack
3. Pressure indicator
4. 665 B Mechanism
5. 665 D Mechanism
6. Mechanism with gage

The output of this module was a set of partners selected according to product characteristics and activities required by the product.

5.3.5 Detailed VO planning

In this phase, the first activity developed was the negotiation process among VO partners; in this process the broker negotiated with each partners, to develop the negotiation three factors had to be prioritized, the factors were:

1. Delivery time
2. Price
3. Quality

The factors mentioned above established the guidelines during the negotiation process. Delivery time was the most important factor, followed by Price and Quality. These factors were defined by the broker and in an indirect manner from the customer.

Once the negotiation was finished; roles and responsibilities were defined through the creation of a Work Breakdown Structure (WBS) (See appendix 2). Figure 31 shows how the functions were decomposed into specific elements.

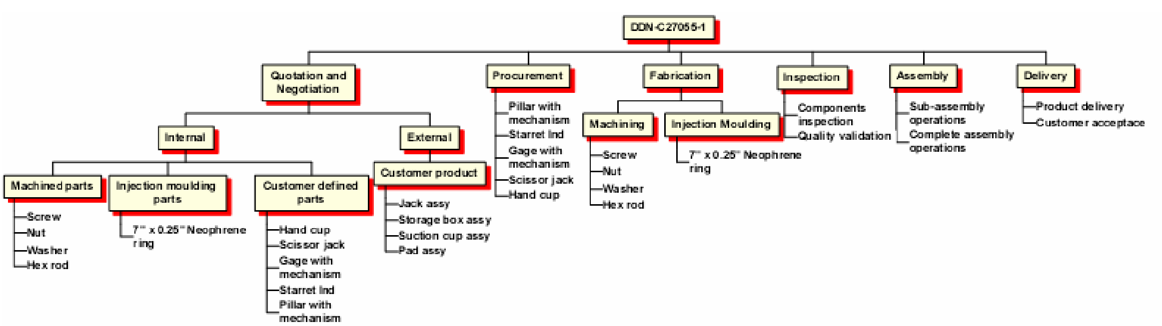

Figure 31 Product Work Breakdown Structure.

In the WBS were defined partner's roles and responsibilities. This was made by defining deliverables to each partners, in each deliverable was included start and finish date, cost, resources required and relationship with other elements. Based on the WBS a linear responsibility charts (See figure 32) was developed; in this chart were prioritized and assigned the responsibilities of the partners.

Project	DDN-C27055-1	**Creation date**	
Manager	Matheiu Metrop	**Release date**	

Task description	**IECOS**	**CSIM**	**HyN del Norte**	**Glevy**	**AvnerCorp**	**Thomson de Mexico**	Codes
1.- Negotiation and Contracting	1						1 = Actual responsability
2.- Quotation							2 = Support
2.1 Machined parts	3	1					3 = Must be notified
2.2 Plastic injection parts	3						Blank = Not involved
2.3 Customer defined parts	3			1	1	1	
2.4 Entire Product quotation	1	2	2	2	2	2	
3.- Procurement	1						
4.- Fabrication							
4.1 Machining		1					
4.2 Plastic Injection Moulding			1				
5.- Pre-inspection							
5.1 Machined parts		1					
5.1 Plastic injection			1				
6.- Assembly	1						
7.- Final inspection	1						
8.- Delivery	1						

Figure 32 VO activities linear responsibility charts

After the roles and responsibilities were assigned, the contracting process was developed. Figure 33 shows the structure of the contracting process between IECOS and other VO partners. During the contracting process IECOS established the contracting issues that partners should fulfil in order to participate in the VO. After some time, contractual issues were solved and deployed among VO members.

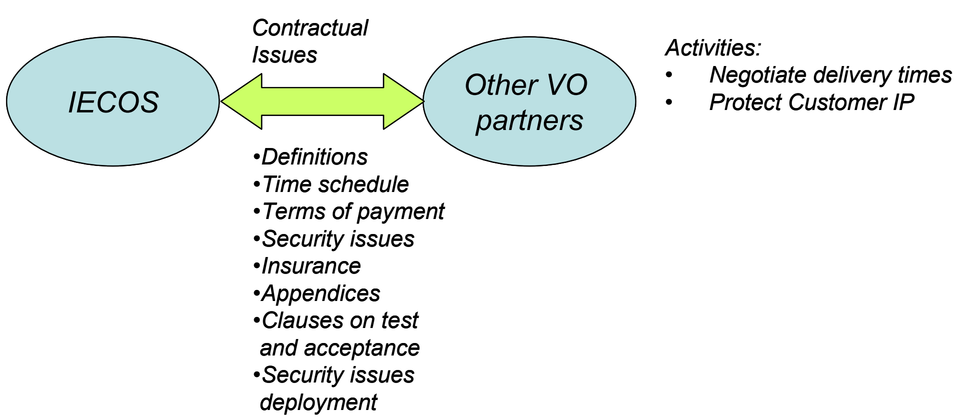

Figure 33 VO Contracting issues and responsibilities

5.3.6 VO Set up

This phase has a major influence of the previous module, The more the detailed VO planning has been developed, the less work has to be made during the VO set up and the more it can be an instantiation of a previously prepared VO. The firs activity developed in this phase was the definition of VO topology. Figure 34 shows the VO topology which is a star type, the topology is composed by a broker and 5 partners, where two of these partners are members of the VBE and the other are external VBE members.

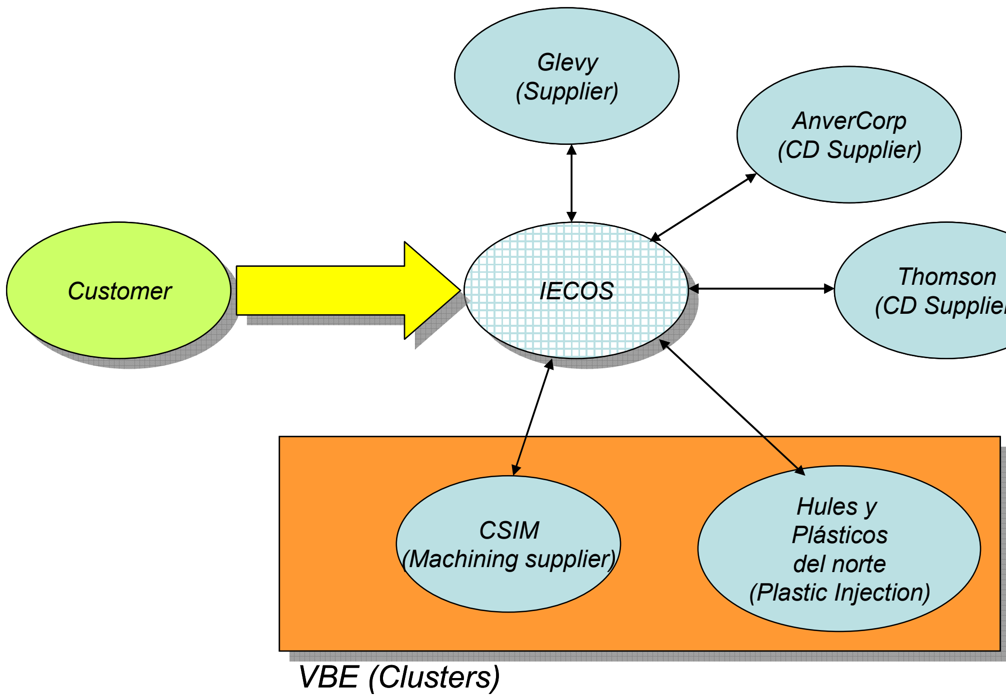

Figure 34 VO topology

Finally, VO operating rules were defined and deployed among VO partners. The operating rules defined were focused in the following areas:

- Process to be used
- Quality management
- Delivery times
- Logistics
- Final outputs
- Coordination
- Communication

The operating rules were deployed among VO members to establish common operating rules in the entire VO.

5.3.7 Scheduling

The objective of this phase was to develop gantt charts that represent activities scheduling in VO operation. In this phase two level of scheduling can be done. First level is focused in creating an inter-enterprise schedule were all VO partners are involved in the activities represented in the schedule; second level is oriented to defining an intra-enterprise schedule were an specific VO partners developed a detailed schedule of the activities to be developed in the VO. Figure 35 shows a first level gantt chart, this diagram provides a detailed description of inter-enterprise activities to be developed in the VO.

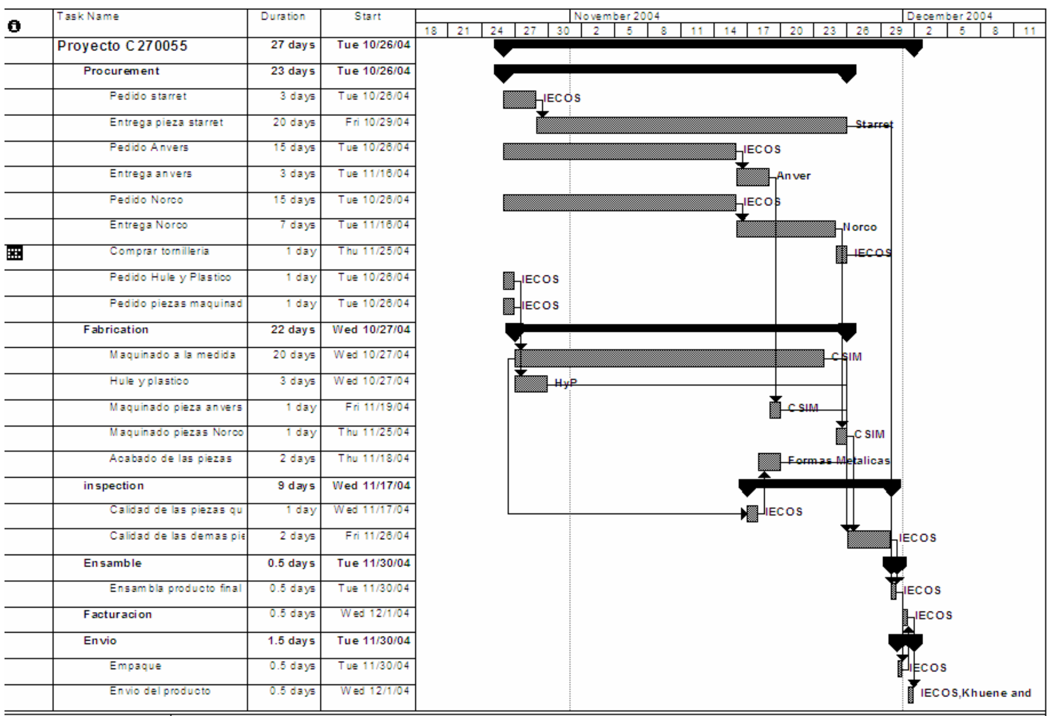

Figure 35 VO scheduling inter-enterprise diagram

Second level scheduling is an optional element in this module; VO partners can select whether or not to develop a detailed scheduling for their intra-enterprise activities. In this study case, the second level diagrams were not created.

5.3.8 VO modelling approach.

Based on the IECOS model, a set of UML diagrams were created to represented this case study particular model. Figure 36 shows an UML use case diagrams which represents VO frame organizational view for this case study; the purpose of this diagram was to show how VO members were involved in VO frame modules during planning and launching.

