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Business Processes of Manufacturing Networks

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Abstract

Collaborative network are a subject with significant growth over the past decades. Some of these collaborative networks are alliances among manufacturing enterprises, and in this case they are called manufacturing networks, this thesis is based on. Although the collaboration between companies exist for quite some time, the integration and collaboration as something organized and structured is still a distant held for most companies. Nowadays, with the increasing customer requirements it is necessary to meet market needs efficiently. Companies that want to be competitive need to be prepared to collaborate efficiently and effectively, creating manufacturing networks capable of producing complex products.

This work was carried out within the European project ADVENTURE and aims at identifying, describing, and validating the business processes and practices that are used by companies for the creation and management of its manufacturing networks. A comprehensive literature review was carried out to identify these processes and practices.

The results of this thesis are thus a set of business processes and practices required to implement and manage a manufacturing network from start to end. Empirical validation of processes and practices was conducted through questionnaires and workshops with experts and with managers in four industrial sectors: aerospace, machinery, energy, and semiconductor.

Acknowledgements

First of all I want to thank Professor Américo Azevedo for the opportunity to work with him, for his guidance and commitment.

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My sincere gratitude goes to all partners of the ADVENTURE project for their interest, comments, and contribution to this research.

To my friends and fellow students, who participated in some way in my development both personal and professional.

A very kind word goes to my parents, my sister and Ana for their support and care, which helped me, accomplish this stage.

To all my sincere gratitude,

David Costa

Table of contents

List of figures

List of tables

Acronyms

AP	ADVENTURE Process
APA	ADVENTURE Process Activity
APP	ADVENTURE Process Practice
APQC	American Productivity and Quality Center
BP	Business Process
BPM	Business Process Management
BPMN	Business Process Management Notation
CN	Collaborative Network
GSCF	Global Supply Chain Forum
ICT	Information and Communications Technology
IT	Information Technologies
MN	Manufacturing Network
PCF	Process Classification Framework
SC	Supply Chain
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SME	Small and Medium Enterprises
SOA	Service Oriented Architecture
VBE	Virtual Breeding Environment
VF	Virtual Factory
VO	Virtual Organization

1 st Chapter

Introduction

This dissertation focuses on the identification, description, and empirical validation of business processes and practices of manufacturing networks. This chapter introduces the work developed, by describing the motivation that led to the realization of this work, the ADVENTURE project, in which context this thesis was carried out, and the objectives and structure of the thesis.

1.1 Motivation

During the literature review on business processes a dominant gap has emerged, mentioned several times by different authors in the papers. Despite the large amount of papers written on collaboration networks, especially in recent years, there is still no empirical validation of business processes for the creation and management of manufacturing networks. For example the framework for VBE's and VO's proposed by Romero &Molina [1] is very comprehensive but lacks empirical validation. Till now, the processes used in frameworks are usually resulting from theoretical analysis, mainly on the collaboration processes[2], or sometimes, they are deducted from some formalization of results from other initiatives that somehow have tacked forms of collaboration among companies[2].

Even with the increasing use of technology, the largest use of business process models, and the growing number of application cases in industry and services[1], recent studies say that there are not many reliable real cases where an analysis can be made and most of the elicitation of business processes of collaborative networks is performed based on the state of the art[2].

Although there are authors that use case studies to validate or create frameworks like Shamsuzzoha et al.(2012)[3] and Verdouw et al.(2011)[4], their studies suggest only a particular case of collaboration (fruit and fashion) and not a general case. They start using a proposed framework (example SCOR) and adapt to the type of collaboration, beyond this the focus of their study is not only to define the processes, but the overall framework without a

deep level of study of the processes involved. As it was also noted the processes must still be adapted to each situation and their study is not complete, serving only to support as a starting point to construct a business process based management framework for VBE's and VO's[1]. They also recognized as the next step, the need to validate this framework through a community of experts[2].

Another noticeable gap is the lack of definition, characterization and standardization of processes used in collaborative networks and also there is not a common understanding of the key business processes[5]. Today more and more companies use processes and document them somehow and when this is not done there is always the possibility of collecting this information through the knowledge that employees have about the processes. Nowadays, organizations have a sizeable intellectual investment in the form of formalizations of processes and these descriptions are essential to train employees, define standards and communicate best practices within the organization[6].

In order to develop a set of business processes for manufacturing networks it's necessary to perform an empirical process validation of collaborative networks based on comparing the resulting list of literature review and analysis of case studies. In addition it is also necessary to characterize all processes of the defined list.

Although several conceptual frameworks have been already developed in the literature to support collaborative networked organizations, these haven't taken a holistic perspective of the creation, execution, and dissolution of a VF with tools for the VF business model definition, VF business processes and management practices for each process. This is the gap that ADVENTURE project aims to address, which is specifically relevant for SMEs to form the VF with the help from an ICT- enabled plug and play infrastructure. The proposed conceptual manufacturing reference model developed within the ADVENTURE project will be beneficial for the individual enterprises to operate and set up a VF of a dynamic and inter-enterprise network for complex product manufacturing.

Beyond that, the elaboration of business processes and practices specific to manufacturing networks help companies to become more competitive and able to respond quickly to market needs.

1.2 The ADVENTURE Project

ADVENTURE – ADaptive Virtual ENTerprise manufacTURing Environment – is a project funded in the Seventh Framework Programme by the European Commission. ADVENTURE creates a framework that enhances the collaboration between suppliers, manufacturers, and customers for industrial products and services.

Lately there has been some research projects related to the study of collaborations between companies, however, this study is usually directed to a section, for example, partners-finding. The importance of this project is in the standardization and interconnection of enterprises, enabling information sharing end-to-end and creating true virtual factories based on ICT.

The Adventure Project proposes to create a framework that facilitates the connection between various companies with the common goal of enabling complex manufacturing processes.

This framework is composed by several tools that allow not only to create and operate manufacturing processes, but also to optimize the overall manufacturing process. Some tools will be partner-finding, process creation, process optimization, information exchange as well as real-time monitoring combined with the tracking of goods. The tools will be based on SOA and web, taking advantage of these latest technologies in order to store data in the cloud, thus providing information for all partners in real time.

This will allow integration and cooperation between partners and more robust IT structures, but also become more flexible and reduce time to market. Besides this, sharing of processes and knowledge allow a constant evolution and development, placing the companies at the forefront of innovation.

This MEng Dissertation Thesis was integrated in the task T3.4 - Conceptual Manufacturing Reference Model of the ADVENTURE project, and the main goal is to identify and describe the business processes and practices of manufacturing networks. Fig 1.1 represents the overview of the research conducted to develop the ADVENTURE Reference Model, the main scope of this thesis is the development of Section 5.

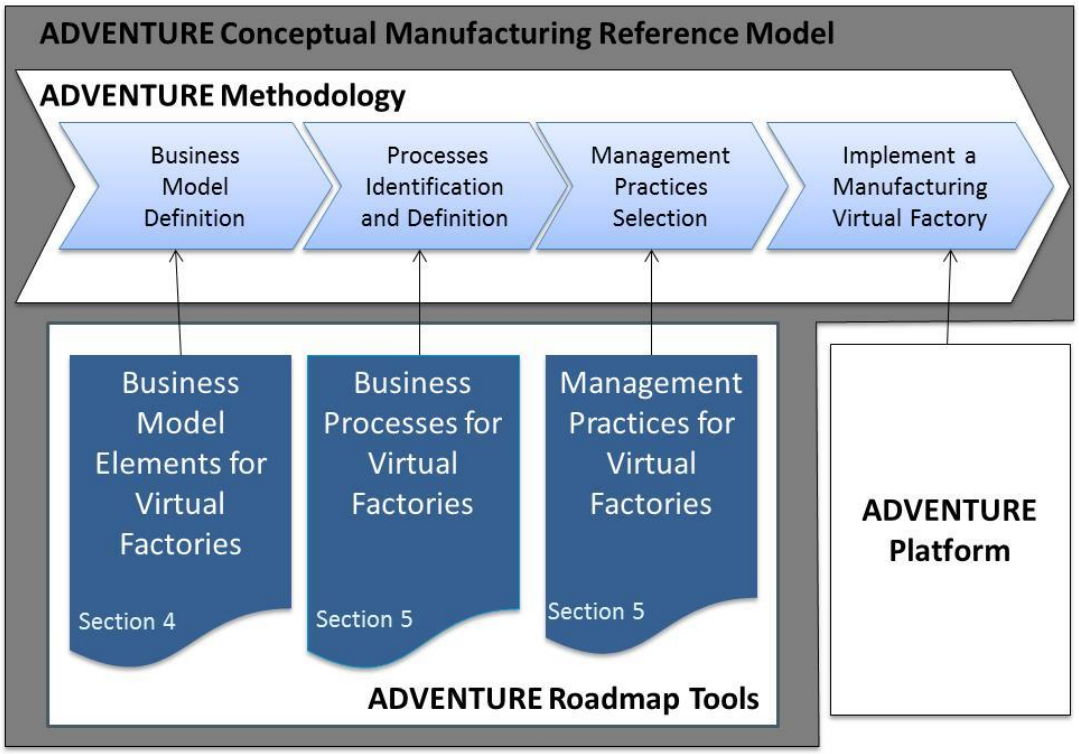

Figure 1.1 - ADVENTURE Reference Model Overview

1.3 Objectives

The main objective of this work is to identify, describe, and empirically validate the business processes and practices needed to create and manage manufacturing networks.

In order to achieve this main objective, the following sub-objectives were defined and served as targets:

- Create a list of business processes of manufacturing networks from literature review.
- Create a list of business processes tailored to manufacturing networks.
- Characterize the business processes using the Input-transformation-output Model and the BPMN.
- Review the literature on management practices of the defined business processes.
- Validate business processes with experts and companies that are involved in collaborative networks.

Since this thesis contributes to a research project of INESC, it has received also some contributions and comments from the other team members that were synthetized and aggregated to build the reference model.

1.4 Structure of the thesis

This thesis is structured in five chapters. The first chapter is an introductory chapter for the reader to the motivation, the context in which the work was carried out, and the objectives of the thesis.

The second chapter reviews the literature and presents an introduction to theory of business process management and the most important frameworks and projects of collaborative networks.

The third chapter explains the methodology used to identify and describe the business processes and practices and its empirical validation.

The fourth chapter is divided into two parts: the first presents an overview of the reference model and the second characterizes the business processes and practices.

The fifth chapter is the conclusion. It's divided into two parts: the first presents the results and conclusions and the second points out considerations in terms of what can be developed in the future.

2 nd Chapter

Business Process Management

Nowadays, most companies are changing their way of operation and structure and are expanding the use of business processes from production to other business areas allowing companies to be managed using operations management methods.

This is an introductory chapter where the reader can find some basic principles of business process management and a review of the most relevant business network frameworks found in literature.

2.1 Business Process Management

Business process management (BPM) has raised interest by business administration and computer science communities that want to improve the operations of companies, investigate structural properties of processes and develop robust and scalable software systems to deal with the amount of complex information of processes[7]. In other words we could say that BPM enables to create agile and flexible organizations capable to adapt their business processes to achieve its overall objectives. This requires companies to be flexible and adapt continually processes to meet market needs and economic, political and social context.

BPM includes not only the representation of business process (e.g. activities and execution constrains), but also allows processes improvements, costs minimization, increase productivity and competitiveness, and increase customers satisfaction.

Usually business processes are performed manually only guided by the knowledge of employees and organizational procedures and regulations. Sometimes it's profitable for enterprises to use software systems to achieve additional benefits and coordinate the activities of business processes, the so called Business Process Management System, a generic software system that is driven by explicit process representations to coordinate the enactment of business processes. It includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of business process[7].

2.2 Business Process

Business processes are the key for the success of collaboration between people, enterprises and IT as processes play a major role in the design and operation of flexible information systems. The activities of business processes can be performed by expert employees manually, by the help of information systems, or even automatically by information systems. Several definitions of a business process were found in the literature:

Hammer and Champy – "Business process is a collection of activities that take one or more kinds of input and create an output that is of value to the customer." [7]

Davenport –" a set of logically related tasks performed to achieve a defined business outcome for a particular customer or market."[7]

Looking for Hammer & Champy and Davenport definitions of a business process, we can define business process as a set of activities performed by employees and the interactions between them in order to achieve a goal and create value.

2.3 Business Process Lifecycle

Business process lifecycle is composed by four phases that are related to each other and organized in a cyclical structure that shows their logical dependencies. Although this cyclical structure is connected by arrows this does not imply a straight temporal ordering of execution [7].

Design and Analysis

During this phase it is usual to use surveys to identify, review, validate and represent the business processes. After all data have been gathered, some formal techniques of modeling and simulation guarantee that the business process has been analyzed and improved until it reaches the desired behavior.

Configuration

Once the business process has passed through Design and Analysis it has to be implemented using a set of policies and procedures. When the process is only used by employees it is necessary to instruct them on how to guide the process. Otherwise, if the process needs to be supported by a process management system, it has to be configured and integrated in the information technology environment.

Enactment

In this phase the business process is initiated and the system starts monitoring the execution to guarantee that the process activities are performed according to specified constrains in the process model.

Evaluation

The information captured in the monitoring system is evaluated using techniques to identify the quality of the business processes. According to the information collected it is possible to make improvements on the business process and achieve better quality.

Administration and Stakeholders

Business process models need to be well-structured as well as the employees knowledge with organizational roles/skills and information technology of the enterprise. Every business process infrastructure has several types of stakeholders with all kinds of knowledge and expertise that need to cooperate in the design of business process and develop great solutions for enacting them.

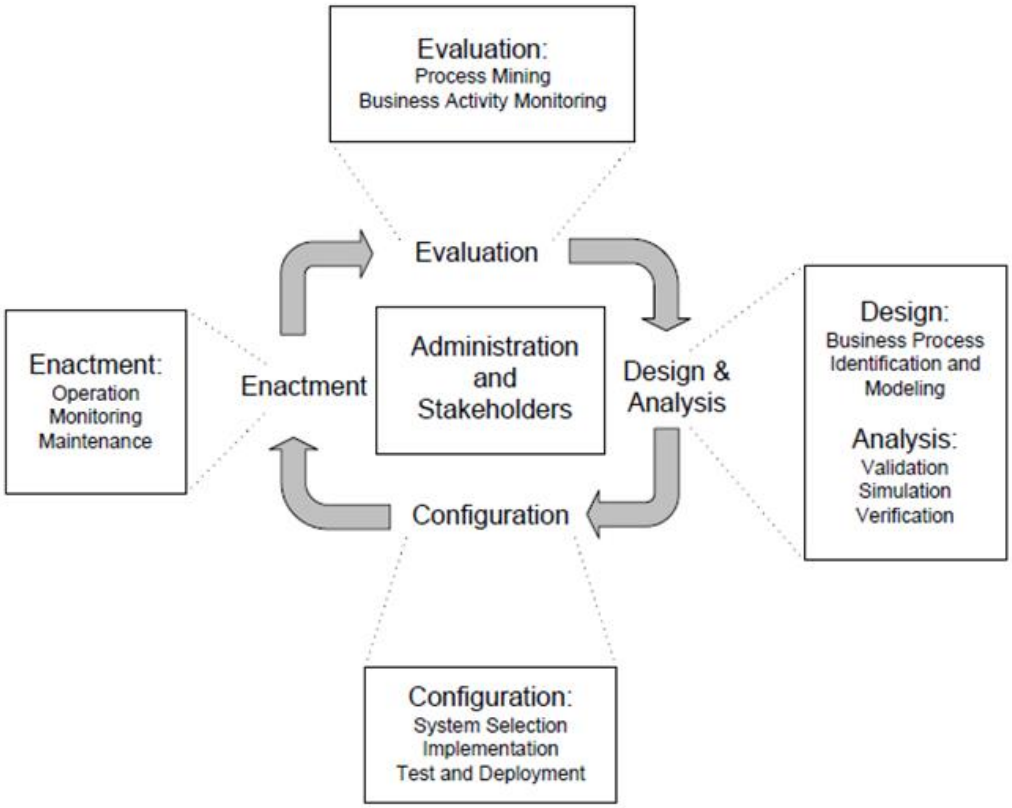

Figure 2.1 - Business Process Lifecycle Diagram [7]

2.4 Input-transformation-output model

Business processes can be documented using different models, one of those is the input-transformation-output model. A simple way to understand processes is to think in processes as a transformation of inputs in outputs, e.g. usually a process as a set of inputs witch are transformed in outputs or responsible for the transformation. Regarding the inputs it could be the resources transformed in the process (information, materials, customers) and transformation resources. Transformation resources refer to people involved in the process and facilities like buildings, tools, machines, etc. An example of input-transformation-output model diagram is shown in Figure 2.2 [8].

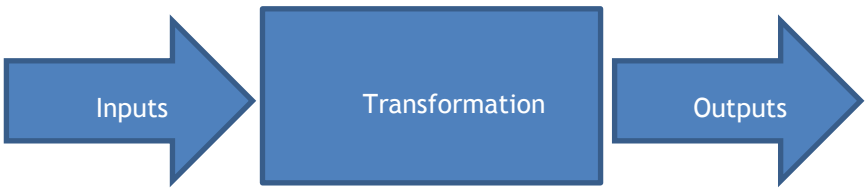

Figure 2.2 - Input-transformation-output Diagram

2.5 Business Process Management Notation (BPMN)

Although textual representation of business processes lists their activities, it doesn't necessary explain the sequence in which these activities are to be performed, so graphical notations of BP's are increasingly used due to the possibility of expressing orderings and interaction between activities. This type of notation focuses on the structure and interactions between activities and participants, besides of the technical aspects of their realization or implementation. The realization of BP by participants can change without affecting the externally visible behavior of the process.

One of this business process models is the Business Process Management Notation, which main objective is to provide a graphical notation that is easily understandable by everyone, from analysts that create the initial models, passing by the developers responsible for implementing the technology, to processes managers and supervisors. The model is a network of graphical objects, figure 2.3, which consist of activities and flow controls that define the order of execution.

The idea behind the BPMN was to create a simple mechanism to develop models that at the same time are able to deal with the complexity inherent to business processes. The

solution was to organize the graphical aspects in specific categories. It's easy to recognize the basic type of elements and understand the diagram; within the basic categories can be added variants and information to support the requirements of complexity without major changes to the appearance of diagrams. A key feature of this notation is the hierarchy of processes in a top-down approach, the processes are progressively detailed and organized into levels. The Macro-processes level corresponds to the business functions that unfold to operational processes and activities, called Processes and Sub-processes.

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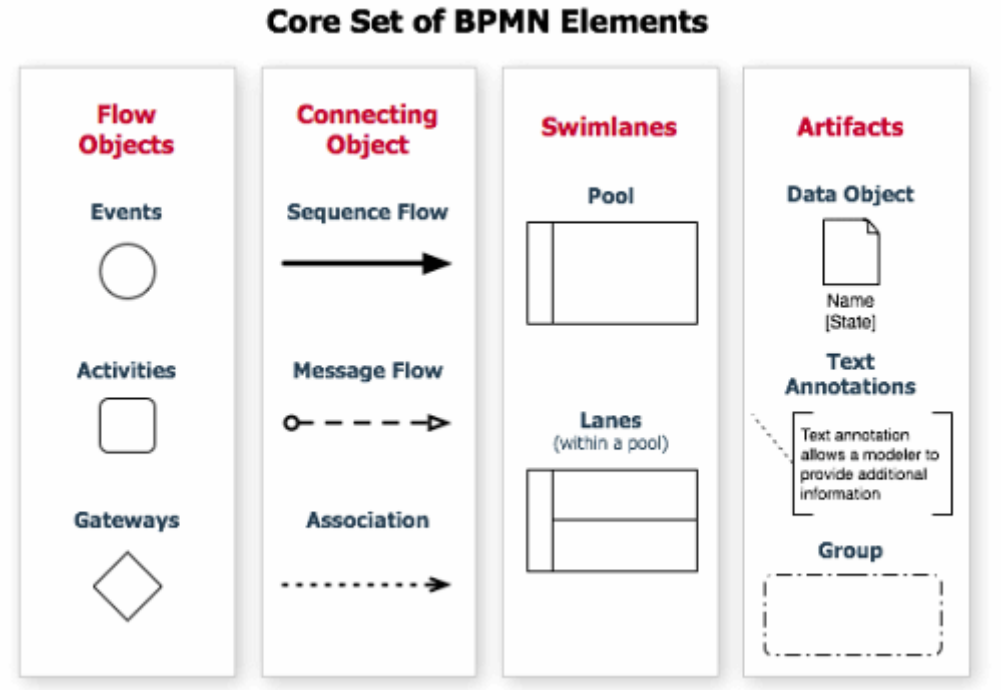


Figure 2.3 - BPMN Elements [http://www.infoq.com/resource/articles/process-component-models/en/resources/bpmn.elements.png]

2.6 Classification of Business Process

Primary, support and development

Business processes can be classified as primary, support and development. Primary processes refer to those that have main value-added activities of the organization, for example, a process where someone is paying for the outcome. In the other hand, support processes represent non-value-added activities but that are necessary for the success of primary processes. Development processes are responsible for increasing the performance of primary and support processes [7].

Organizational vs. Operational

Different levels can be identified in business process management, ranging from high level business strategies to implement business process.

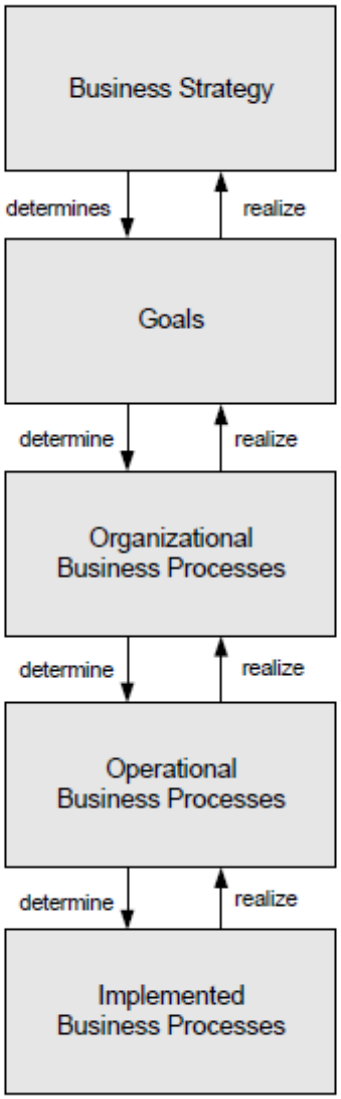


Figure 2.4 - Levels of Business Processes [7](page17)

As Figure 2.4 shows, at the top level the strategy of the company is specified, it describes the long term concepts to develop a sustainable competitive advantage in the market. On the next level, the strategic operational goals are described, which can be divided into a set of sub goals.

The third level is the high level processes also known as organizational business process. At this level processes are described in plain text, enriched with diagrams or expressed in an

adhoc notation, using informal techniques inputs, outputs, expected results and dependencies are specified.

In the two lower levels it is expected to find several operational business processes that contribute only to one organizational business process (at this level the activities and the relationship between them are described). Implemented business processes are developed from operational business processes that contain the information of technical and organizational environment and how to execute the process activities.

Intra-organizational processes vs. process choreographies

Most BP interacts with BP in other organizations forming process choreographies. Otherwise when there is no interaction in the business process with other parties it is classified as intra-organizational. Intra-organizational BP objective is to streamline internal processes by eliminating activities that do not provide value, usually they are supported by workflow management systems [7].

Interacting business processes always bring some issues and it is important to be careful not only with the communication aspects of the structures, but also with the legal matters and in the technical layer ensure a heterogeneous software infrastructure.

Degree of automation, repetition, structuring

Business processes can diverge in the level of automation. There are BP fully automated, meaning that no human is involved in the enactment of such a BP. Many BP require manual activities, but they also include automated activities.

Processes could be more or less repeated. The processes with high repetition are usually automatic and the less repeated are usually manual. It is important to analyze the frequency of a process, to define the level of investment in modeling and automation of the process in order to guarantee more efficiency. In the other hand, for the less repeated processes it is questionable if it worth the investment of modeling because of the cost. Most of these processes are not fully automated and have a collaborative character.

The degree of structuring can almost be defined according to the degree of repetition, usually the processes with high degrees of repetition could have a more rigid structure. For process participants with the knowledge sometimes have a rigid structure can be an obstacle, in order to balance the degree of structure it is important to guarantee some flexibility. Business process models should define business process in a less rigid manner to make possible different sequences of activities and the knowledge worker should determine when all the activities of the goal have been reached.

The different processes classification can be resumed using a table as presented bellow. In the Table 1 it's possible to see the most common classification found in literature.

Table 2.1 - Process Classification by the Author

CN	Ecolead[1]	APQC[9]	Weske[7]	Garvin[10]	Croxton[5]
Structural	Management	Management	Organizational	Organizational	Strategic
Componential	Operational	Operational	Operational	Management	Operational
Functional		Support			
Behavior					

2.7 The Four V's of Processes

Despite all the differences between processes, they all have some characteristics in common, e.g. volume, variety, variation and visibility are four of them [8].

Volume

Usually the high output volume of a process represents repeatability and the need of specialization, in this case special staff and resources are necessary to maximize efficiency.

Variety

This represents the number of different activities performed. High variety processes are invariably more costly than low variety processes. A process with these characteristics implies a wide range of inputs and additional operational complexity.

Variation

Predictable processes are easier to manage, unpredictable processes demand more effort to meet the customer needs and extra resources for sudden surge is needed.

Visibility

It refers to how much of the process does the customer actually experience. In other

words, this represents the lag between the process execution and the “deliver” of the final product.