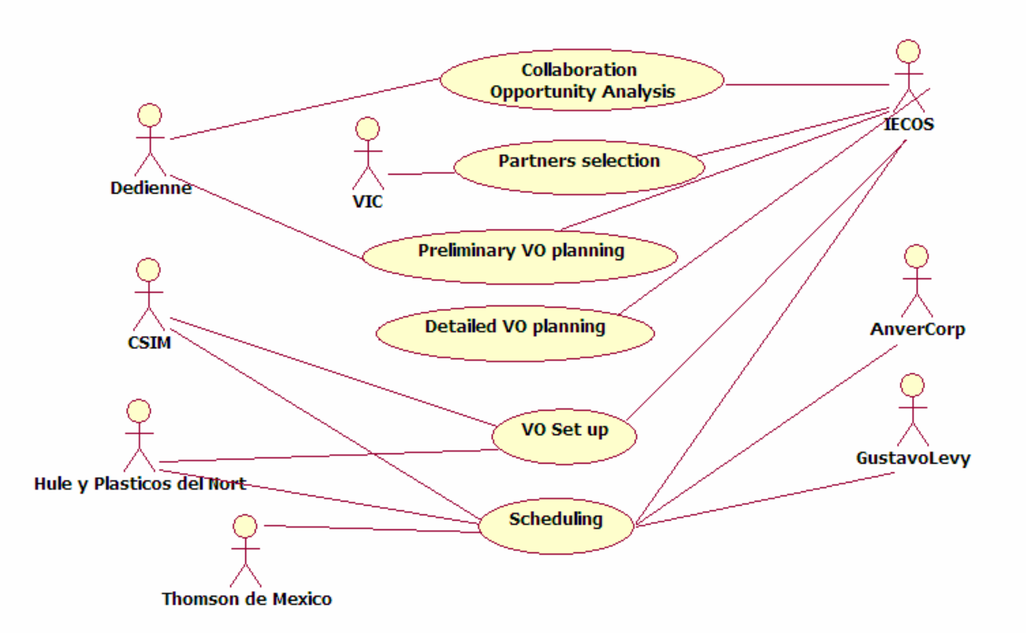

Figure 36 Use case diagram representing IECOS organizational view

Functional view was focused in representing how each VO Frame module will be developed and show the partners responsibilities in the activities included in the module. To represent this modelling view, an activity diagram was used. Figure 37 depicts the activity diagram corresponding to VO Frame scheduling phase.

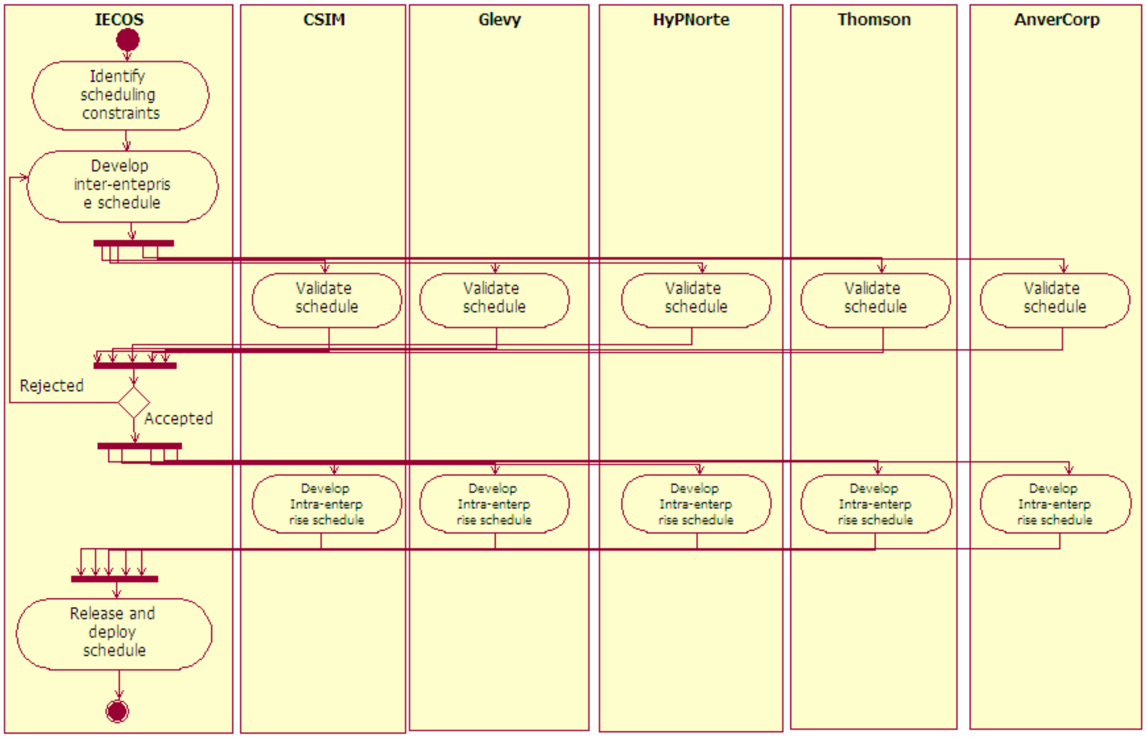

Figure 37 Activity diagram representing IECOS functional view

In information view were represented the interactions between partners during VO Frame phases. To represent these interactions, UML sequence diagrams were used to create models which clearly represent information and data exchange among VO members during VO planning and launching. Figure 38 shows the sequence diagram created to show information exchange between VO members in VO Frame scheduling phase for IECOS model.

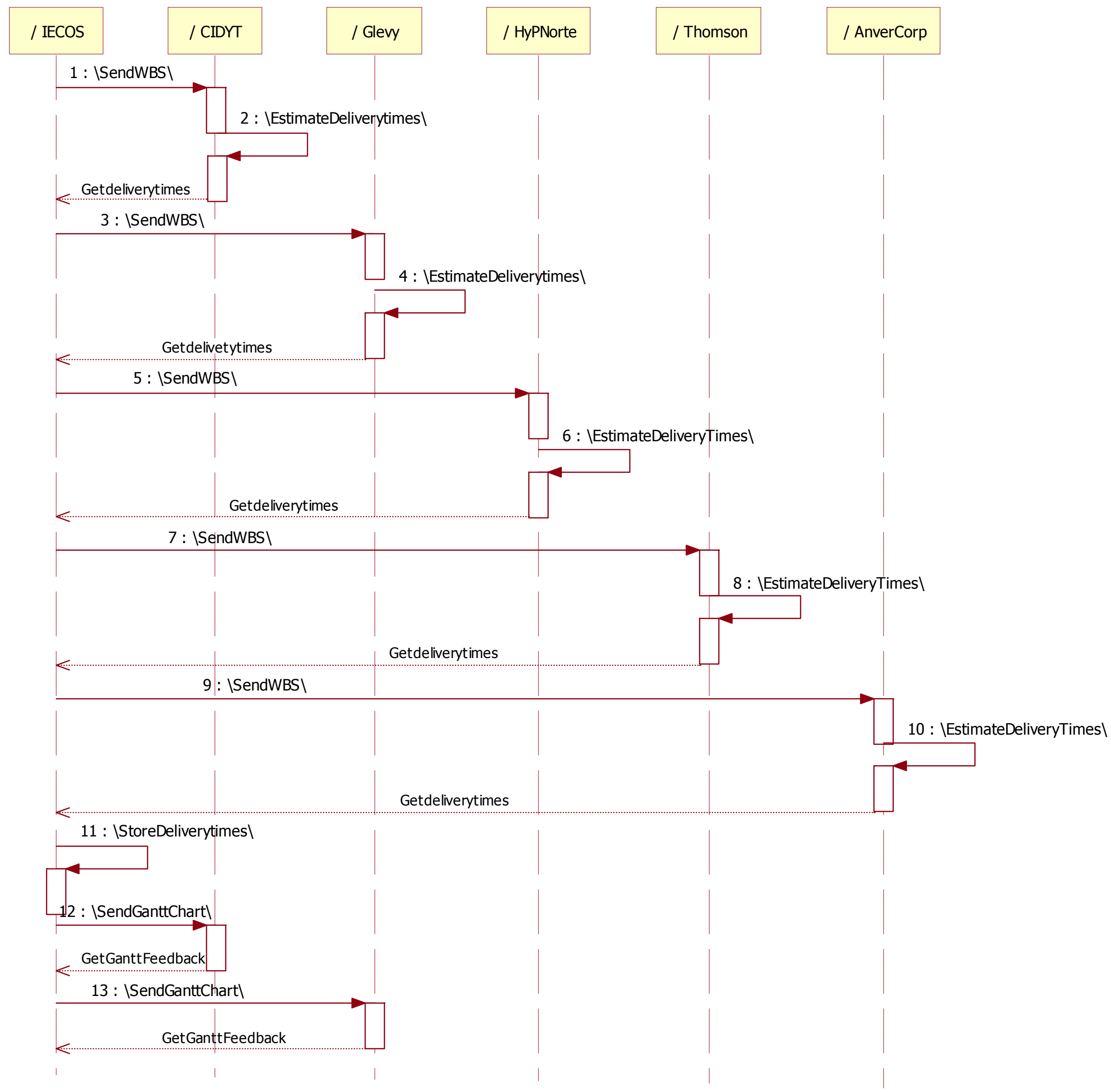

Figure 38 Sequence diagram used to represent IECOS information view.

The purpose of resource view was to represent partner's resources involved in VO planning and launching. In this view an UML classes diagram was used to represent the resources of IECOS and its partners for this particular case. Based on figure 27 an instantiation process was developed for this study (See figure 39) where instances of the classes were created based on VO characteristics.

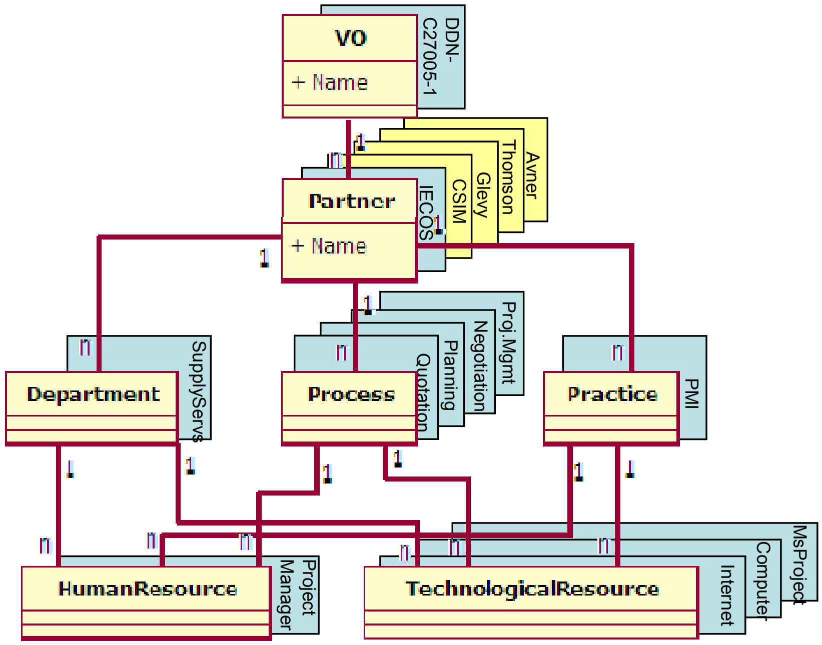

Figure 39 IECOS resource model instantiation process

In Figure 40 is shown the class diagram used to describe IECOS resources, the first level was class that represented VO name, and second level classes are partner's names. In this diagram only one second level class was deployed, the class deployed was IECOS, third level classes for IECOS were practices (PMI), process (quotation, planning, negotiation and project management) and department (supply services). At fourth level only supply services class was instantiated, supply services class included technological (MS Project, Computer, Internet) and human resources (ProjectManager)

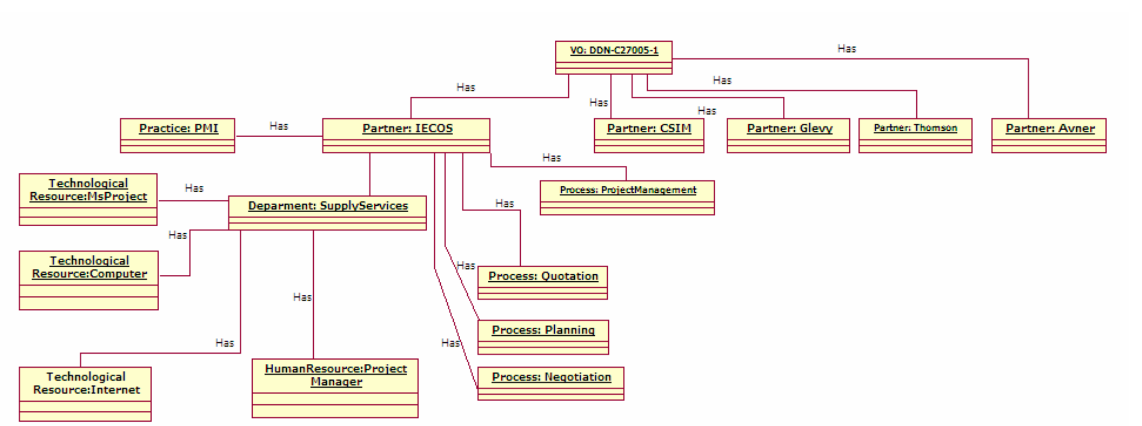

Figure 40 Class diagram used to represent IECOS resource view

During the modelling process, a set of diagrams were developed to demonstrate VO Frame modelling scheme based on IECOS model. The diagrams developed were, one diagram in organizational view, in functional and information view one diagram was developed for each of use case included in organizational view. Finally one class diagram was developed in resource view. Based on these diagrams a VO model (see figure 41) was instantiated from IECOS model, the purpose of this model was to provide a multidimensional perspective of the behaviour of the element involved in planning and launching implementation of VO Frame.