2.8 Measuring Business Process Performance

Measuring the process performance is not always easy, as seen before, processes can be found in lots of different situations and ambient. In order to know the performance of the process we have to understand what customer wants and define KPI’s to calculate objective performance. There are countless possible measures of process performance, most of them derive from this four performance dimensions: Quality, Cost, Time and flexibility.

Productivity, efficiency and cycle time are often used to measure process performance. Productivity is the unit of output per unit of input, and usually is measures in units. Efficiency is the ratio of actual outputs to standard outputs, expressed in percentage terms, this standard could be based on studies or historical results.

Organizations are always trying to reduce the cycle time, to do this it is necessary to perform well on other dimensions such as quality, delivery, productivity and efficiency. The cycle time is the elapsed time needed to complete a business process. Sometimes is also useful to measure the percent value-added time, which is the percentage of total cycle time that is spent on activities that actually produce value.

2.9 Process Improvement Tools

Organizations are more and more interested in improving and re-engineering processes, making small improvements that can increase process efficiency. Business process mapping plays a major role in the improvement of BP, helping to understand the processes by developing graphic representations and organizational relationships. Data analysis tools make part of the organizations quotidian, the most relevant data analysis tools are Root Cause Analysis, Open Phase, Cause and Effect Diagram, Five M’s, Five Why’s, Scatter Plot, Check Sheet, Pareto Chart and Bar Graph [11].

Frameworks for Business Process Design in Different Fields of Research

2.10 Supply Chain Management

SCOR

The Supply Chain Operations Reference (SCOR) model, created by The Supply Chain Council, use process building blocks to describe simple and complex supply chains a common set of definitions across disparate industries. In order to describe and represent all the business activities related with satisfying customer demand, the model is organized according to five primary management processes:

-Plan, analyzes the entire chain, from purchasing and customer needs to the production and delivery of products.

-Source, handles all the purchasing of raw materials and its infrastructure in the entire logistics chain.

-Make, takes care of all matters related to the manufacturing of the product.

-Deliver, analyzes demand management and storage applications from the distribution channels to the end customer.

-Return, analyses returned products throughout the supply chain and the return of materials.

Figure 2.5 - SCOR Model Overview [http://supply-chain.org/SCOR-overview 27/7/2013]

Considering this primary management processes, the model has more two levels of processes. This classification was created not to conduct a straight business or system but to achieve a better performance.

The model was designed and maintained to support supply chains of different complexities and industries, analyzing a supply chain and identifying opportunities to improve workflow and information.

Supply performance could be difficult to analyze so SCOR has a set of attributes to measure the performance. The council developed five core supply chain performance attributes: Reliability, Responsiveness, Agility, Costs and Asset Management. These attributes allow not only to measure the performance of a supply chain but also the comparison between different kinds of SC. Associated with some attributes there are a set of strategic metrics divided in three levels and hierarchical organized.

Another section of the SCOR is the best practices that contain some management practices, software solutions and definitions of each process. These practices were created not only to ensure better performance in supply chain optimization but also to provide risk management and environmentally responsible management[12].

Supply Chain Management Processes

The Global Supply Chain Forum define a set of eight processes capable of characterize the core of supply chain management.

-Customer Relationship Management, how the relationship with the customer is developed and maintained.

-Customer Service Management provides the single source of customer information (shipping date, product availity and order status).

-Demand Management, responsible to link customers' needs with supply capabilities.

-Order Fulfillment, allow integration with manufacture, logistics and marketing plans to meet customer requirements and reduce costs.

-Manufacturing Flow Management, represent the products manufacturing and flexibility to reach market target.

-Supplier Relationship Management, how the company interacts with its suppliers.

-Product Development and Commercialization integrate customers and suppliers to develop new products and put them quickly and efficiently in the market.

-Returns, develop guidelines to analyze return and procedures to return the products.

The processes are described according to two levels, strategic and operational. The strategic level has an important role integrating the company with the other members of the

supply chain, it provides the establishment and strategic management of each process and a guide for implementation. On the other hand, the operational level has the role of continuous updating the process once established.

As it's possible to see in Figure 2.6 the processes cover all the supply chain and are transversal to all companies and functional silos (Marketing, Research and Development, Finance, Production, Purchasing and Logistics). The authors describe and define each of the sub-processes and activities of the eight processes and the link between them, although the activities and importance of the processes may vary according to the firm [5].

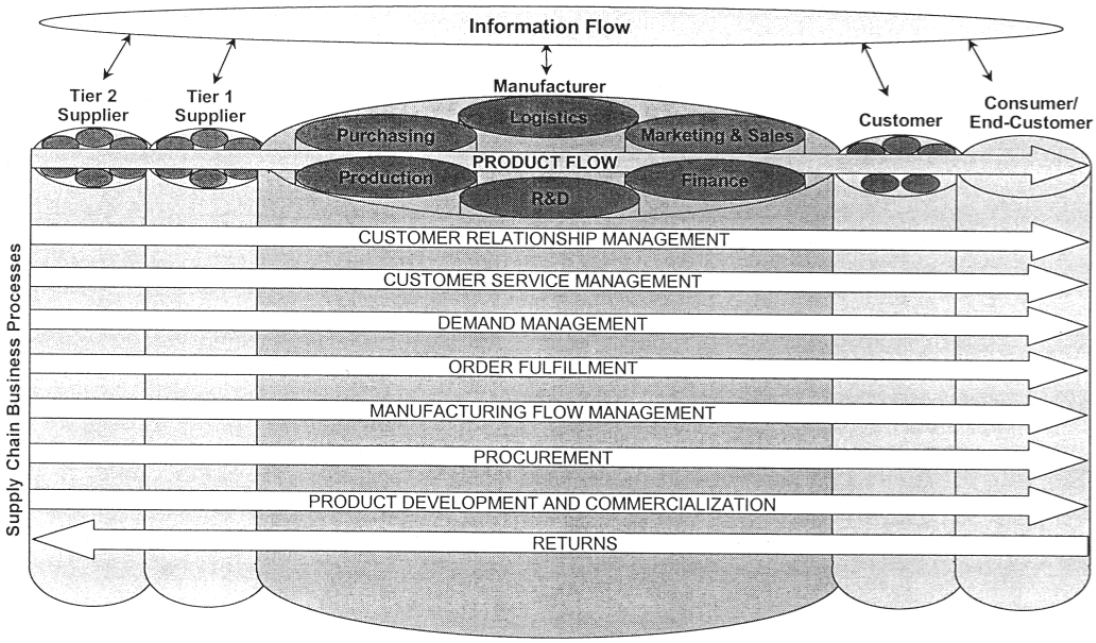


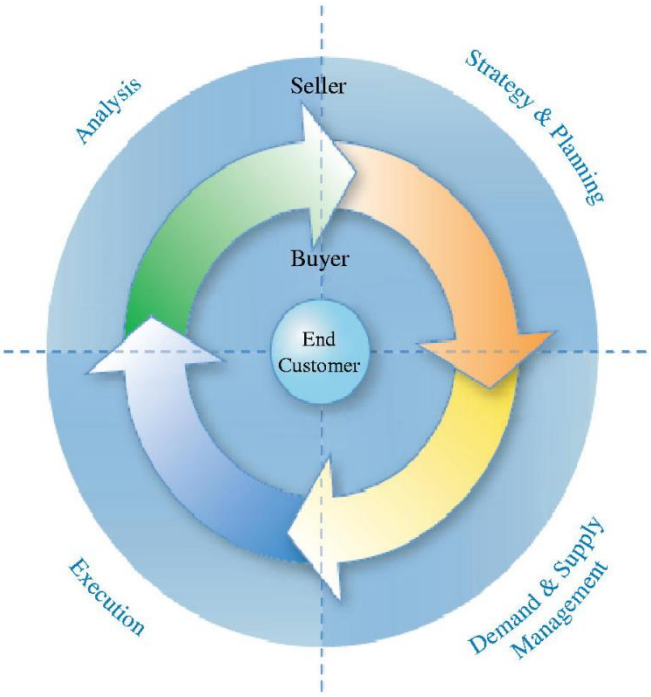
Figure 2.6 - Integrated Business Processes within a Supply Chain (Lambert and Cooper 2000)

CPFR

Collaborative Planning, Forecasting and Replenishment (CPFR) is a business practice created with the objective of putting together multiple partners involved in manufacture and fulfill the customer demand.

The Voluntary Inter-industry Commerce Standard Association with this publication of CPFR guidelines make possible stock improvements and inventory reductions for lots of companies. This was possible because CPFR links sales and marketing best practices with supply chain planning and execution processes, making possible a reduction in inventory, transportation and logistics costs and increasing availability.

The figure 2.7 is an illustration of the CPFR framework. The image shows a seller and a buyer who work together to satisfy the end customer, represented in the center.



Source: Voluntary interindustry commerce standards

Figure 2.7 - CPFR Framework Illustration

The CPFR present a set of 4 main activities to help improve performance, each one of this can be executed as any time without a predefined order, or in some situations the company may use only one of this and perform the rest according to their internal processes.

Strategy & Planning – Responsible for establishing the guidelines for the collaboration

Demand & Supply Chain – Manage customer demand and plan order and shipment requirements

Execution – Order to cash cycle, e.g. place orders, manage payments, deliver products

Analysis – Monitor and control processes trough the KPI's and adapts processes to better performance

The framework has a second level of detail called Collaboration Tasks, this level has eight tasks, two for each activity. In figure 2.8 it's represented the four activities and the eight tasks.

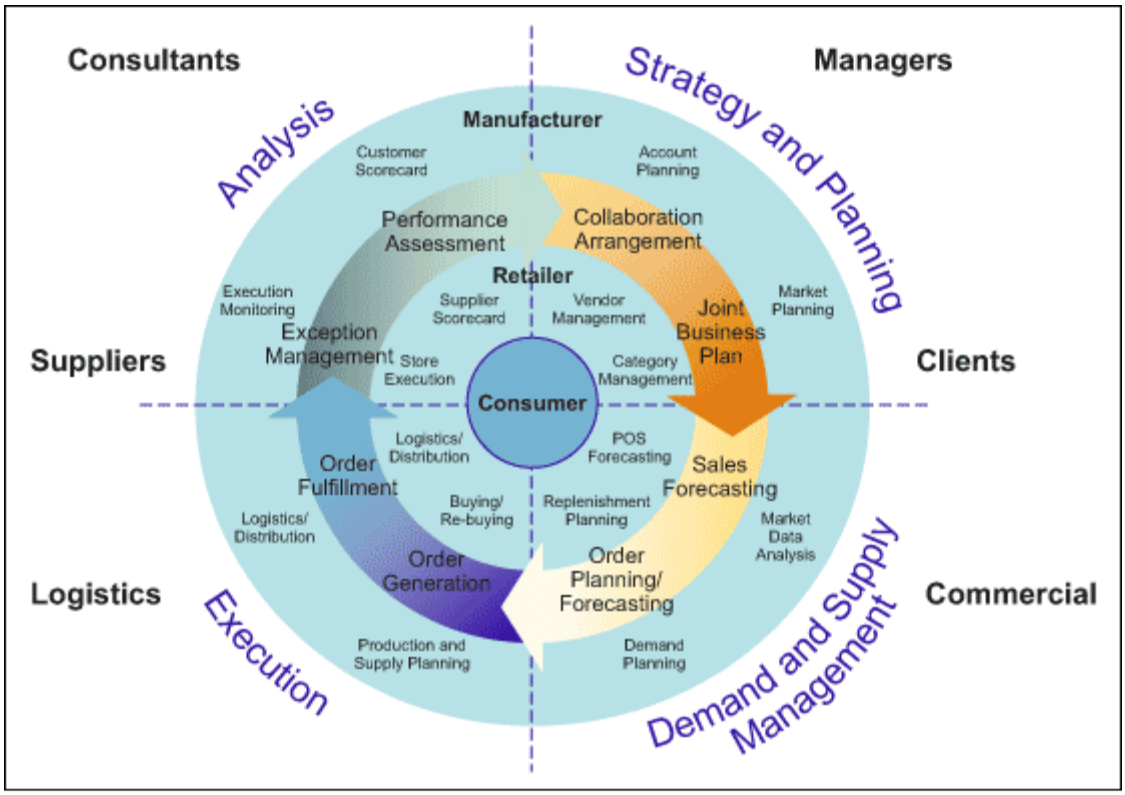


Figure 2.8 - CPFR Activities and Tasks

Although CPFR has already guidelines to four specific scenarios it can be adapted to many scenarios according to the particular needs of the collaboration relationship.[13]

2.11 Organizational Management

PCF (APQC)

The Process Classification Framework (PCF) developed by the American Productivity & Quality Centre is a taxonomy of cross-functional business processes intended to allow the comparison of organizational performance within and among organizations.

The APQC and its members developed a set of business processes and a common language to enable a universal benchmarking and a dynamic framework constantly updated by the members. The PCF is continuously improved and enhanced to help organizations adapting to constant market changes, build and improve way of work and stay competitive.

The framework is organized in twelve different levels of operational and management processes and also includes the best practices, methods of improvement, training and tools to succeed. Figure 2.9 represents the twelve different levels of enterprise processes.

In the end we could say they developed an open standard to ensure process management improvement and beneficial benchmarking, independently from industry, size or location. In fact the PCF is a high level, industry-neutral enterprise process model allowing the enterprises to see their process in a cross-industry perspective due to this beneficial benchmarking.[9]

Figure 2.9 - Twelve Processes Levels of PCF

2.12 Collaborative Networks

Collaboration is becoming more and more essential in today's society and collaborative networks can be found in different situations, from manufacturing networks to emergency situations caused by natural disasters. A collaborative network can be defined as a set of organizations/persons organized/integrated to achieve common goals in the most efficient way and with the help of computer networks. Usually these entities can be autonomous,

geographically distributed and very different in terms of operating environment, goals, culture and social capital.

Although most of the collaboration are still disorganized, the idea of these frameworks or projects is to provide some guideline of how to organize the activities, distribute roles among entities and manage collaboration [14].

ECOLEAD

European Collaborative networked Organizations LEADership initiative, ECOLEAD, is a project co-funded by the European Commission within the 6th Framework Programmer. The ECOLEAD focus on the paradigm of creating collaborative networks capable of responding fast to constant change in market conditions, and present a set of tools and mechanisms to allow collaborative networks work as breeding environments facilitating the formation of dynamic virtual organizations.

The project follows a holistic approach to achieve substantial impact in networks and due to the complexity and multiple inter-decencies between entities, it claims the necessity of incremental innovation among entities and flexible and managerial projects. The VO Breeding Environments, Dynamic Virtual Organizations and Professional Virtual Communities are the three vertical focus areas and the basis for dynamic and sustainable network organizations, Figure 2.10. To support this vertical focus the framework has two horizontal areas, the theoretical foundations for collaborative networks responsible for providing technology-independent understanding and an ICT infrastructure to enable a low-cost establishment of truly dynamic collaborative network [15].

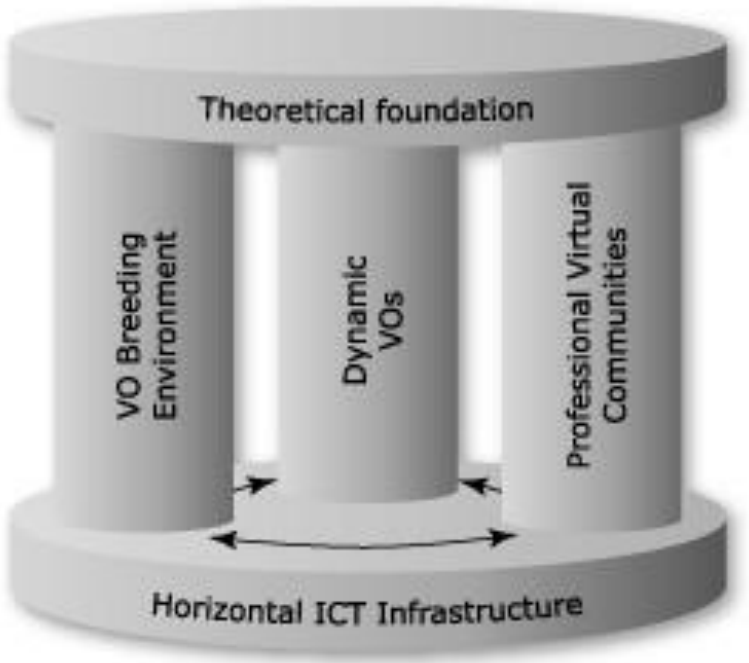


Figure 2.10 ECOLEAD Organizational Diagram [http://www.ve-forum.org/default.asp?P=284 2/8/2013]

Net-challenge

The net-challenge project is integrated in the FP7 and the main goal of this project is to support the collaboration between SME's by creating and managing business networks to help then become more competitive and integrated in the global market in the development and manufacturing of complex products.[16]

In order to enable a quick response to the market, differentiated products and competitive prices, this framework provides a set of methods and tools like manage and develop business communities, create and manage collaboration projects, decision support tools and IT infrastructure.

The methodology was designed to allow a practical and phased approach in the development and management of Business Communities and creation of collaboration projects. Beyond the guidelines and best practices, it also includes tools to build and measure trust, share knowledge, promote collaboration and monitor performance of the network.

Furthermore, some collaboration business processes were created to enable a quick and real adaption to each business network, these processes are:

-Business Communities creation and management;

-Capacity management;

-Collaborative planning;

-Event management;

-Performance management

3 rd Chapter

Research Methodology

This chapter describes the methodology used in the three main parts of this work. Initially it's presented the methodology used to characterize the business processes, including the BPMN models. Secondly it's shown the methodology to search and select practices to be used in each process. Finally, it is described how the empirical validation was done, explaining the method used for processes validation and the practices associated with the project collaborators and some industries that have in their manufacturing process some collaboration networks.

3.1 Manufacturing Networks Business Processes

The first step to identify the business processes for manufacturing networks went through a review of existing literature on collaborative networks to arrive to a comprehensive list of business processes several fields of research. Some of the fields considered were: Collaborative Networks, Supply Networks, Manufacturing Networks; Supply Chain Management, and Business Processes. Towards this end, several online repositories as Web of Knowledge, Scopus, and Google Scholar search engine were used to obtain articles in scientific peer-review journals in these fields.

The keywords used in the search were "collaborative networks", "business networks", "supply chain networks", "virtual factory", "virtual collaboration", "business processes of collaborative networks", "collaborative frameworks", "manufacturing business processes".

The following procedure was used to identify and describe the business processes for manufacturing networks:

1 Papers selection, according to the guidelines on the subject, the type of papers (journal, conference) and the reputation (rating).
2 Analysis to the papers selected to collect a set of business processes capable of filling the needs of manufacturing networks. This way it was possible to prepare the table A1 (Annexes) where an extensive set of business processes is presented, organized according to four different phases and sub-phases considered in the project ADVENTURE.
3 Review of each process and fusion of those that somehow had the same purpose synthesizing the initial table in a new table with only 15 business processes that represent the four phases initially defined to represent the entire manufacturing network.
4 Perform a summary of the literature used and the goal was to find the original source of each business process, reaching in some cases the frameworks of existing collaboration as is the case SCOR APQC, CPFR .
5 Process characterization based on the papers.

A simple way to understand processes is to think in processes as a transformation of inputs into outputs. Each process was characterized by filling in the template in Figure 3.1, with process title, mission, short description, ID, Type, process initiator, inputs, activities, practices, outputs, customer, supporting tools and Monitoring and Control. The business processes were modeled using the tool BizAgi according to the logical sequencing of its activities and the description of the inputs, outputs, practices and supporting tools for each process were provided.

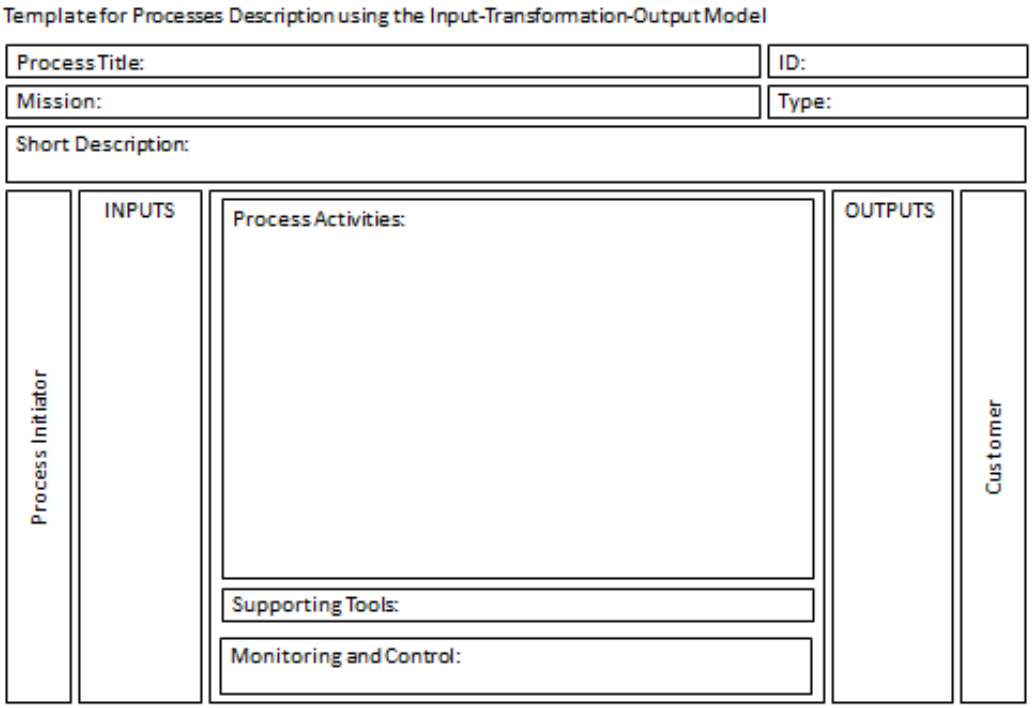


Figure 3.1 - Business Process Description Template

In table 2 it's possible to see the business processes organized according to the four phases defined and the references that were the basis for the process. Furthermore, it's possible to see in the last column a set of tools that support the execution of each process.

Table 3.1 - Manufacturing Network Business Processes 2

		CN			SN	MN	SCM			BP			
Phase	**Process**	Camarinha-Matos & Afsarmanesh (2007)[14]	Romero & Molina (2009)[17], Hormazabal & Rosa, (2011)[18]	Shamsuzzoha et al. (2012)[3], Ferreira et al. (2012)	Harland et al (2004)[19]	Montreuil et al. (2000)[20]	Croxton et al. (2001)[5]	SCC (2008)[12]	VICS (2004)[13]	Garvin (1997)[10]	APQC (2012)[9]	**Comments**	**Supporting tools**
JOIN	Set-up the manufacturing network framework	X[1]	X[2]	X[3]	X[4]				X[5]		X[6]	[1]ICT infrastructure [2]ECOLEAD framework [3]Net-Challenge framework [4]Information systems integration [5]CPFR Technology [6]Manage information technology	Installation Guide
	Provide information about products, services, competencies and capacity	X	X	X		X							Data Provisioning and Discovery Component
	Leverage networking to find new business opportunities												

PLUG	Define the manufacturing network business model	X	X[7]	X		X[8]			X		X	[7]Collaboration opportunity characterization [8]Collaborative strategy definition	Business Model Framework Process Designer component Data Provisioning and Discovery component Process Simulation component
	Search and assign partners	X	X	X	X								Process Designer component Data Provisioning and Discovery component
	Design network's governance and operational plan and processes (incl. simulation and optimization)	X	X	X		X	X	X	X	X[9]	X	[9]Work processes (operational, administrative), Behavioral processes (decision-making, communication, learning), Managerial processes (direction-setting, negotiating and selling, monitoring and control)	Business Process Catalogue Process Designer component Process Simulation component Process Optimization component
	Negotiate manufacturing network agreements	X	X	X		X	X[10]					[10]Develop product/service agreement with suppliers	Not supported
	Manage risk	X	X	X	X			X			X		Smart Process Engine component Process Monitoring component

PLAY	Design and develop product			X			X			X	X		Smart Process Engine component Process Monitoring component
	Manufacture product			X			X	X	X	X	X		Smart Process Engine component Process Monitoring component
	Fulfill Order	X	X	X		X	X[11]	X	X[12]	X	X	[11]Order fulfillment [12]Order generation	Smart Process Engine component Process Monitoring component
	Monitor and adapt processes	X	X	X	X[13]	X	X	X	X	X		[13]Shared decision-making and control	Process Monitoring component Smart Process Execution component
DISSOLVE	Collect feedback from stakeholders		X	X									
	Evaluate performance	X	X	X									Process Monitoring component (KPI subcomponent)
	Share the benefits and assign liabilities	X		X	X		X[14]				X[15]	[14] Customer service management, Returns Management [15]Manage customer service	Data Provisioning and Discovery component (Data access only)

3.2 Manufacturing Networks Practices

In the case of practices the methodology used was similar to the business processes. A survey to create a list of practices presented in papers was conducted and subsequently practices were selected and assigned to each process according to the context.

The table 3.2 list all processes and practices associated with each process. The next step was a second analysis of the papers to collect practices' descriptions.