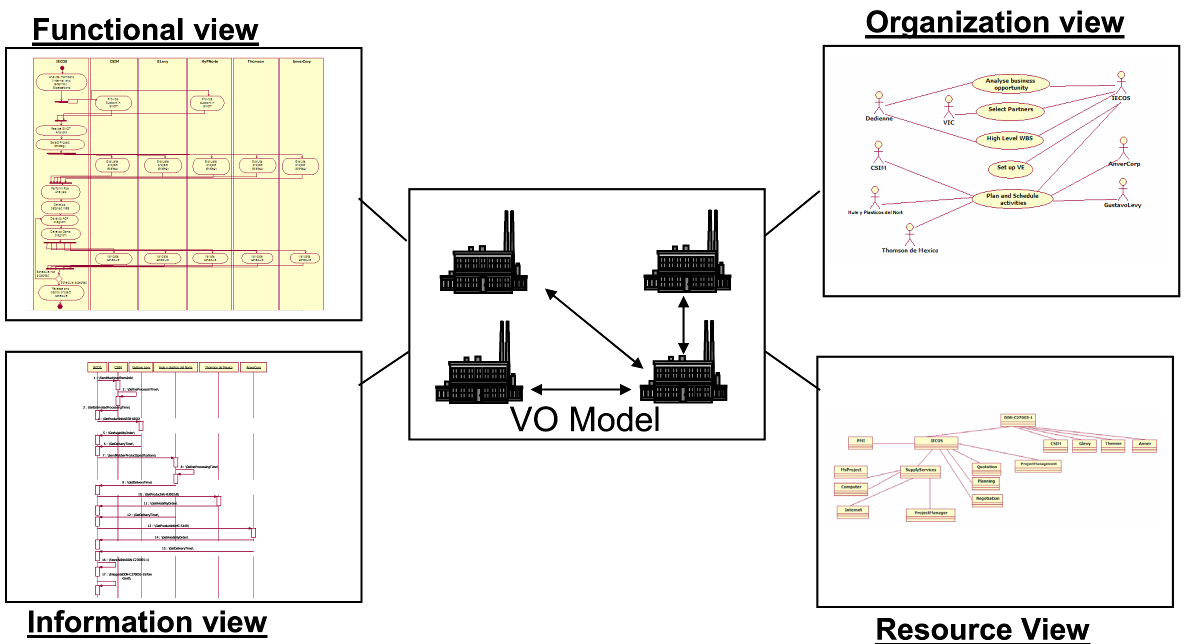

Figure 41 Integration of VO Frame modeling views into VO model ((Adapted from Molina, 2004)

5.4 Study Case: Aerospace Maintenance tooling equipment embodiment design.

5.4.1 Description

The purpose of this study case is to demonstrate VO Frame implementation outside a VBE context. The objective of the Virtual Organization crated in this study case is to provide an e-engineering service for an Aerospace Maintenance Tooling. The e-engineering service consists of developing an Embodiment Design service for five variants of a product.

In this study case, VO Frame implementation is developed with VBE absence. VO planning and launching stages are triggered by a business opportunity identified by an enterprise which does not have the technological and human resources required to explode the business opportunity: due to this, the role of the enterprise that identified the business opportunity was to manage the project. For this study case, VO frame modules were used as a General Use (Step-by-Step), other VO Frame elements also are included during the implementation. The following section describe the implementation of VO Frame phase according to figure 11. In this study case VO Frame phases were developed according to figure 42; in each VO frame phase specific activities were develop using particular methods and tools.

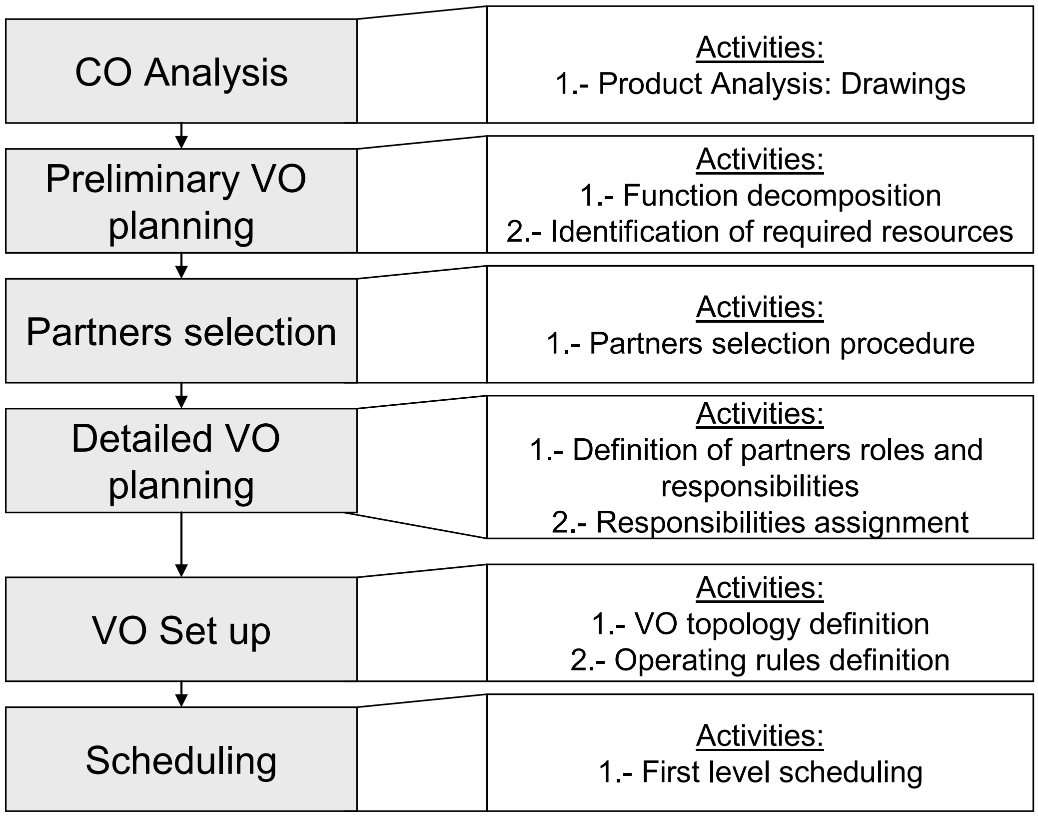

Figure 42 VO Frame development scheme

5.4.2 Collaboration Opportunity Analysis

The main actor in this phase was the enterprise which identified the business opportunity. The first activity was to identify the CAD format and software to be used, The CAD software defined was CATIA[4]; the second activity was to analyze products characteristics; the analysis was focused in geometrical, assembly and variants characteristics. In this analysis the drawings from all product variants were analyzed to understand product characteristics. Figure 43 shows a graphical description of one product variant.

[4] CATIA is a CAD software property of Dassault Systemes which enables digital product definition and simulation

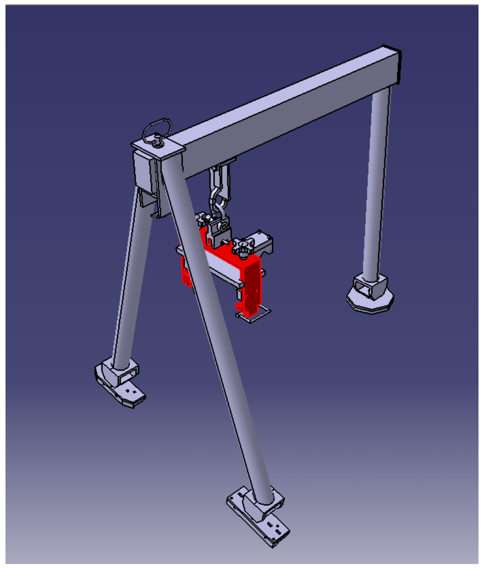

Figure 43 Aerospace Maintenance Inspection Equipment Variant 1

Finally VBE capabilities do not were analyzed because in this study case non VBE was considered, due to this partners capabilities were analyzed during partners selection phase.

5.4.3 Preliminary VO planning

In this phase a functional approach was selected to decompose the five product variants. The variants were analyzed as a single business opportunity. Table 10 shows the decomposition of all product variants. The decomposition included the following functions: (1) Quotation and Negotiation, (2) PDM Set up, (3) Embodiment design and (4) Validation. For embodiment design, a relationship was established for each product variant according to embodiment design function. In validation two activities were required; these activities were (1) internal and (2) external validation. Validation activities were required for each product variant.

Project Name	Aerospace Maintenance Tooling Embodiment design and analysis				
Functions	Activities required				
Quotation and Negotiation	Project quotation				
PDM Set up	Database set up				
Embodiment design	ED:RMVL/INS TL -1	ED:RMVL/INS TL -56	ED:RMVL/INS TL -3	ED:RMVL/INS TL -58	ED:RMVL/INS TL -59
Validation	Internal Validation	External Validation			

Table 10 Function based product decomposition

Once the decomposition was finished; Human and Technological resources required were selected; human resources contained four product engineers with CATIA experience and one project manager; technological resources consisted in workstations, CAD and PDM software and basic ICT (Internet, email, fax).

5.4.4 Partners Selection

In this study case the project manager role was developed by the partner who identified the business opportunity. The activities developed within this phase were subject to project manager ability to detect the required competencies in local engineering enterprises. During the search process, the first activity was to contact engineering enterprise with CAD and PDM experience; the results of this activity were a group of local Small and Medium enterprise (SME) capable to develop engineering services and a university research center.

After the possible partners were identified, the next step was to evaluate their capabilities. A capability analysis was developed in order to support partners selection; the first stage of this evaluation was to analyze technological aspects (Infrastructure, Software, ICT, etc), finally a second stage was oriented to analyze engineer's expertise (CAD, PDM, Product development, etc). After partner's evaluation, one engineering services SME and one university research center were selected to join the e-engineering VO.

The result of this phase was a set of partners that allows the development of the required e-engineering service.

5.4.5 Detailed VO planning

This phase was composed by four main activities: (1) negotiation, (2) Work breakdown, (3) Responsibilities definition and (4) contracting. The first activity in this phase was negotiation; within this activity the project manager was the entity responsible to coordinate the negotiation process with the others VO members. In this process, delivery time and price were the factors that defined the guidelines for negotiation among VO members.

After the negotiation process was finished, project deliverables were defined through a Work Breakdown Structure (See appendix 2). Figure 44 shows how the functions identified in section 4.3.3 were decomposed into specific deliverables.