Table 3.2 - Manufacturing Network Practices

Phase	Process	Practices
JOIN	Set-up the manufacturing network framework	Have an IT infrastructure with appropriate hardware, software, and technical support available to all VF personnel(Barczak and Kahn, 2012)[21] Create a compatible communication/ information system within the VF. (Narasimhan et al. 2008)[22]
	Provide information about products, services, competencies and capacity	Share information about products, services, competencies and capacity
	Leverage networking to find new business opportunities	Find networking partners and manage networking relationships (Mu and Di Benedetto, 2012)[23] Build networking activities in order to leverage partner's resources, capacity, skills, knowledge, and specialization (Mu and Di Benedetto, 2012, Min et al., 2005)[23, 24]
PLUG	Define the manufacturing network business model	Use the business model framework for virtual factories (Soto et al., 2012)[25] Create a core cross-functional team which remains on the project from beginning to end. (Barczak and Kahn, 2012)[21] Nominate a project leader. (Barczak and Kahn, 2012)[21]
	Search and assign partners	Vision the network architecture and identify the right individuals or organizations for the VF (Mu and Di Benedetto, 2012)[23] Build strategic partnerships with VF members (Li et al., 2005)[26]

Phase	Process	Practices
	Design network's governance and operational plan and processes (incl. simulation and optimization)	Share information (Costs, Customer demand, Materials requirement, Price changes, Production capacity and scheduling, Inventory-holding costs, On-hand inventory levels, Inventory policy, Supply disruptions, Order status, Delivery schedules) (Li et al., 2005[26]; Min et al., 2005[24]; Narasimhan et al., 2008[22]; Simatupang and Sridharan, 2005[27]) Design facilities network and transportation (Cigolini et al., 2004[28]) Leverage partner's resources, capacity, skills, knowledge, and specialization (Min et al. (2005)[24]; Mu and Di Benedetto (2012)[23]) Develop and clearly communicate VF goals (Barczak and Kahn, 2012)[21] and needs (Narasimhan et al., 2008)[22] Document operational processes (Barczak and Kahn, 2012)[21] Design flexible and adaptable processes (Barczak and Kahn, 2012)[21] Plan collaboratively (Min et al., 2005[24]; Simatupang and Sridharan, 2005[27]) Make decisions jointly concerning sourcing (Narasimhan et al., 2008)[22], manufacturing (Barczak and Kahn, 2012)[21], logistics (Barczak and Kahn, 2012)[21], marketing (Barczak and Kahn, 2012[21]; Narasimhan et al., 2008[22]), and sales (Barczak and Kahn, 2012)[21].
	Negotiate manufacturing network agreements	
	Manage risk	Exchange relevant and value-adding information in an accurate, timely and credible manner (Li et al., 2005[26]; Wiengarten et al., 2010[29]) Solve problems jointly (Li et al., 2005[26]; Simatupang and Sridharan, 2005[27]) Maintain close contact with customers (Wu et al., 2012)[30] Evaluate formal and informal complaints of customers (Li et al., 2005)[26] and VF partners Respond quickly to complaints (Wu et al., 2012)[30] Share risks (Wiengarten et al., 2010)[29]

Phase	Process	Practices
PLAY	Design and develop product	Involve ccustomers/users (Barczak and Kahn, 2012)[21], suppliers (Li et al., 2005[26]; Narasimhan et al. 2008)[22], product designers and manufacturers (Swink et al., 2005) [31] Use modular design of parts (Li et al., 2005[26]; Narasimhan et al., 2008)[22] Use concurrent engineering (Narasimhan et al. 2008[22]; Wu et al., 2012)[30] Simplify and standardize component parts (Narasimhan et al. 2008)[22] Use value analysis/value engineering (Narasimhan et al. 2008)[22] Use Quality Function Deployment (House of Quality) (Narasimhan et al. 2008)[22] Formally evaluate the results of testing (concept, product, market) (Barczak and Kahn, 2012)[21] Cleary pre-define Go/No-Go criteria for each review gate (Barczak and Kahn, 2012)[21] Design for manufacture and assembly (Narasimhan et al., 2008[22]; Swink et al., 2005[31]; Wu et al., 2012[30]) Design for SCM (Cigolini et al. 2004)[28] Design of products for reduced consumption of material/ energy (Green et al., 2012)[32] Design of products for reuse, recycle, recovery of material and/or component parts (Green et al., 2012)[32] Design of products to avoid or reduce use of hazardous products and/or their manufacturing process (Green et al., 2012)[32]

Phase	Process	Practices
	Manufacture product	Use lean practices: reduced set-up times, small lot sizes, and pull-production (Chavez et al., 2013[33]; Cigolini et al., 2004[28]; Li et al., 2005[26]; Mackelprang and Nair, 2010[34]; Narasimhan et al. 2008[22], Swink et al., 2005[31]; Wu et al., 2012[30]) Use quality management practices: supplier certification, inspection, statistical process control, continuous quality improvement programs, competitive benchmarking (Chavez et al., 2013[33]; Li et al. 2005[26]; Narasimhan et al., 2008[22]; Swink et al., 2005[31]; Wu et al., 2012[30]) Cooperate with partners for environmental objectives: reduce transportation, energy consumption, carbon and other emissions; implement cleaner production and green packaging (Green et al., 2012)[32]. Use continuous replenishment and VMI (Cigolini et al., 2004)[28] Reserve upstream capacity /stock (Cigolini et al., 2004[28]) Use postponement: move forward operations or activities (e.g. final assembly, delivery) to the later possible point in the supply chain (Li et al., 2005)[26]
	Fulfill Order	Deliver on-time to the customer's point of use (Narasimhan et al., 2008)[22]
	Monitor and adapt processes	Measure performance jointly (Min et al., 2005)[24] Track environmental information (such as toxicity, energy used, water used, air pollution) (Green et al., 2012)[32] Monitor emissions and waste production (Green et al., 2012)[32] Redesign business processes (Cigolini et al., 2004)[28] Improve processes (Narasimhan et al., 2008)[22]
DISSOLVE	Collect feedback from stakeholders	Measure customer satisfaction (Li et al., 2005[26]; Wu et al., 2012[30]) Collect feedback from VF members
	Evaluate performance	Define standard criteria for evaluating VF's (Barczak and Kahn, 2012[21]) Share the evaluation report in the ADVENTURE platform
	Share the benefits and assign liabilities	Share savings (Simatupang and Sridharan, 2005)[27] Assign responsibilities for post sales customer assistance

3.3 Empirical Validation

The business processes and practices for manufacturing networks were validated both with the researchers of project ADVENTURE and with the companies on the Advisory Board of the ADVENTURE project.

To present the work and explain the type of involvement required for the validation of the reference model a presentation integrated into the project ADVENTURE workshop in Porto was done. This presentation presented the work developed and how it was structured, then explained the two phases of validation, through an online application form and a workshop with companies. The online survey gathered feedback on the business processes, while the workshop with companies selected the practices used, e.g. through the presentation of practices it was possible to notice what is actually useful and used by companies. Thus it was possible to validate and adjust processes to the reality of companies and select only the most relevant ones.

In the case of collaborators and researchers of the project, their contribution was the response to online questionnaire where they were asked to give feedback of the processes. Through the questionnaire different views of people directly connected to the project and with technical knowledge in the area of collaborative networks were collected.

Companies that make part of the Advisory Board had a key role as they have experience in a real context. To validate processes and practices, companies were asked to think of a collaborative network that needed to assemble and use the processes and practices to structure the collaboration. In the case of business process, Skype sessions were held. During these sessions an introduction to the processes was made and then were flown all the processes and the company answered the questionnaire giving their. Subsequently, in accordance with the availability, hands on workshops were held in companies to validate the practices, photo C1 and C2 Annexes. In this specific case was used the scheme figure D1 Annexes, and a set of post-it's with all the practices associated with each process, the companies were then guided sequentially through all the processes and practices and questioned about what they would use for the collaborative network used earlier.

The four companies from the advisor board that collaborate were:

- Manufacturing network to design, build and deliver aero structures: Aerospace Wales Forum, UK (B1 annexes)
- Manufacturing network to design, build and deliver a new machine: Azevedos Indústria S.A., Portugal (B2 annexes)

- Manufacturing network, build and promote new technologies in the energy technology sector, Oy Merinova Ab, Finland (B3 annexes)
- Manufacturing network to industrialize a new technology and launch it: Nanium S.A., Portugal (B4 annexes)

After data collection an analyze was performed and subsequent changes to the processes and practices were made according to the suggestions considered relevant. The final results are in Chapter 4.

4 th Chapter

Business Process Modeling for Manufacturing Networks

This chapter presents the business processes and practices developed for manufacturing networks that will be integrated into the ADVENTURE project. In the first part an overview of the processes organization. The second part presents the business processes and practices according to the logic presented in chapter 2 each process has its input-transformation-output model, the description of the associated practices and the BPMN process model).

4.1 Reference Model Overview

As mentioned in the first chapter this work was developed based on the needs, but considering manufacturing networks in general. Thus the business processes and practices have been developed to incorporate a framework to construct business models to manufacturing network.

The business processes were divided as mentioned in chapter 3 into four main phases that represent the life cycle of a manufacturing network. The first phase is independent from the other three phases and it is specific for projects where it is necessary to register on a platform. The other phases are the network construction, real collaboration and dissolution of the network. In figure 4.1 is possible to see a diagram that represents the processes distribution for each phase.

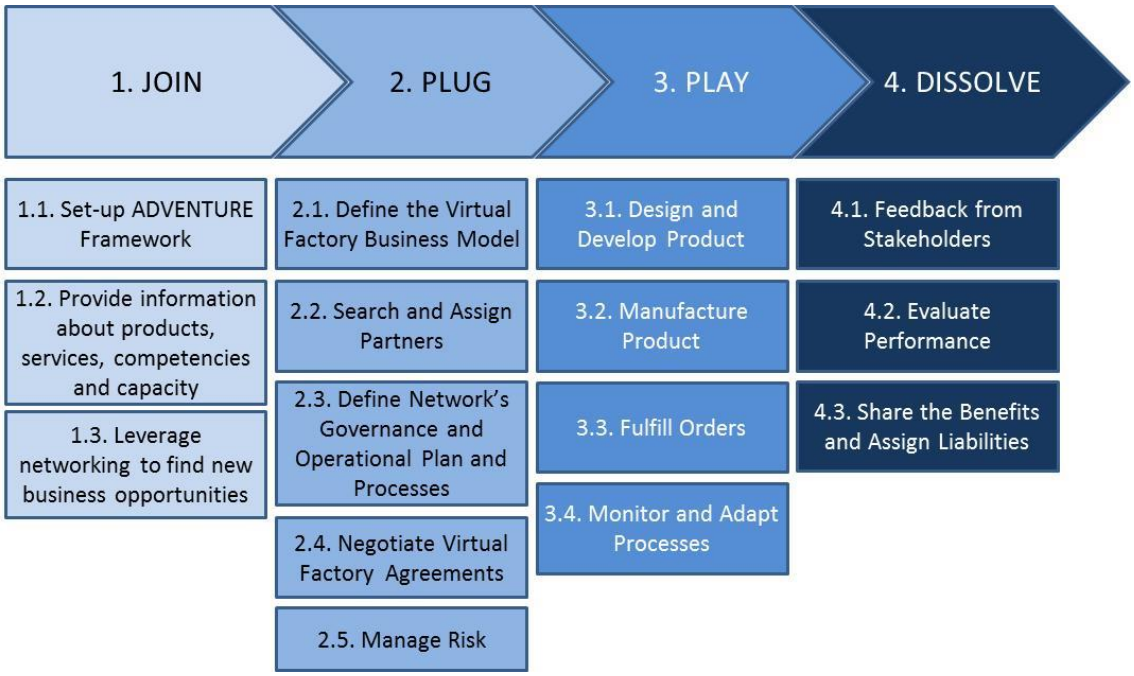


Figure 4.12 - Business Processes Overview Diagram

The implementation of the reference model can be divided into two essential parts, the implementation of the business processes developed for managing the collaboration are applied, this set of processes operate at a high level and integrate with the processes of the lower level of the company, finally an analysis must be made to each individual process and understand which practices should be used for each individual case.

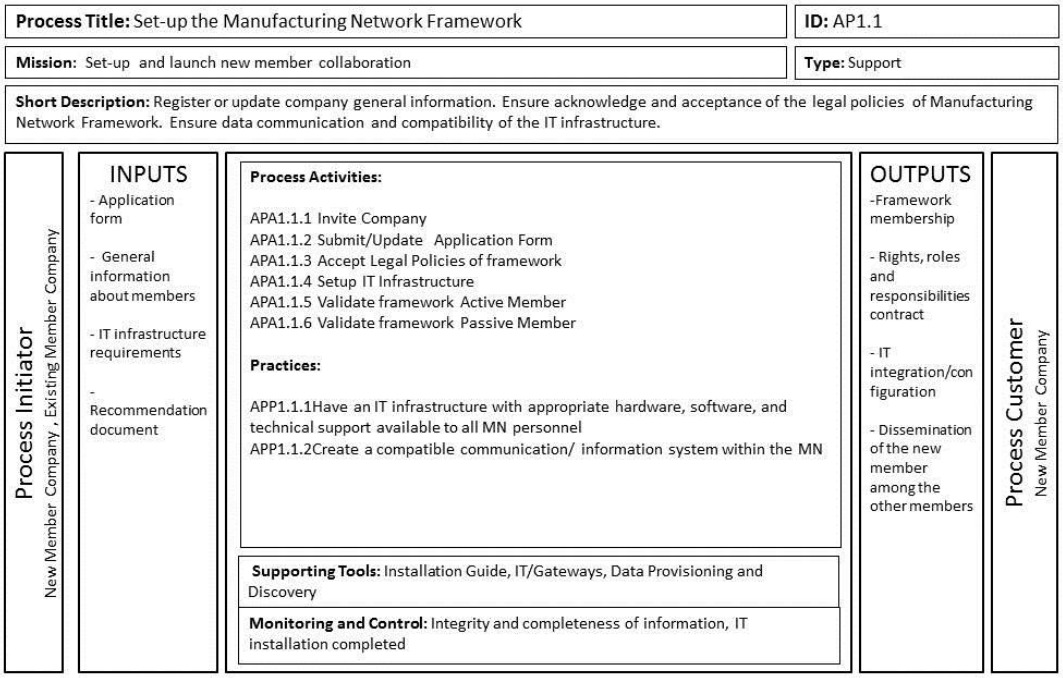
4.2 Processes and Practices for Manufacturing Networks

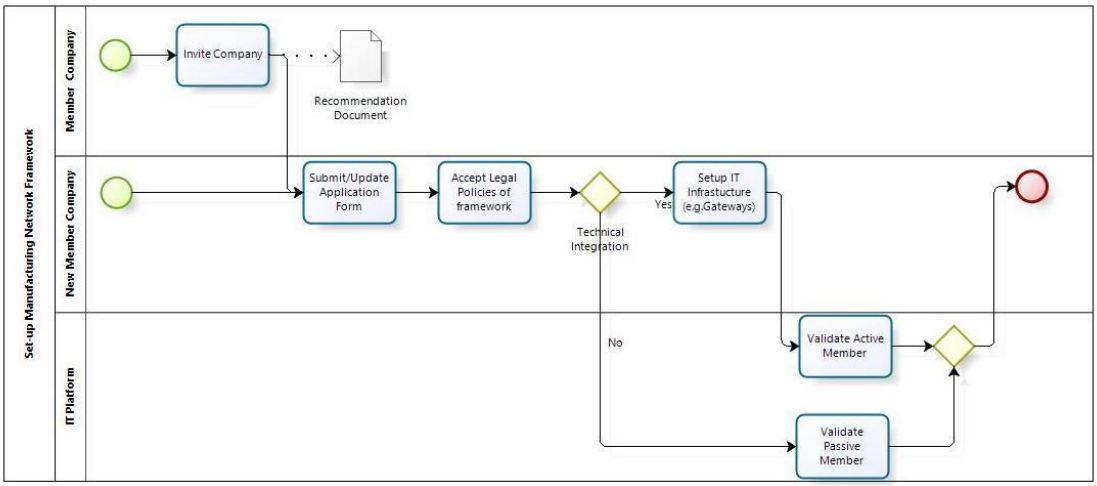
JOIN

The first phase of the reference model aims at guiding companies interested in register into the platform and integrating the systems to enable real-time collaboration, e.g. ERP systems, providing information about the company in the Platform and finding new business opportunities. At this stage there are three main processes: the registration on the platform, the information update and search for new business opportunities. This phase can be

executed only once in the beginning or can be initialized whenever is necessary to update the information about the member.

AP1.1. Set-up the Manufacturing Network framework





AP1.1. Set-up the manufacturing network framework		
INPUTS	*Application Form*	Online registration form for the platform

AP1.1. Set-up the manufacturing network framework		
	General information about members	General company information, such as name, field of business, location, and responsible person.
	IT infrastructure requirements	Type of integration: (1) access to Web platform or (2) full integration with ERP systems through gateways.
	Recommendation document	Recommendation letter in case the new member has been recommended by another member
OUTPUTS	*Framework membership*	Confirmation of registration on the platform as a member (Email, Letter)
	Rights, roles and responsibilities contract	Documents describing the duties and rights of each member
	IT integration / configuration	Provision of access to the platform and in some cases physical integration through the gateways
	Dissemination of the new member among the other members	Dissemination of new members among members of the same business field, through the newsletters and / or alerts on the platform
PRACTICES	*Have an IT infrastructure with appropriate hardware, software, and technical support available to all MN personnel*	MN partners have an ICT-enabled platform that supports the establishment of a real time communication system with the other MN partners.
	Create a compatible communication/ information system within the MN	Partners align their individual communication and information systems in order to implement an effective and efficient collaborative environment.
Supporting Tools	*Installation Guide*	Consists on a document to help companies integrating their legacy systems with the platform technically. This will also contain guidelines to help companies with no legacy systems integration to use the web-based user interface to manage their virtual factories.
	IT/Gateways	Gateways are the connectors that make possible the integration between the different legacy systems with platform. Semantic Mappings are easy with these tools, specially designed to an easy integration.

AP1.1. Set-up the manufacturing network framework		
	Data Provisioning and Discovery	The Data Provisioning and Discovery module is the profiles manager. It allows companies to register their profile and publish their services. The companies search functionality is also accomplished by this module.

AP1.2. Provide information about products, services, competencies and capacity

Process Title: Provide Information about Products, Services, Competencies and Capacity | **ID:** AP1.2

Mission: Register and update manufacturing competencies and capacity that a company offers | **Type:** Support

Short Description: Create or update a profile with the production competencies and capabilities a member company has to offer to the partners or market. Insert product/service portfolio.

Process Initiator
Member Company

INPUTS
- Description of competencies
- Production capacity
- Product portfolio
- Service portfolio

Process Activities:

APA1.2.1 Register/Update Profile
APA1.2.2 Validate Information
APA1.2.3 Disseminate Member's Information in IT Platform

Practices:

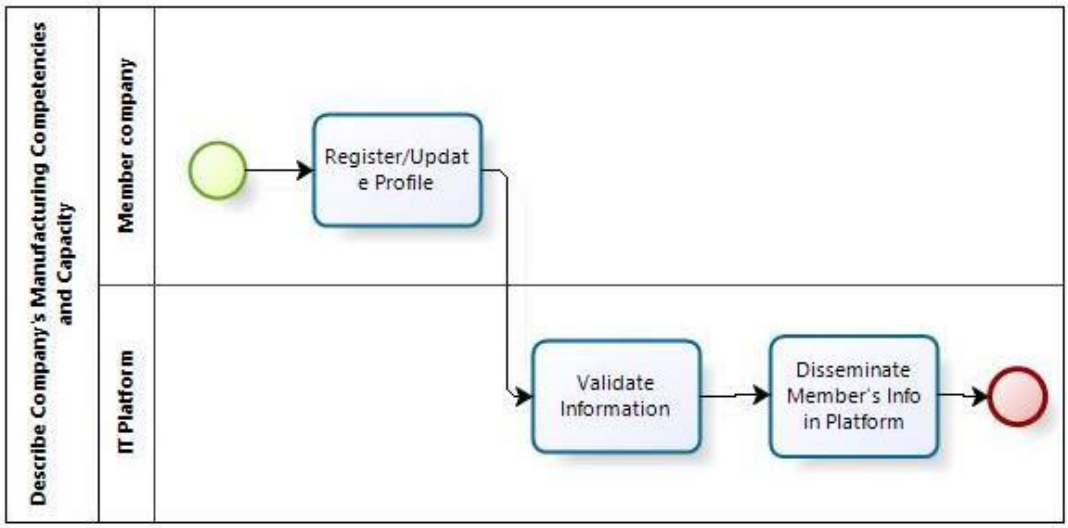
APP1.2.1 Share information about products, services, competencies and capacity

Supporting Tools: Data Provisioning and Discovery Component

Monitoring and Control: Integrity and completeness of information

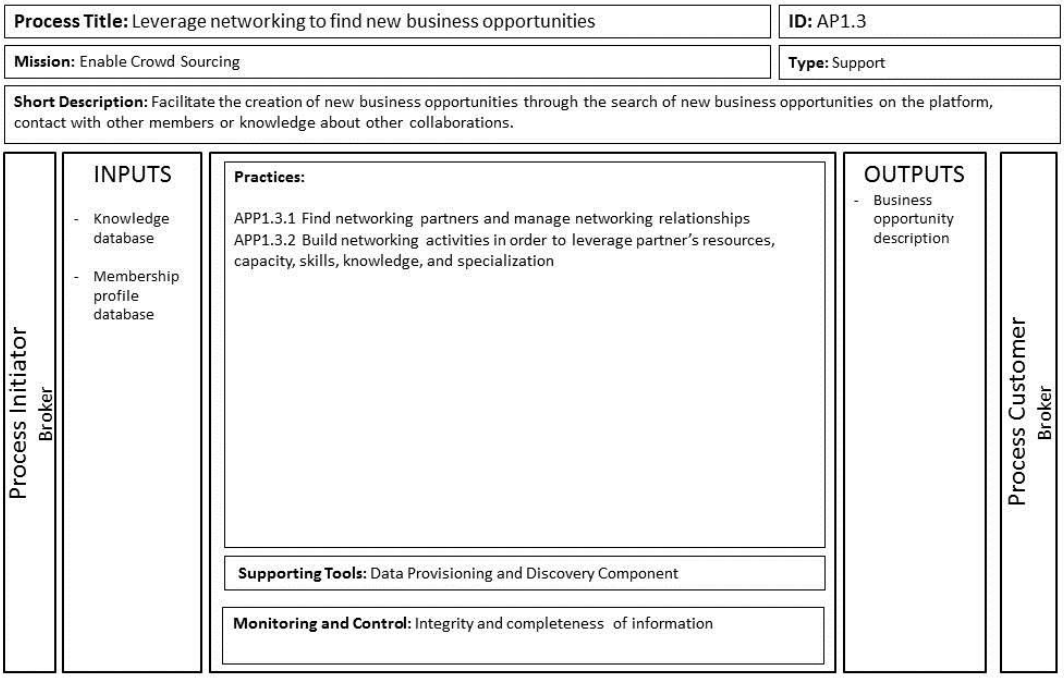
OUTPUTS
- Membership profile database
- Dissemination of member competencies and capacities

Process Customer
Member Company



AP1.2. Provide information about products, services, competencies and capacity		
INPUTS	*Description of competencies*	Detailed description of the company's competencies in engineering, manufacturing, logistics, etc. and the industrial sectors of intervention, such as, automobile, semiconductors, electronics, machinery & equipment, etc.
	Production capacity	Estimated annual production capacity of each business unit.
	Product portfolio	Catalog of products usually manufactured by the company
	Service portfolio	Catalog of services provided to customers.
OUTPUTS	*Membership profile database* Input of AP1.3, AP2.2	Full information sheet of companies organized to be easily searchable and accessed by other members.
	Dissemination of member competencies and capacities	Dissemination of member's competencies and profile among all members, through newsletters, alerts on the platform, or the search engine.
PRACTICES	*Share information about products, services, competencies and capacity*	Essential information of each MN partners is stored within the business network and is available on demand. Such information can be about manufactured product(s), offered service(s), capacities and capabilities, competencies level, etc.
Supporting Tools	*Data Provisioning and Discovery Component*	By using the DPD module, companies are able to publish their profiles and services and also search for new partners