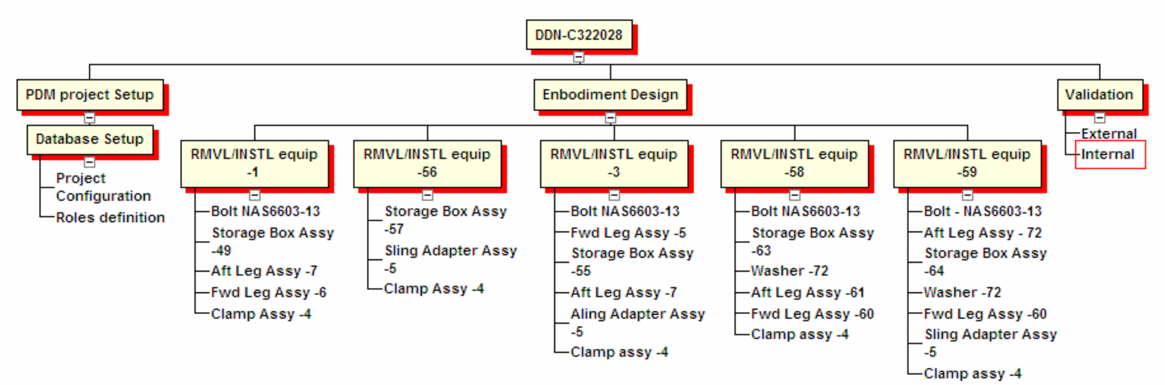

Figure 44 Product Work Breakdown Structure.

The main objective of the WBS was to define specific project deliverables using a structured project planning tool. The WBS was developed using information such as start and finish date, cost, required resources and relationships between WBS elements. Once the WBS was finished, a linear responsibility chart was made, through this chart it was possible to define VO members (including the customer) responsibilities according to the functions defined in preliminary VO planning phase. Figure 45 shows the responsibilities of each VO members, this chart included three types of roles for each activity, the roles are (1) actual responsibility, (2) Support, (3) must be notified, as the number included in the cell decrease the level of responsibility increase.

Project	Aerospace Maintenance Inspection Equipment	**Creation date**	
Manager	Matheiu Metrop	**Release date**	

Task description	**CSIM**	**Okurrencia**	**Broker**	**Customer**	Codes
1.- Quotation and negotiation			1		1 = Actual responsability
2.- PDM Set up					2 = Support
2.1 Database set up	1		3		3 = Must be notified
3.- Embodiment design					Blank = Not involved
3.1 RMVL/INSTL -1	1	2	2		
3.2 RMVL/INSTL -56	2	1	2		
3.3 RMVL/INSTL -3	1	2	2		
3.4 RMVL/INSTL -58	2	1	2		
3.5 RMVL/INSTL -59	1	2	2		
4.- Validation					
4.1 Internal	2	2	1		
4.2 External	2	2	1	1	

Figure 45 linear responsibility chart

After the deliverables, roles and responsibilities were defined, the contracting process was developed. The contracting process was developed. Within the contracting process two stages were considered, the first stage was developed between the project manager and the customer; this stage included contracting issues such as price target, technologies to be used, main deliverable, intellectual property rights handling and global delivery time; second stage was related to the contracting issues of project manager with the other VO members; in this stage were defined specific responsibilities of the partners, information management, customer restrictions and terms of payment.

5.4.6 VO Set up

As mentioned in the first study case, this phase has a major influence from the previous module (detailed VO planning), the more detailed VO planning has been developed, the less work has to be made during VO set up and the more it can be an instantiation of a previously prepared VO. The first activity developed in this phase was the definition of VO topology. Figure 46 shows VO topology, were three members are involved, (1) the project manager and (2) two engineering services enterprises. The topology was a star type topology, where the project management was responsible to coordinate VO activities where the other VO members were involved.

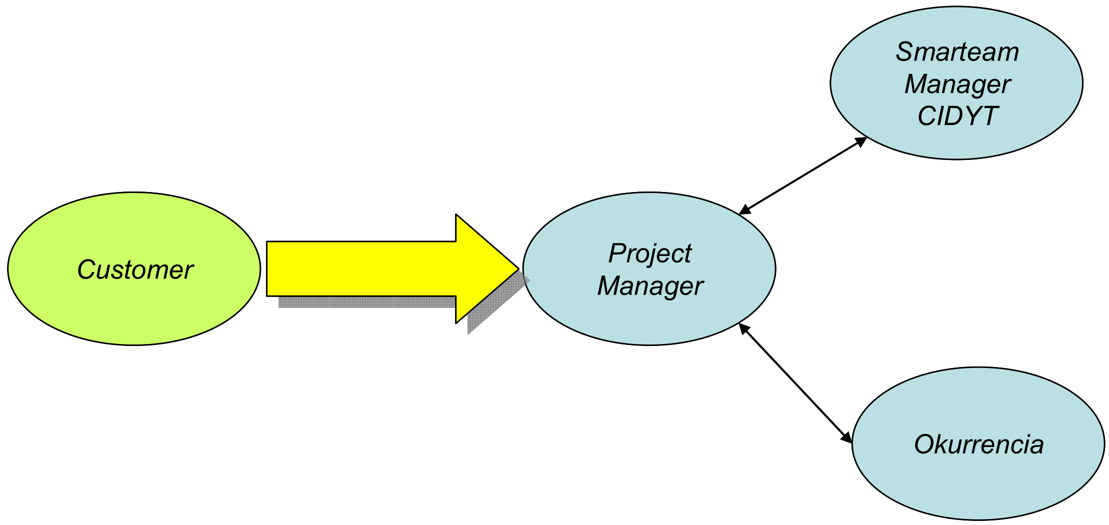

Figure 46 VO topology

Finally, VO operating rules were defined and deployed among VO members. The defined operating rules were focused on:

- PDM handling
- CAD formats management
- Coordination
- Delivery time penalties
- Final outputs
- Communication

The operating rules were deployed among VO members in order to define common operation methods during VO operation.

5.4.7 Scheduling

The purpose of this phase was to develop Gantt charts in order to support VO scheduling. To develop the VO scheduling two levels had to be considered. First level was focused in creating an inter-enterprise schedule and second level is oriented to defining an intra-enterprise schedule. For this study case, the project manager was the member responsible for first level scheduling. Figure 47 shows a first level gantt chart, this chart provides a detailed description of inter-enterprise activities to be developed in the VO.

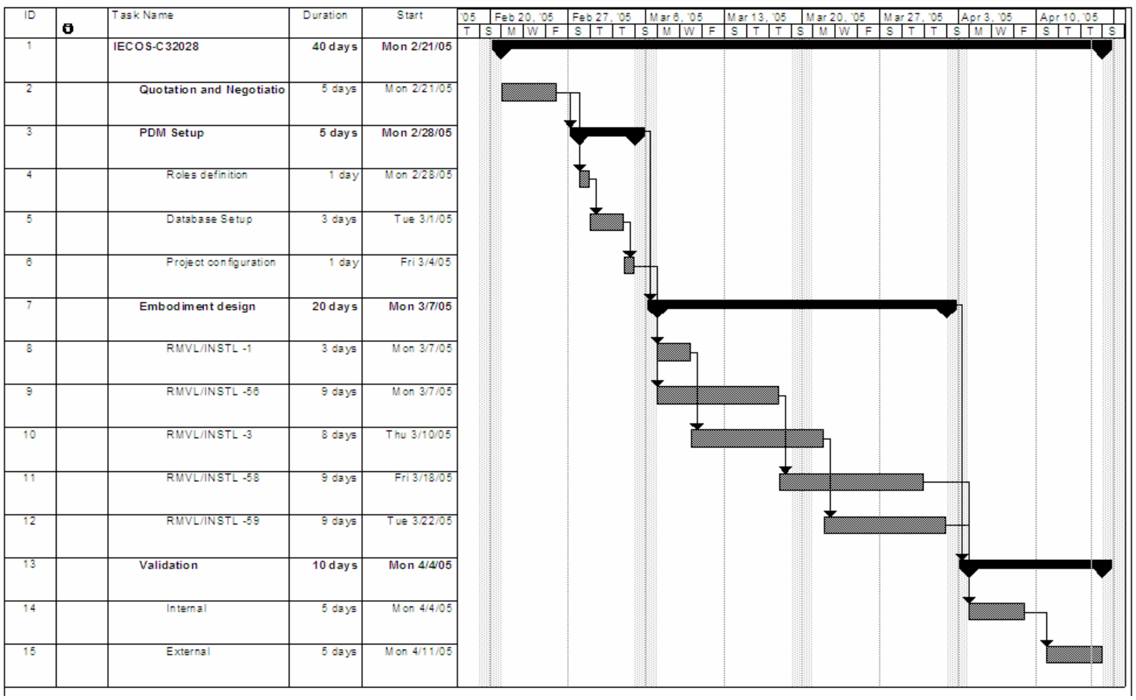

Figure 47 VO scheduling inter-enterprise diagram

In this study case Smarteam Workflow[5] (See Appendix 2) was used to create an interactive schedule for VO operation, through this tool it was possible to create a collaborative interface for VO operation. To implement the workflow tool it was needed to create a process that define the activities required to develop the e-engineering service (embodiment design). Figure 48 shows an example of a Smarteam workflow. Within the

[5] Smarteam Workflow is a tool property of Dassault Systemes which provides workflow automation and management that streamlines business processes and expedites engineering changes.

workflow, four processes were defined according to product development stages defined by Aca (2004).

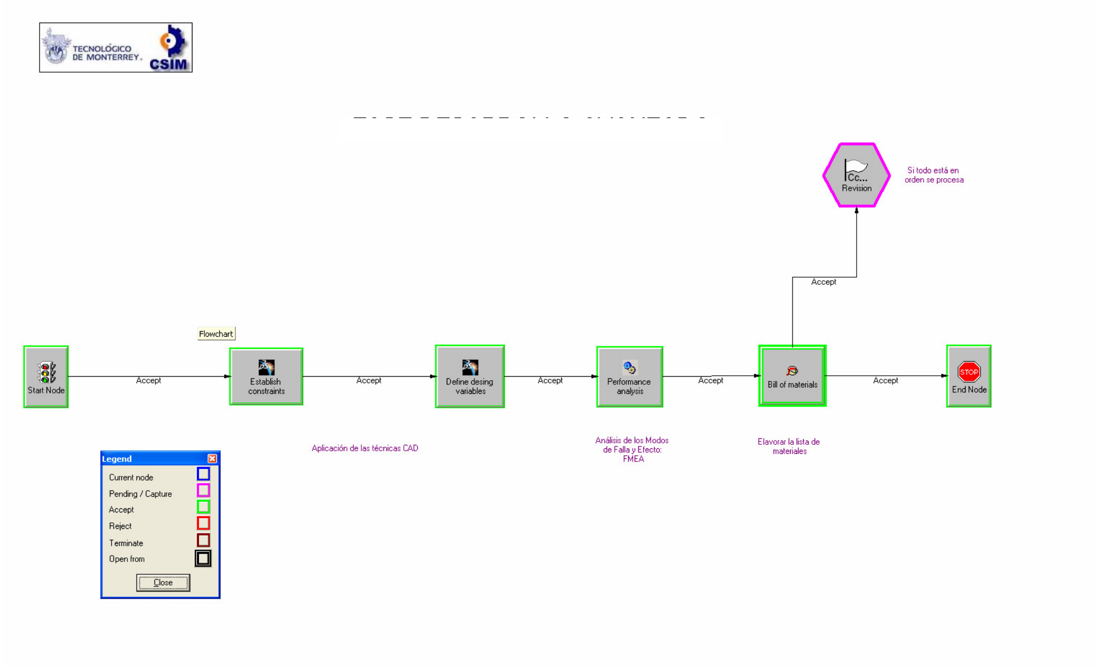

Figure 48 Smarteam workflow for advanced development stage

After the first level schedule was completed. The second level scheduling was not developed because this element was presented as an optional element for VO members.

5.4.8 VO modeling approach

Using IECOS model as basis, a set of UML diagrams was used to create a particular case of IECOS model. The purpose of the models created was to describe each IECOS modelling views.

To develop these diagrams rational rose XDE[6] modeller was the modelling tool used, XDE modeller provided a user-friendly interface for the creation of UML diagrams.

[6] Rational Rose XDE modeler is a UML modeling tool included in Rational Rose XDE developer suite; Rational Rose is a software tool property of IBM.

In this particular model a use case diagram was used to represent IECOS organizational view (see figure 49), the objective of this diagram was to show partners involvement during VO planning and launching phase in this particular case.

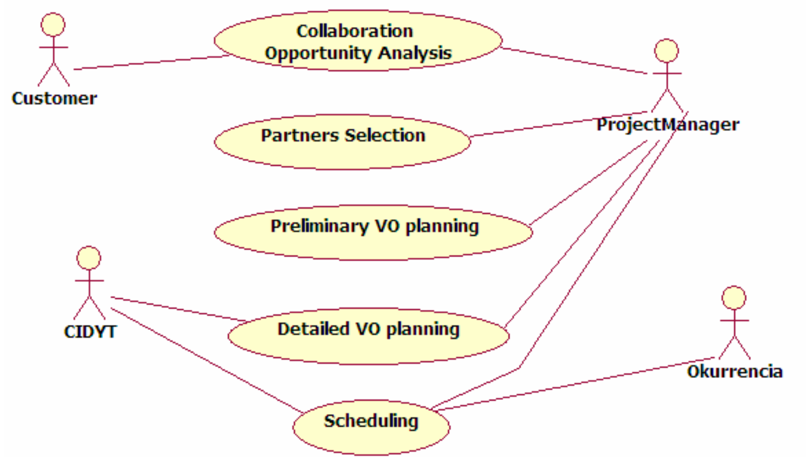

Figure 49 Use case diagram representing VO Frame organizational view

The purpose of the functional view was to represent the activities included in each IECOS phase (See figure 23). Figure 50 shows the activity diagram developed for IECOS scheduling phase.

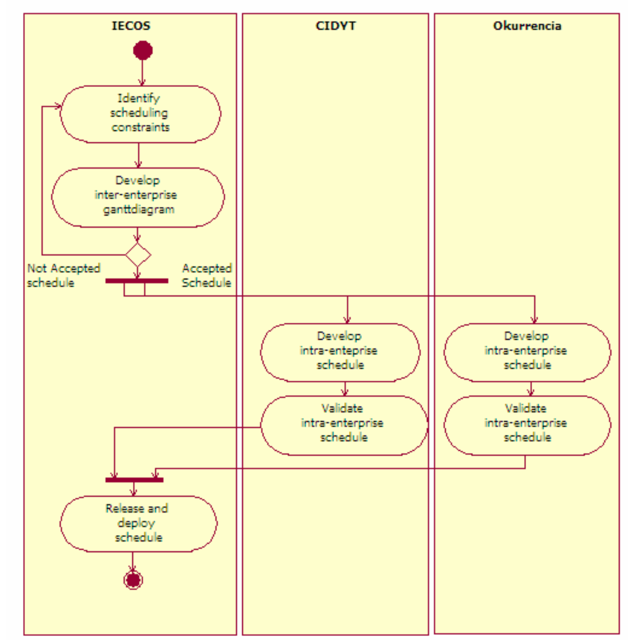

Figure 50 Activity diagram representing VO Frame functional view

In information view was represented information and data exchange between VO members. To represent these interactions a sequence diagram was developed for each IECOS phase (See figure 23). Figure 51 shows the sequence diagram developed for IECOS scheduling phase. For these study case three VO members were involved in VO scheduling.

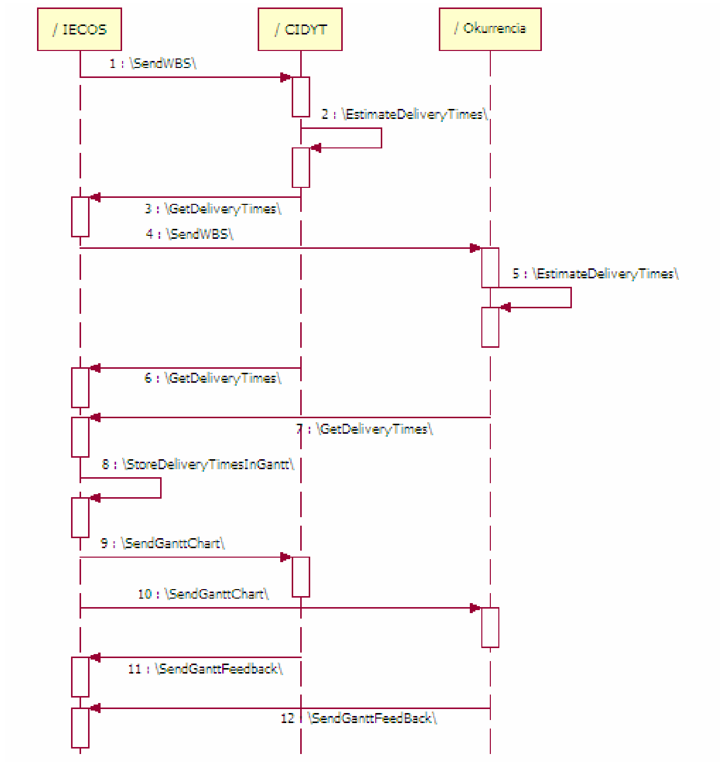

Figure 51 Sequence diagram used to represent VO Frame information view.

The goal of IECOS resource view is to represent partners resources involved in VO planning and launching activities, to achieve this goal, an UML classes diagram was selected to represent VO members resources.

Based in IECOS resource model (See figure 27), an instantiation process was developed using several levels of classes, Figure 52 show the instances created from IECOS resource model in order to represent the resources of IECOS and its partners.

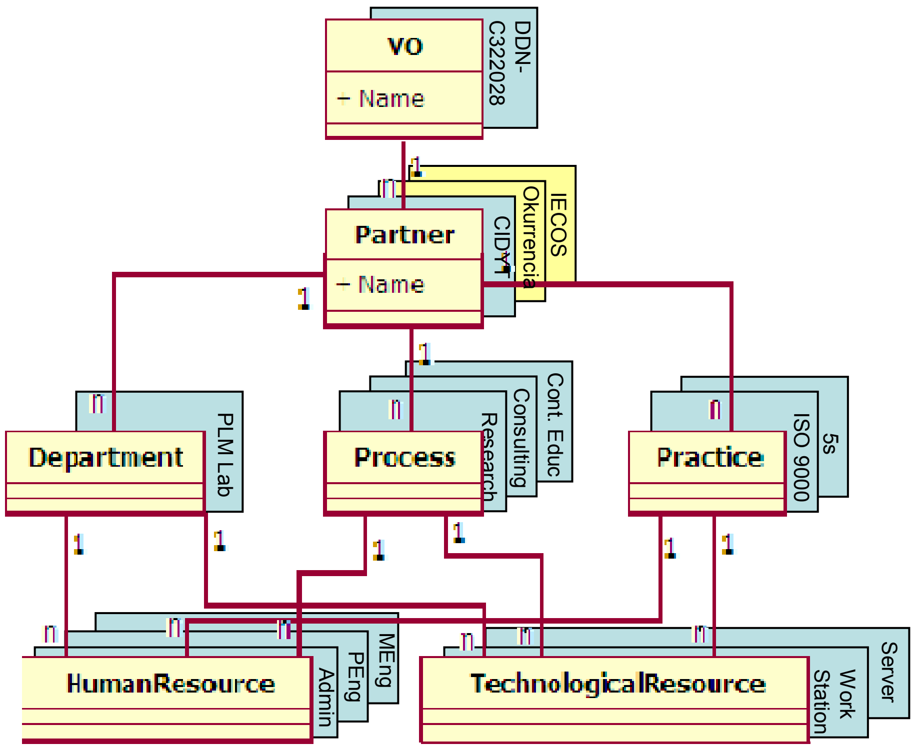

Figure 52 IECOS resource model instantiation process

For this study case, the resources of one IECOS partner were represented in the model. Figure 53 depicts the class diagram used to describe CIDYT resources, the first level class represent product name, and second level classes are the partners involved in the VO. In this diagram only one second level class was deployed, the class deployed was CIDYT, third level classes for CIDYT were practices (ISO 9000:2000)), process (Consulting, Research and Continuous Education) and department (PLM Lab). Only PLM Lab class was instantiated into fourth level instances, the instances represented PLM Lab technological (Workstation and Server) and (2) human resources (Administrator, Product engineer and Manufacturing Engineer).

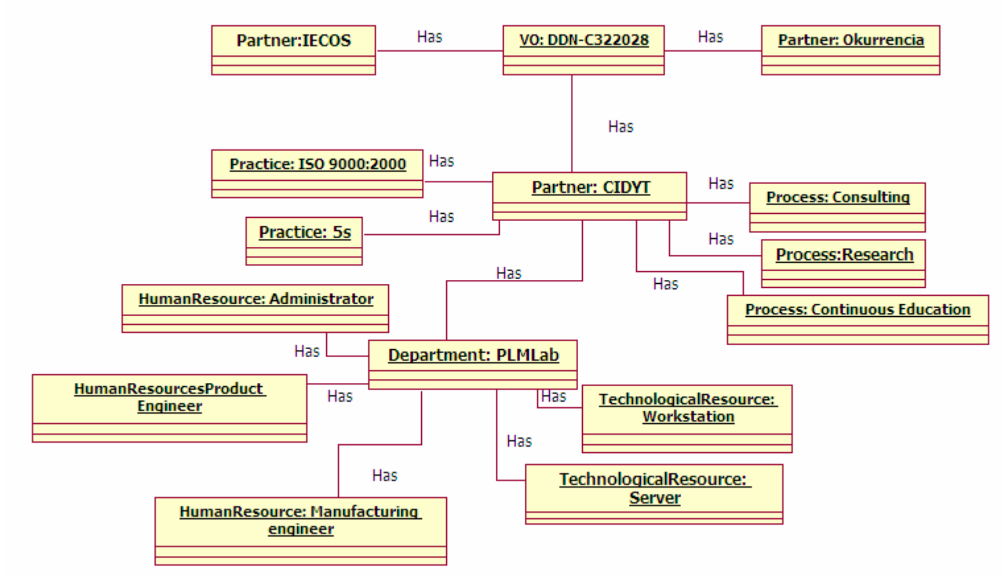

Figure 53 Class diagram used to represent VO Frame resource view

Once the models for each modelling view were developed, it was possible to create the VO model. VO model was composed by integrating IECOS modelling view into a concept where all UML diagrams developed can be included in one entity. Figure 54 depicts the VO model created through the integration of the UML diagrams that represents VO Frame modelling view. The VO model provided a multidimensional perspective about behaviour of the VO entities involved in planning and launching.

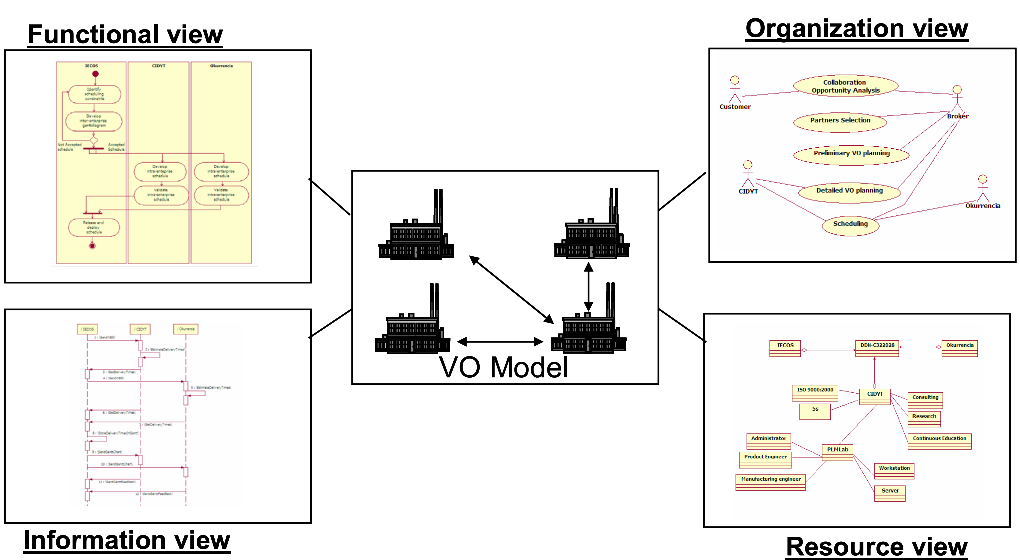

Figure 54 Integration of VO Frame modeling views into VO model (Adapted from Molina, 2004)

Chapter 6. - Results, conclusions and further work

6.1 Results.

After the execution of this research, the next results were achieved:

> A reference model for VO planning and launching (VO Frame). This reference model described how VO planning and launching can be developed through the use of three main element: (1) a set of phases capable to be personalized into specific VO characteristics, (2) a modeling approach that enable the understanding of VO planning and launching activities from a multidimensional perspective and (3) a knowledge management mechanism which allow the capture and share the knowledge generated during VO planning and launching among VO members.