AP1.3. Leverage networking to find new business opportunities

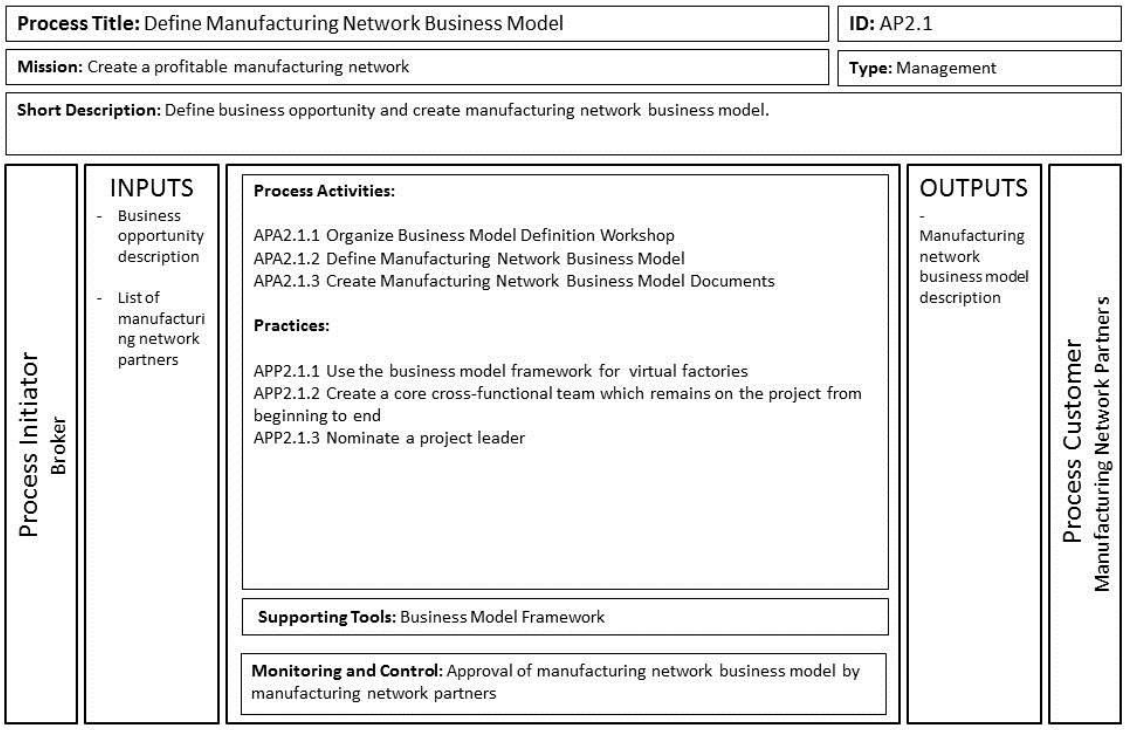


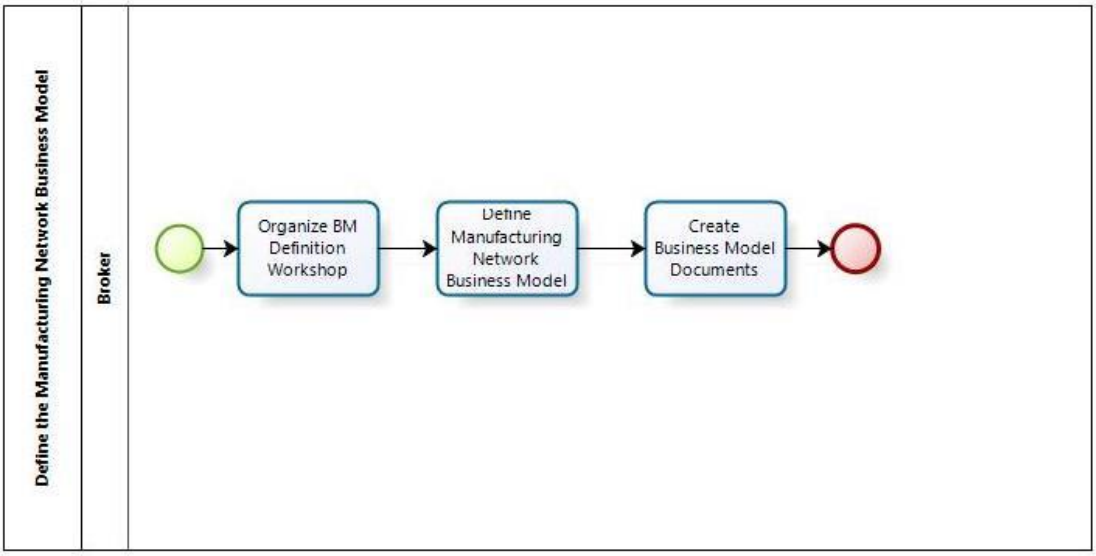
AP1.3. Leverage networking to find new business opportunities		
INPUTS	*Knowledge Database* Output of AP4.2	Evaluation reports of previous collaborations undertaken.
	Membership profile database Output of AP1.2	Database with complete information for all members
OUTPUTS	*Business opportunity description* Input of AP2.2	Document with the description of the business opportunity.
PRACTICES	*Find networking partners and manage networking relationships*	Select networking partners, whose commercial activity allows a company to reducing risks while maximizing benefits. Manage the networking relationships carefully in order to fully exploit the potential for competitive advantage embedded in network relationships.
	Build networking activities in order to leverage partner's resources, capacity, skills, knowledge, and specialization	By getting involved in networking activities a company will be able to determine if it can access, deploy, and mobilize the complementary network relationships/resources to create value-added products, processes or services.

PLUG

In Plug phase, starts the collaboration and the structuring of the business. When a business opportunity is found the responsibility of the broker is to start building the business model, select partners and jointly plan the network governance and operations and creates a risk management plan. This step is essential to the success of the manufacturing network not only because it defines the network operation, but also because it defines the rights and duties of each partner.

AP2.1. Define the manufacturing network business model





AP2.1. Define the manufacturing network business model		
INPUTS	*Business opportunity description* Output of AP1.3	Document with the description of the business opportunity.
	List of manufacturing network partners Output of AP2.2	List of partners those match the needs to develop the business opportunity.
OUTPUTS	*Manufacturing network business model description* Input of AP2.2, AP2.3, AP2.4	Document with the description of the business model elements for the manufacturing network: Customer Needs, Value Proposition, MN Key Activities, MN Partners (Actors, Roles, Core Competences, Partners Evaluation Criteria Definition), Relations/Ties (Shared resources and Shared information), Technology Support; Cost, Revenues, Risks and Benefits Sharing, Network's KPIs, and Security Policies.
PRACTICES	*Use the business model framework for manufacturing networks*	Design the MN business model to be implemented in order to fulfill the pre-identified business opportunity.
	Create a core cross-functional team	Create a core team of MN partners involved in the definition of the MN business model and in the monitoring and management of the cross-partners business processes and activities until the business opportunity is fulfilled.
	Nominate a project leader	Select a project leader among the network partners to organize the discussions and come to a consensus about the MN business model.

AP2.1. Define the manufacturing network business model		
Supporting Tools	*Business Model Framework*	The Business Model Framework specifies the Manufacturing Network elements canvas and enables network partners to discuss about the main topics of the future virtual factory, in order to get consensus and develop their tailored business model.

The figure 4.2 represents the business model framework developed to be used in this process to develop the manufacturing network business model. It's based on the Osterwalder model, but tailored to manufacturing networks. The model propose as initiator the identification of customer needs then the collaborative network should respond with an innovative response, i.e., what it proposes to do. After defining that the characterization of network and the definition of all components is presented in figure 4.2.

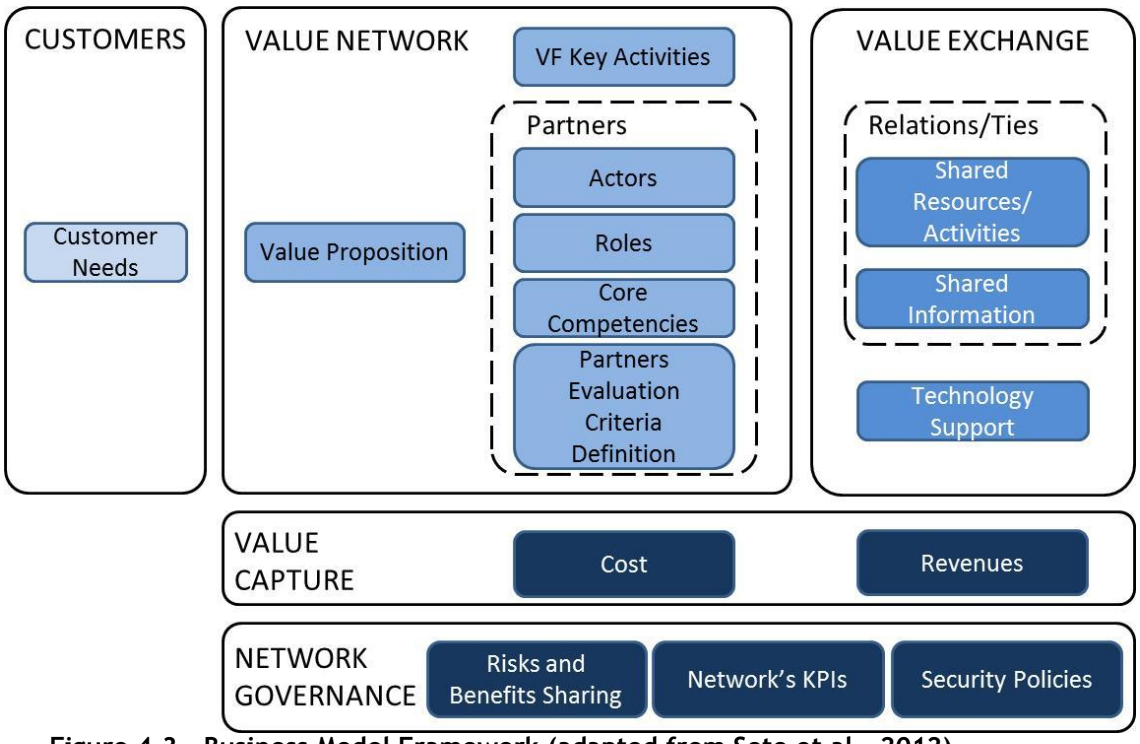


Figure 4.3 - Business Model Framework (adapted from Soto et al., 2012)

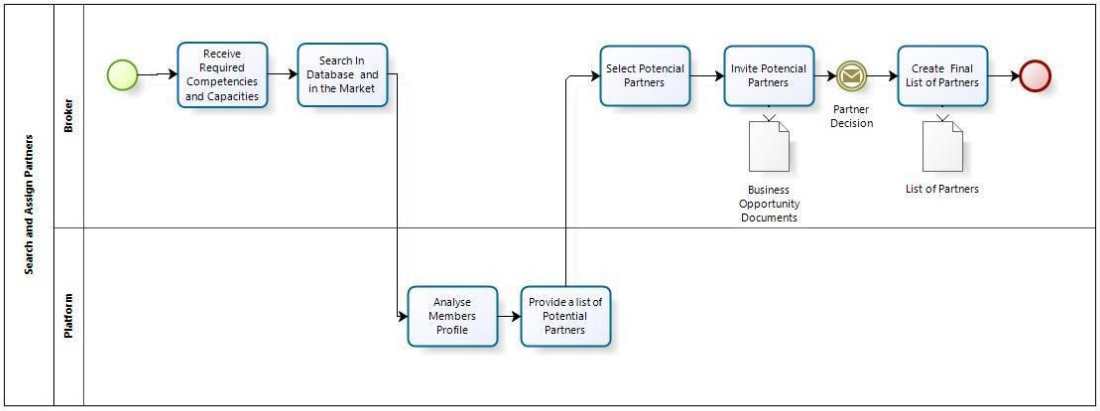
AP2.2. Search and assign partners

Process Title: Search and Assign Partners	**ID:** AP2.2
Mission: Select and assign partners according to Business Opportunity requirements	**Type:** Management
Short Description: Search in the IT database and on the market for potential partners and validate ability to collaborate in business opportunity. Invite companies to integrate manufacturing network and create a final list of manufacturing network partners.	

Process Initiator Broker	INPUTS	Process Activities	OUTPUTS	Process Customer
	- Manufacturing network business model description: elements "Value Proposition" and "Key activities" - Membership profile database	APA2.2.1 Receive Required Competencies and Capacities APA2.2.2 Search in IT Database and in the Market APA2.2.3 Analyze Members Profile APA2.2.4 Provide a List of Potential Partners APA2.2.5 Select Potential Partners APA2.2.6 Invite Potential Partners APA2.2.7 Create Final List of Partners **Practices:** APP2.2.1 Vision the network architecture and identify the right individuals or organizations for the MN APP2.2.2 Build strategic partnerships with MN members	- List of manufacturing network partners	AP2.1 Define the Manufacturing Network Business Model AP2.3 Design Virtual Governance's and Operational Plan and Processes

Supporting Tools: Data Provisioning and Discovery

Monitoring and Control: Degree of compatibility with the requirements, Partners commitment



AP2.2. Search and Assign Partners		
	Manufacturing network business model description: elements "Value Proposition" and "Key activities". Output of AP2.1	Description of the virtual factory value proposition, its key activities and the set of competencies, skills and capacities necessary to accomplish the value proposition.

AP2.2. Search and Assign Partners		
	Membership profile database Output of AP.1.2	Database with complete information for all members.
OUTPUTS	*List of manufacturing network partners* Input of AP2.1	List of partners those match the needs to develop the business opportunity. This list of partners will be included in the element "Actors" of the manufacturing network business model description.
PRACTICES	*Vision the network architecture and identify the right individuals or organizations for the MN*	Design manufacturing network architecture and assign competent partner(s) to each of its component in order to leverage partners' resources, capacity, skills, knowledge and specialization.
	Build strategic partnerships with MN members	Establish trust and commitment among the MN partners in order to leverage the strategic and operational capabilities of the individual partners leading to the achievement of benefits to all members.
Supporting Tools	*Data Provisioning and Discovery*	All information about partners is stored at the Data Provision and Discovery module and can be accessed through the process designer; a set of partners can be assigned to each task. Then, the optimization component will optimize it and define the best set of partners.