> A set of methods and tools that support VO planning and launching were identified and classified according to VO Frame phases, these methods and tools are proposed in order to support VO planning and launching independent of the type of VO; but, considering the basic requirements for each phase of the reference model.

> A formalization of VO Frame according to GERAM was developed in which it was identified that the reference model includes seven of nine GERAM elements. Based on the formalization it was possible to validate reference model instantiation capability.

> Two particular study cases were developed to demonstrate how the reference model can be used to plan and launch broker-based VOs for aerospace industry equipment fabrication.

6.2 Conclusions.

> The use of VO frame in two study cases allowed validating reference model capability to create an integrated approach during VO planning and launching; the integration was achieved through establishing VO Frame phases as the main

element and linking the modeling approach and knowledge capturing and sharing mechanism into each phase of the reference model.

> The reference model provides a customizable structure based on the method, tools and models used in particular VOs, To enable this customization, it is necessary that each VO defines specific methods, models and tools for each of the phases of the reference model; these elements should be structured according each of the phases of the reference model.

> Through the development of two study cases, it was identified that VO planning and launching lead time within a VBE context is smaller than a VO created outside a VBE context.

> Through the integration of GERAM elements in the reference model it is possible to provide a robust approach during VO planning and launching. GERAM elements considered in the reference model are: (1) Generic Enterprise Reference Architecture, (2) Enterprise Engineering Methodologies, (3) Enterprise Modeling Language, (4) Enterprise Engineering Tools, (5) Partial Enterprise Models and (6) Enterprise Models.

> Based on the study cases developed in this research work it was shown that VO Frame can be instantiated into specific planning and launching approaches through the creation of particular enterprise models.

> The experiences in creating VOs have showed that ICT tools may not be an obstacle to create VOs. Companies involved in a VO can interact advanced ICT Tools. However, is important to develop appropriate ICT Tools in order to increase agility and response during VO planning and launching.

> Before implementing the reference model. It is important to identify the future VO scenario prior to develop the stages of VO planning and launching, this visionary perspective improve VO creation lead time by using only the required resources.

> Based on the four modeling views of the reference model it was possible to created a multidimensional model (VO model) that allow managers to understand the behavior of each of the VO member during planning and launching and to provide a basis for future VO planning and launching phases.

6.3 Further work.

After the experiences in VO planning and launching new opportunities for further research were identified:

- This research work presented a reference model which support VO planning and launching stages, however, there is a need to extend the scope of the reference model to entire VO life cycle.
- An important field is ICT implementation in VO planning and launching. This is a field which requires specialized knowledge in computer science. Several ICT tools that could help in VO planning and launching have been developed by other researchers. Based in this, there is an open research line in the implementation of VO Frame using other ICT tools in VO creation process.
- This research work presented a basic mechanism for knowledge management in VO planning and launching. The purpose of this mechanism was to shown the need of manage knowledge in VO planning and launching and promote a research line focused on developing novel mechanisms for VO knowledge management.
- In this research the reference model was formalized according to GERAM elements, however, the reference model does not include all GERAM elements. Based on this, there is a need to explore the two GERAM elements not included in the reference model; regarding to GEMC (Generic Enterprise Modeling Concepts) a VO ontology or glossary should be considered, finally EM (Enterprise Modules) should be supported by a set of common tools that can be used according to reference model phases.
- During this research work, two study cases were developed within a manufacturing context. However, is important to develop study cases in environments not related with manufacturing activities.
- In this research a modeling approach is proposed; however there is a need to develop modeling approaches that provide a holistic modeling method in order to represent the interactions between organizations.

- This research work proposed a basic knowledge structure that enables knowledge capturing and sharing within a VO; however there is a need to extend the scope of the knowledge domains included in the structure.
- Based on the literature review developed in this research, there is a need to explore and develop the following themes in order to support VO planning and launching: (1) Partners search and selection, (2) VO structure and topology and (3) VO partnership forms.

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Appendixes.

Appendix 1 GERAM Components description

GERAM provides a description of all the elements recommended in enterprise engineering and integration and thereby sets the standard for the collection of tools and methods from which any enterprise would benefit to successfully tackle initial integration design, and the change process which may occur during the enterprise operational life.

GERA (Generic Enterprise Reference Architecture)

The GERAM framework identifies in its most important component GERA (Generic Enterprise Reference Architecture) the basis concepts to be used in enterprise engineering and integration. These concepts can be categorized as:

a) Human Oriented Concepts
    1) To describe the role of humans as an integral part of the organizations and operation of an enterprise.
    2) To support humans during enterprise design, construction and change.
b) Process oriented concepts for the description of the business processes of the enterprise.
c) Technology oriented concepts for the description of the business processes supporting technology involved in both enterprise operation and enterprise engineering efforts.

EEMs (Enterprise Engineering Methodologies)

EEMs describe the processes of enterprise engineering and integration. An enterprise engineering methodology may be expressed in the form of a process model or structured procedure with the detailed instructions for each enterprise engineering and integration activity.

EMLs (Enterprise Modelling Languages)

EMLs define the generic modelling constructs for enterprise modelling adapted to the needs of people creating and using enterprise models. In particular enterprise modelling languages will provide construct to describe and model human roles, operational processes and their functional contents as well as the supporting information, office and production technologies.

GEMCs (Generic Enterprise Modelling Concepts)

GEMCs define and formalize the most generic concepts of enterprise modelling. Generic enterprise modelling concepts may be defined in various ways. In increasing order of formality generic enterprise modelling concepts may be defines as:

- Natural language explanation of the meaning of modelling concepts.
- Some form of meta model describing the relationship among the modelling concepts available in enterprise modelling language.
- Ontological Theories defining the meaning (semantics) of enterprise modelling languages, to improve the analytic capability of engineering tools, and through them the usefulness of enterprise models.

PEMs (Partial Enterprise Models)

PEMs capture characteristics common to many enterprise within or across one or mode industrial sectors. Thereby these models capitalise on previous knowledge by allowing model libraries to be developed and reused in a 'plug-and-play' manner rather than developing the models from scratch. Partial Models make the modelling process more efficient.

The scope of these models extends to all possible components of the enterprise such as models of human roles, operational processes and technology components, infrastructure components.

A partial model may cover the whole of a part of a typical enterprise. They may concern various points of view such as data models, process models, and organization models, to name a few.

EETs (Enterprise Engineering Tools)

EETs support the processes of enterprise engineering and integration by implementing and enterprise engineering methodology and supporting modelling language. Engineering tools should provide for analysis, design and use of enterprise models.

EMs (Enterprise Models)

EMs represents the particular enterprise. Enterprise models can be expressed using enterprise modelling languages. EMs includes various designs, models prepared for analysis, executable models to support the operation of the enterprise, etc. They may consist of several models describing various aspects (or views) of the enterprise.

EMOs (Enterprise Modules)

EMOs are the products that can be utilised in the implementation of the enterprise. Examples of enterprise modules are human resources with given skills profiles, types of manufacturing resources, common business equipment or IT infrastructure intended to support the operational use of enterprise modules.

EOSs (Enterprise Operational Systems)

EOSs support the operation of a particular enterprise. Their implementation is guided by the particular enterprise model which provides the system specifications and identifies the enterprise modules used in the implementation of the particular enterprise system.

Appendix 2 VO Frame Enterprise Engineering Tools

This appendix shows a brief description of the enterprise engineering tools used in VO frame implementation in the study cases developed. It important to mention that VO Frame in does not impose any particular set of tools or methods, but defines the criteria to be satisfied by any set of selected tools of methods.

IBM Rational Rose XDE Developer (XDE Modeller)

The Unified Modelling Language (UML) has become the industry's standard notation for software architecture and design. Rational led the development of the UML so that software professionals could model their analysis and design activities in a uniform, consistent manner. With the UML, you and your team have a common way to communicate and document your software.

To make the UML more practical to work with, we created the industry leading and award-winning Rational Rose XDE family of visual modelling and development tools. IDC and Gartner both recognize Rational Software as the industry's leader for Analysis, Modelling, and Design (AMD) tools.

The Rational Rose XDE family provides all of the essential elements of UML modelling in one robust product. Applicable to analysts, architects, designers, and implementers, Rational Rose XDE gives you and your team common tools for creating and maintaining UML models of your software project. They support forward and reverse engineering of code and both automatic and on-demand modes for round-trip engineering that allow you to control if, when, and how your models are synchronized with your code.

In the case of this thesis the XDE Modeller will be the module of XDE developer that will be used because our main objective is to model all the elements within the Virtual Organization using UML as modelling language.

Workflow Management System (WFMS)

What is Workflow?

Workflow can be described simply as the movement of documents and tasks through a business process. Workflow can be a sequential progression of work activities or a complex set of processes each taking place concurrently, eventually impacting each other according to a set of rules, routes, and roles.

Workflow Management Systems

Workflow Management Systems allow organizations to ***define*** and ***control*** the various activities associated with a business process. In addition, many management systems also allow a business the opportunity to ***measure*** and ***analyze*** the execution of the process so that **continuous improvements** can be made. Such improvements may be short-term (e.g., reallocation of tasks to better balance the workload at any point in time) or long-term (e.g., redefining portions of the workflow process to avoid bottlenecks in the future). Most workflow systems also ***integrate*** with other systems used by the organization: document management systems, databases, e-mail, office automation products, Geographic Information Systems, production applications, etc. This integration provides structure to a process which employs a number of otherwise independent systems. It can also provide a method (such as a project folder) for organizing documents from diverse sources.

Typical Features

Listed below are some typical features associated with many Workflow Management Systems.

• ***Process Definition Tool****:* A graphical or textual tool for defining the business process. Each activity within the process is associated with a person or a computer application. Rules are created to determine how the activities progress across the workflow and which controls are in place to govern each activity. Some workflow systems allow dynamic changes to the business process by selected people with administrative clearance.

• ***Simulation, Prototyping and Piloting****:* Some systems allow workflow simulation or create prototype and/or pilot versions of a particular workflow so that it can be tried and tested on a limited basis before it goes into production.

• ***Task Initiation & Control****:* The business process defined above is initiated and the appropriate human and IT resources are scheduled and/or engaged to complete each activity as the process progresses.

• **R*ules Based Decision Making****:* Rules are created for each step to determine how workflow-related data is to be processed, routed, tracked, and controlled. As an example, one rule might generate email notifications when a condition has been met. Another rule might implement conditional routing of documents and tasks based on the content of fields. Still another might invoke a particular application to view data.

• ***Document Routing****:* In simple systems, this might be accomplished by passing a file or folder from one recipient to another (e.g., an email attachment). In more sophisticated systems, it would be accomplished by checking the documents in an out of a central repository. Both systems might allow for redlining of the documents so that each person in the process can add their own comments without affecting the original document.

• ***Invocation of Applications to View and Manipulate Data****:* Word-processors, spreadsheets, GIS systems, production applications, etc. can be invoked to allow workers to create, update, and view data and documents.

• ***Worklists****:* These allow each worker to quickly identify their *current tasks* along with such things as due date, goal date, priority, etc. In some systems, *anticipated workload* can be displayed as well. These systems analyze where jobs are in the workflow and how long each step should take, and then estimate when various tasks will reach an individual's desk.

• ***Task Automation****:* Computerized tasks can be automatically invoked. This might include such things as letter writing, email notices, or execution of production applications. Task automation often requires customization of the basic workflow product.

• ***Event Notification****:* Staff and/or managers can be notified when certain milestones occur, when workload increases, etc.

• ***Distribution (Routing) Lists for Messages/Mail****:* Distribution lists can be created for sending ad-hoc messages among the staff.

• ***Process Monitoring****:* The system can provide valuable information on current workload, future workload, bottlenecks (current or potential), turn-around time, missed deadlines, etc.

• ***Access to Information over the World Wide Web****:* Some systems provide Web interfacing modules in order to provide workflow information to remote customers, suppliers, collaborators, or staff.

• ***Tracking and Logging of Activities****:* Information about each step can be logged. This might include such things as start and completion times, person(s) assigned to the task, and key status fields. This information might later be used to analyze the process or to provide evidence that certain tasks were in fact completed.

• ***Administration and Security****:* A number of functions are usually provided to identify the participants and their respective privileges as well as to administer routines associated with any application (e.g., file back-ups, archiving of logs).

Unified Modelling Language (UML)

UML represent the unification of the three main modelling language methods within the industry: Booch, Rumbaugh and Jacobson. UML went through a standarization process y the Object Management Group (OMG) and it is now an OMG standard. UML is a modelling language. As such, it contains a set of symbols (notation) and group of rules (semantics) that manage the language.

The most important concepts in understanding UML are: (1) the UML architecture, (2) notation (diagrams), (3) constraints and (4) extension mechanism. The diagrams, constraints and extension mechanism have direct connection to the business modelling.

UML diagrams

UML contains nine types of diagrams, of which seven are used in business modelling. The *class diagram* is composed of classes and relationships. It describes the structure of a system. The classes may represent information, products, documents, or organizations. The classes in a class diagram are linked via associations, which may be aggregations, composition, generalization and dependencies. An *object diagram* represents an instantiation of a class diagram for a specific situation.

The *statechart diagram* shows the possible states of a system. They capture the lifecycle of objects and systems, showing the states they can be in and how different events may affect those states over time. *Activity diagrams* describe activities and actions occurring in a system. In business modelling, activity diagrams may be used to model business processes. This modelling can be achieved via object or control flow.

The *sequence diagram* describes sequences of messages between a set of objects. The order and timing of objects are clearly depicted. Messages in a sequence diagram may have parameter and guards. Messages may also be synchronous or asynchronous. *Collaboration diagrams* are similar to sequence diagrams. However, they are capable to express more complex interactions and relations between collaborating objects. This comes to the expense of being to the expense of being less readable, compared to a sequence diagram.

Use Case diagram describe parts of the system functionality. A use case diagram is one use of the system by an actor. The use case diagram describes relations between use cases. Use cases may include, extend or generalise other use cases. *Component diagram* are mainly used to structure components in software systems. They are not used as yet in business modelling. *Deployment diagrams* are class diagrams depicting the hardware within a software system. Therefore, in their current form deployment diagrams are not used in business modelling.

UML is still evolving. UML aims to capture the three main aspects of a system: its structure, behaviour and functionality.

Work breakdown structure (WBS)

What it is:

A work breakdown structure (WBS) is a process for defining the final and intermediate products of a project and their relationships.

Generally, WBS uses a tree diagram/structure diagram to show the resolution of overall requirements into increasing levels of detail.

WBS allows a team to accomplish its general requirements by partitioning a large task into smaller components and focusing on work that can be more easily accomplished.

When to use it:

A work breakdown structure is an essential element in project planning and project management. In the quality planning process, WBS begins with a generalized goal and then identifies progressively finer levels of actions needed to accomplish the goal. In the quality improvement process, the tool is especially useful for creating an implementation plan to remedy identified process problems. For WBS to accurately reflect the project, however, it is essential that the team using it have detailed understanding of the tasks required.

How to use it:

Identify the primary requirement or objective. This should be a clear item, based on customer requirements, to which the entire team agrees. Write this requirement at the top of the chart.

Subdivide the requirement statement into major secondary categories. These branches should represent requirements, products, or activities that directly lead to the primary objective or that are directly required to fulfil the overall requirement. The team should continually ask, “What is required to meet this condition?”, “What happens next?”, and “What needs to be addressed?” Write the secondary categories below the primary requirement statement. Using sticky notes at this stage makes later changes easier to accomplish.

Break each major heading into greater detail. As you move from top to bottom in the WBS, products and activities should become more and more specific. Stop the breakdown when each task is tiny enough to be easily completed and evaluated for accuracy. If the team does not have enough knowledge to continue at some point, identify the individuals who can supply the information and continue the breakdown later with those individuals present.

Review the WBS for logic and completeness. Make sure that each subheading and path has a direct cause-and-effect relationship with the one before. Examine the paths to ensure that no obvious products or actions have been left out. Also ensure that the development of listed products or completion of listed actions will indeed lead to the anticipated results.

General Knowledge Base (GKB)

General Knowledge Base is program which provides an opportunity to create and manage your own knowledge base. Using General Knowledge Base the creation of your own knowledge base becomes quick and simple. The program's interface makes it easy to use and handle.

General Knowledge Base allows users to create knowledge base substantiated on any category of documents. It is an optimal tool for categorizing, processing, finding and describing documents, information and data. It allows user to keep documents systemized, to add notes and attachments, and to export articles into different file formats at any time.

Creating, editing and deleting articles with General Knowledge Base is very simple, and does not require any specific knowledge. Every article can contain additional notes and attachments, which are also easy to create and manage.

General Knowledge Base makes documents easy to find and retrieve. There is no need to spend time searching for files and folders on your computer. Using own knowledge base user can see all documents and information systemized in categories and topics. Powerful search and filtering engines makes documents easy to find just knowing essence.

Product Lifecycle Management: SMARTEAM

SMARTEAM delivers enterprise-scale, real-time visual collaboration to distributed project teams in the manufacturing industry. Its comprehensive enterprise PLM functionality is delivered via a flexible, dynamic product suite noted for rapid implementation, easy scalability and customizability, and best-of-breed integrations that create a true multi-CAx environment. SMARTEAM's diverse product offering leverages the latest information technology to provide organizations with robust, enterprise-scale PLM infrastructure and capabilities for managing Bills of Material, engineering change process, workflow, and more, while achieving collaboration across projects, design teams, the extended enterprise, and different players in the product's value chain.

The product suite features highly intuitive, easy-to-use administrative and user work environments, including role-based cockpits tailored to the user's scope of work. All SMARTEAM products are built on flexible, open architecture and use the latest technology standards.

SMARTEAM products combine seamlessly to bring secure, unified, and highly accessible enterprise PLM to teams, sites, suppliers, customers, and other business partners, across different sites, platforms, and regions. In addition to robust multi-CAx integrations, SMARTEAM products support a collaborative, comprehensive workspace that features integration with different work tools and applications, including Office and different email systems, project planning tools and different enterprise and manufacturing systems. SMARTEAM facilitates enterprise collaboration via the latest web technologies, data exchange via interconnectivity with universal EAI middleware, and an infrastructure that supports delivery of SMARTEAM PLM across different platforms.

The following sections describe the SMARTEAM Modules used in this research work:

SMARTEAM WORKFLOW

SMARTEAM Workflow is a change management and workflow automation solution that streamlines business processes by driving information automatically within the workgroup, throughout the enterprise (e.g. cross-department and to field personnel), and across the supply chain (e.g. customers, suppliers and sales channel).

SMARTEAM Workflow gives users the ability to initiate, track, and monitor processes and enhance the flow of work from person to person and team to team. Work is automatically routed from one stage to the next, while information about the status of the work, the users and the tasks is instantly available. As a result, projects move faster toward completion, reducing the time required for engineering change processes and all other standard authorization and implementation procedures. SMARTEAM - Workflow eliminates errors and improves quality by working in a paperless mode, keeping all parties on the same page within a highly secured environment.

SMARTEAM BOM

SMARTEAM BOM streamlines the processes related to the creation and change of the Bill of Materials (BOM) throughout the product lifecycle and across the value chain.

SMARTEAM BOM enables companies to collaborate on and manage product structures, including structure effectivity, by enabling dynamic hierarchical navigation through various view formats, and simplified change tracking, as well as workflow automation on BOM changes.

SMARTEAM - BOM empowers companies with product development collaboration with suppliers and customers by enabling users to effortlessly extract BOM data, images, assembly drawings, and other documents - with all related files and metadata--into a lightweight Briefcase.

SMARTEAM - Foundation is a complete enterprise product information collaboration platform that enables teams across the extended enterprise to collaborate on product data in a concurrent engineering environment. It delivers complete organizational collaboration across all enterprise applications and is configured for optimal use of the company's IT infrastructure. As manufacturing enterprises grow, the need to control and share vast amounts of product information grows exponentially. SMARTEAM - Foundation leverages a unique combination of leading-edge technologies to create a robust, secure, open, flexible and scalable collaborative product data management solution, enabling global manufacturers to achieve their goals.

SMARTEAM FOUNDATION

SMARTEAM Foundation provides secure, real-time access to product data for authorized users, from virtually anywhere on the globe. The SMARTEAM repository ensures data integrity and core technologies enable global access. LDAP support enables all SMARTEAM products to support user authentication against Directory Services (Windows Active Directory, IBM Directory Server, and others).

Required for each SMARTEAM user, SMARTEAM - Foundation is included in all SMARTEAM configuration packages.

SMARTEAM EDITOR

SMARTEAM Editor is the primary, and richest in functionality, of the Dashboards into the SMARTEAM environment. Easy to use and efficiently customizable, this Windows-based collaborative PLM solution enables users to share, exchange, view and manages product information throughout the product lifecycle.

As the core of SmarTeam's best-in-class collaborative Product Lifecycle Management solutions, SMARTEAM - Editor is complemented by an entire application suite and best practices. These include workflow and change management, Bill of Materials (BOM) management, Product Structure and configuration management, integration to leading CAD and Enterprise applications, multi-site support and more - all designed to address the needs of product teams in workgroups, extended enterprises and their value chains.

SMARTEAM WEB-EDITOR

SMARTEAM - Web Editor (WED) utilizes standard web technologies to provide local and remote company users working on multi-platforms, with collaborative Product Lifecycle Management through standard Internet browsers, enabling them to access and manipulate SMARTEAM product data easily in a dynamic and secure environment from anywhere.

Whether within the enterprise inside the corporate LAN, or dispersed in remote locations, across the corporate firewall using a WAN, SMARTEAM - Web Editor users can perform advanced searches and view documents easily. SMARTEAM - Web Editor allows users to create, edit, control, and annotate engineering and office-type documents, as well as perform lifecycle operations on them. In this manner, users can easily track and manage product data, improve worldwide collaboration and decision-making.

SMARTEAM- CATIA INTEGRATION

Developed by of Dassault Systemes, S.A., SMARTEAM - CATIA Integration (CAI) is an intuitive, easy-to-use and Windows-based integration of SMARTEAM within the CATIA environment. Bringing the benefits of collaborative PLM to CATIA V5 and ENOVIA DMU Navigator users SMARTEAM - CATIA Integration supports the "in-process" methodology, enabling users to manage vast amounts of documents and drawings directly from within the CATIA environment. A Default CAI toolbar is launched in addition to CATIA menu.

With SMARTEAM - CATIA Integration, CATIA users easily manage, create, edit and annotate designs and other related documents, including Office type documentation. Eliminating the need to re-key data and the inefficiency of working on outdated designs, SMARTEAM - CATIA Integration dramatically reduces errors and saves time, while ensuring revision accuracy and facilitating substantial design efficiencies.
Working in a multi-CAD environment

SMARTEAM creates a true multi-CAD environment, enabling CATIA users to deploy additional CAD Integrations, such as AutoCAD, on their own desktop. CATIA V4 models, as well as DPM, NC products, are also supported through CATProcess documents. Likewise, SMARTEAM enables the enterprise to manage all CAD and related product data from a single collaborative PLM system, providing a common collaborative platform among diverse engineering teams.

Appendix 3 Efforts made to enable Knowledge Capturing and Sharing in VO planning and launching

Based on the knowledge capturing and sharing mechanism included in the reference model (See section 3.1.4), several efforts were made in order to demonstrate the applicability of this mechanism.

Most of the efforts were made in the study cases: regarding to IECOS model, to enable knowledge capturing and sharing during VO planning and launching, a knowledge repository based in figure 14 was created, the tool used to create IECOS knowledge repository was General Knowledge Base. To implement General Knowledge Base it was required to create an object oriented database based on the model presented in figure 14, once the database was created, a knowledge server was created to enable distributed access for IECOS and its partners for particular VO's. To enable distributed access it was required to configure the database according to specific IP address, once the database was linked into a specific IP address, Information access privileges were defined for the different types of users of the knowledge repository.

Based on the knowledge repository created for IECOS model, two instances of this knowledge repository were created for each study case included in this research work.

Knowledge repository instance 1: Knowledge capturing and sharing efforts in study case 1 (Aerospace Maintenance Tooling Equipment Fabrication)

The implementation of the knowledge repository within VO Frame phases was developed before the topology was finished, the document repository was implemented using General Knowledge Base (GKB)[7] (See appendix 2); in this database the knowledge generated during the VO life cycle were stored. For this study case, the knowledge

[7] General Knowledge Base is a program which provides an opportunity to create and manage your own knowledge base. This product is property Baltsoft Corporation.

generated in VO planning and launching stages and few others from operation were stored in the knowledge repository. Furthermore, the information access rights were defined for all VO partners that will be using the repository.

During the execution of VO Frame phases according to IECOS model, huge amounts of knowledge were generated and exchanged. To structure knowledge execution and sharing during VO planning and launching a knowledge repository based on the structure presented in figure 14 was built; the purpose of the knowledge repository was to validate VO Frame knowledge capturing and sharing mechanism. The repository was implemented using General Knowledge Base[8] software as a client/server system. Before the repository was structured, information access rights were defined for all VO members; finally, VO partners were able to access the knowledge repository to store and exchange the knowledge generated during the VO.

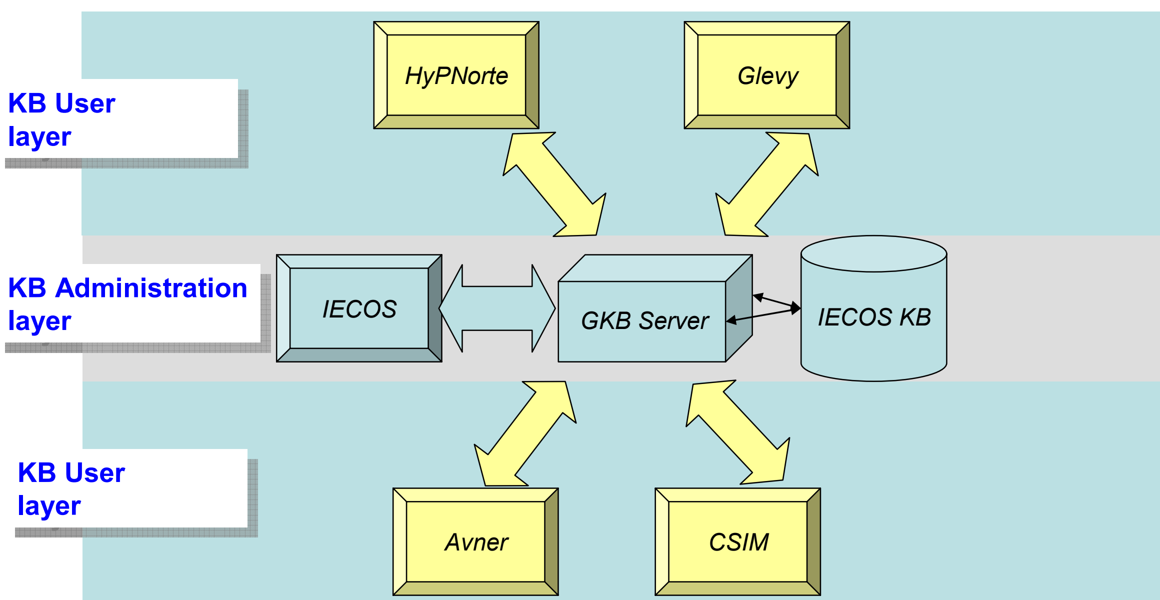

Figure 55 Knowledge repository-VO members interaction

Figure 55 shows the knowledge repository-VO members interaction scheme, the repository was developed using a client/server interface. The repository was composed by

[8] General Knowledge Base is software which provides an opportunity to create and manage your own knowledge base. This product is property Baltsoft Corporation.

two layers, first layer was responsible to design, operate and maintain the knowledge repository; this layer was called KB administration layer; IECOS was the entity involved in this layer during the VO. KB User layer was the second layer; KB user layer was subject to the privileges within the administration layer by IECOS. Through KB user layer was possible the interaction between VO members and the knowledge repository.

From users viewpoint, a windows based interface was used to enable partners access the knowledge repository (See figure 56). Through this interface VO members were able to create articles in order to capture the knowledge generated during VO planning and launching; these articles can include two types of knowledge (tacit and explicit). Once the articles were stored, knowledge sharing process was possible to develop, this process was made through downloading and visualizing the articles included in the knowledge repository.

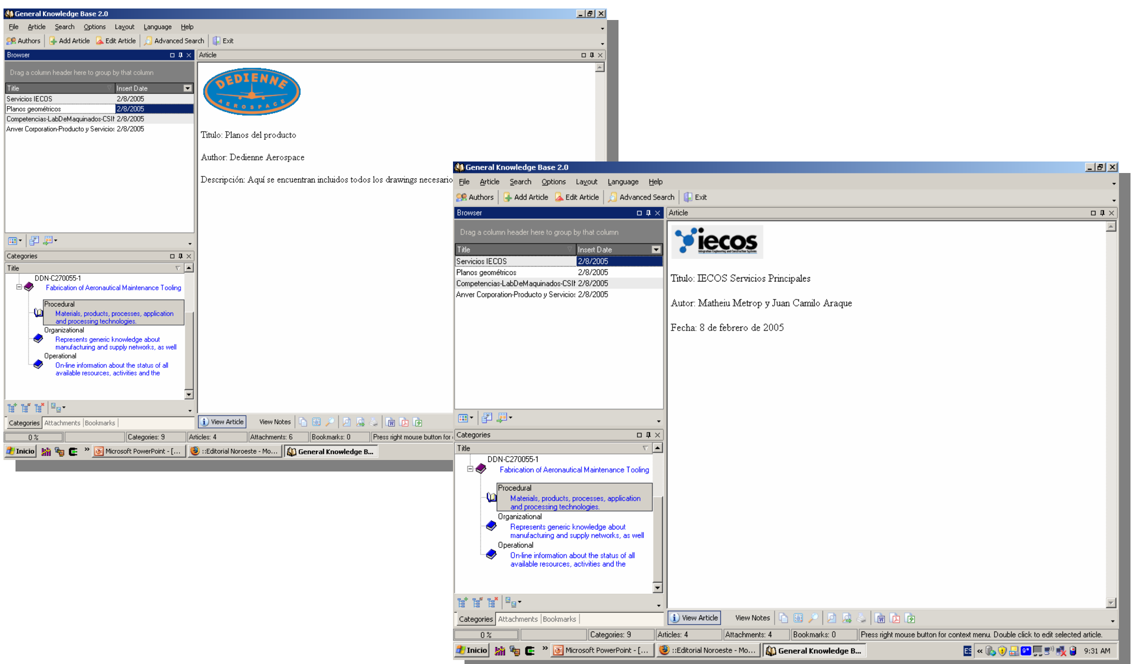

Figure 56 Knowledge repository interface

Knowledge repository instance 2: Knowledge capturing and sharing efforts in study case 2 (Aerospace Tooling Equipment Embodiment design)

In the second study case, once the topology of the VO was defined, General Knowledge Base (GKB) was used to create an inter-enterprise knowledge repository; in this repository was stored the knowledge generated during VO life cycle; the storage of this knowledge was made according to the knowledge domains (organizational, procedural and operational) described in section 3.1.4 .In this study case only the knowledge generated during VO planning, launching and operation was stored in the repository. Furthermore, the information access privileges for the repository were defined for each VO member in order to enable the interaction between VO members and the repository.

In this study case two tools were used as mechanism to support knowledge capturing and sharing. The first tool was General Knowledge Base, through this tool it was possible to create a knowledge repository according to the knowledge structure presented in figure 14; this repository provided distributed access to the knowledge generated during VO planning and launching. Figure 57 depicts knowledge repository-VO members interaction scheme, this scheme was composed by two layers; the first layer was KB administration layer; project manager was the entity responsible to manage this layer, the activities developed in this layer were: (1) design and (2) operation of the knowledge repository. The second layer was KB user layer, through this layer it was possible the interaction between VO members and the knowledge repository; an important activity to enable VO members interaction was the definition of information access rights for VO members, this activity was developed by the project manager within KB administration layer. The knowledge repository was created to demonstrate the application of knowledge domains included in IECOS model.

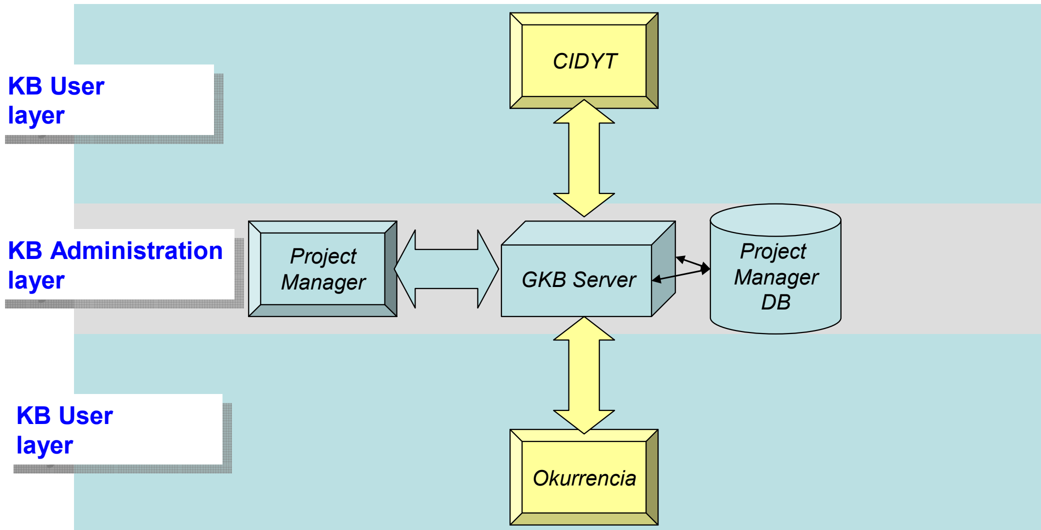

Figure 57 Knowledge repository-VO members interaction

Another tool that could support knowledge management during VO lifecycle (Creation, Operation, Evolution and Dissolution) is Smarteam vault. This vault provided a pre-defined architecture that enable knowledge capturing, sharing and exploiting in e-engineering VOs; in this research Smarteam Vault was created to support VO planning and launching through the creation of detailed workflow systems for the development of embodiment design service.

Regarding to the knowledge repository created in this study case using General Knowledge Base, users were utilizing the knowledge repository through a windows based interface (See figure 56). For this study case, VO members involved with the knowledge repository needed to create articles (electronic articles which serves as templates for knowledge capturing) to capture the knowledge generated during VO planning and launching, these articles provide the capability to attach several types of information. Once the articles were stored, knowledge sharing among VO members was made through downloading and visualizing the articles included in he knowledge repository.