AP2.3. Design network's governance and operational plan and processes

Process Title: Define Manufacturing Network Governance and Operational Plan and Processes	**ID:** AP2.3
Mission: Organize the manufacturing network to start its operation	**Type:** Management
Short Description: Define organizational structure. Design the manufacturing network operational processes according to the tasks, activities and roles that each partner should perform. Perform simulation and optimization of the manufacturing network and operational processes.	

Process Initiator
Broker

INPUTS
- Manufacturing network business model description

Process Activities:
APA2.3.1 Define Organizational Structure
APA2.3.2 Create Operation Plan
APA2.3.3 Design Operational Processes
APA2.3.4 Simulate Processes
APA2.3.5 Optimize Processes
APA2.3.6 Assign Processes to Partners

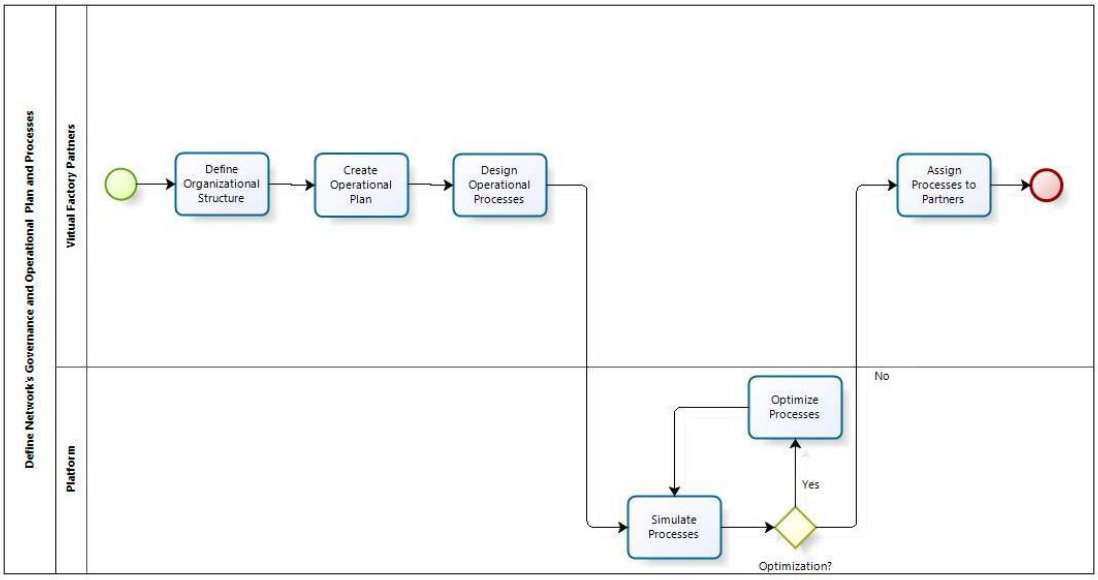
Practices:
APP2.3.1 Share information
APP2.3.2 Design facilities network and transportation
APP2.3.3 Leverage partner's resources, capacity, skills, knowledge, and specialization
APP2.3.4 Develop and clearly communicate MN goals and needs
APP2.3.5 Document operational processes
APP2.3.6 Design flexible and adaptable processes
APP2.3.7 Plan collaboratively
APP2.3.8 Make decisions jointly concerning sourcing, manufacturing, logistics, marketing, and sales.

Supporting Tools: Process Catalogue, Process Designer, Simulation and Optimization

Monitoring and Control: Completeness of the documentation and dissemination among partners of the manufacturing network governance and operational plan and processes

OUTPUTS
- Description of manufacturing network governance
- Operational processes
- Operational plan

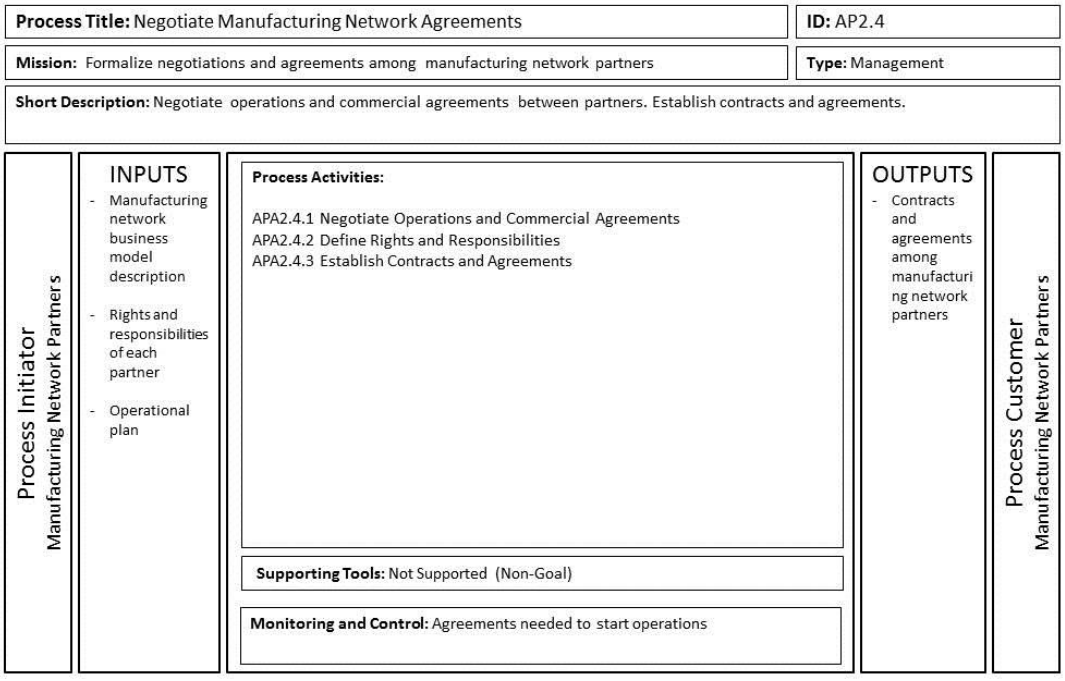
Process Customer
Manufacturing Network Partners

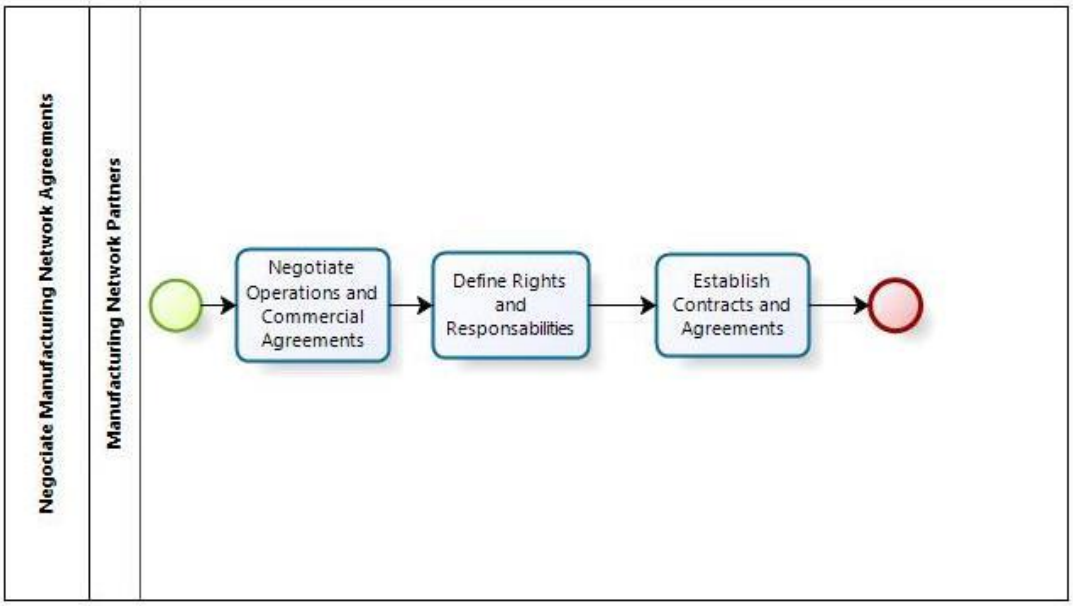


AP2.3. Define Manufacturing Network Governance and Operational Plan and Processes		
INPUTS	*Manufacturing network business model description* Output of AP2.1	Document with the description of the business model elements for the manufacturing network.
OUTPUTS	*Description of manufacturing network governance*	Documents defining the role of each partner in the management and governance of the network.
	Operational processes Input of AP3.1, AP3.2, AP3.3, AP3.4	Design and documentation of the manufacturing network processes for the PLAY phase.
	Operational plan Input of AP2.4, AP3.1, AP3.2, AP3.3, AP3.4.	Plan of the manufacturing network operations covering the time period of the PLAY phase, including product delivery quantities and schedule.
PRACTICES	*Share information*	MN partners may share various types of information, such as, costs, customer demand, materials requirement, price changes, production capacity and scheduling, inventory-holding costs, on-hand inventory levels, inventory policy, supply disruptions, order status, and delivery schedules.
	Design facilities network and transportation	Define the location and capacity of the manufacturing sites and warehouses and the transportation mode and capacity of the fleet to execute the manufacturing network.
	Leverage partner's resources, capacity, skills, knowledge, and specialization	Mutually leverage each other's resources, capacity, skills, knowledge, and specialization in order to optimize the utilization of resources and create higher benefits to all MN partners.
	Develop and clearly communicate MN goals and needs	Set up and clearly communicate specific business goals and requirements of the manufacturing network after consultation and agreement with the network partners.
	Document operational processes	Make a list of necessary operational processes, explain them clearly and store within the network database.
	Design flexible and adaptable processes	Design and develop processes that allow the MN to respond to changes in a flexible way and are easily adaptable to new market and business conditions.
	Plan collaboratively	Cross-functional teams make decisions concerning process planning and execution in order to co-align operations as well as capacities of each MN partner.

AP2.3. Define Manufacturing Network Governance and Operational Plan and Processes		
	Make decisions jointly concerning sourcing, manufacturing, logistics, marketing, and sales.	Cross-functional teams decide jointly about strategic matters concerning sourcing policy, manufacturing, supply chain management, logistics, marketing, and sales.
Supporting Tools	*Process Catalogue*	Consists on a set of process templates that will assist MN brokers in designing their virtual factories.
	Process Designer	The Process Designer allows brokers to design their manufacturing virtual factories using a standard notation, which can be interpreted by most of the state of the art workflow engines.
	Simulation and Optimization	Simulation and optimization components are used to find the best set of conditions to execute successfully the MN.

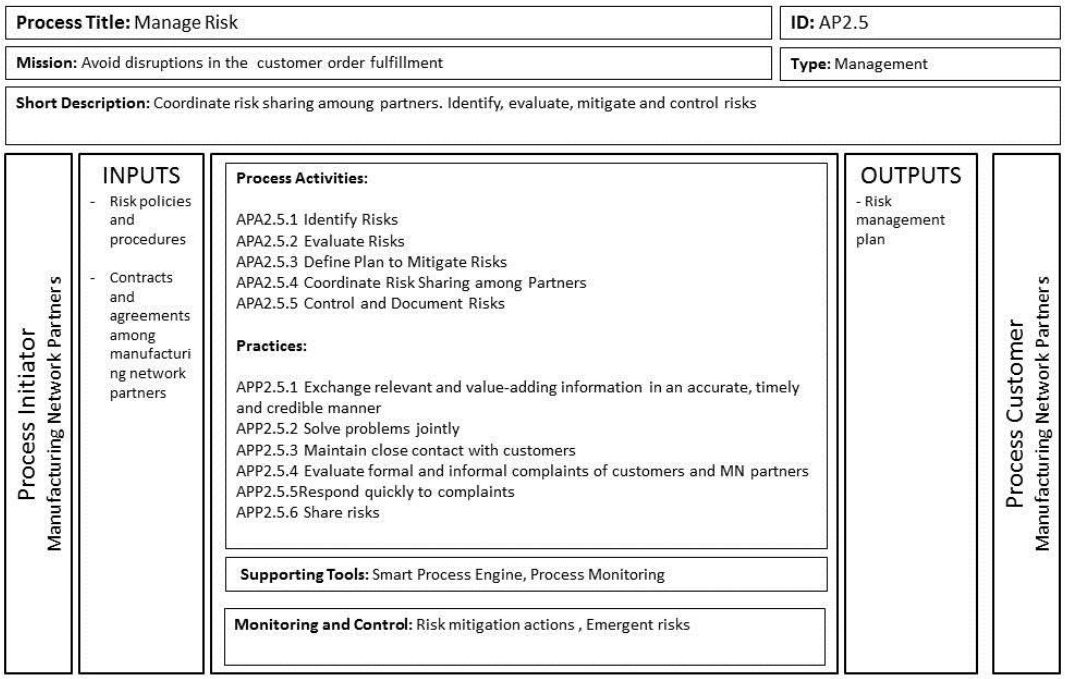
AP2.4. Negotiate manufacturing network agreements

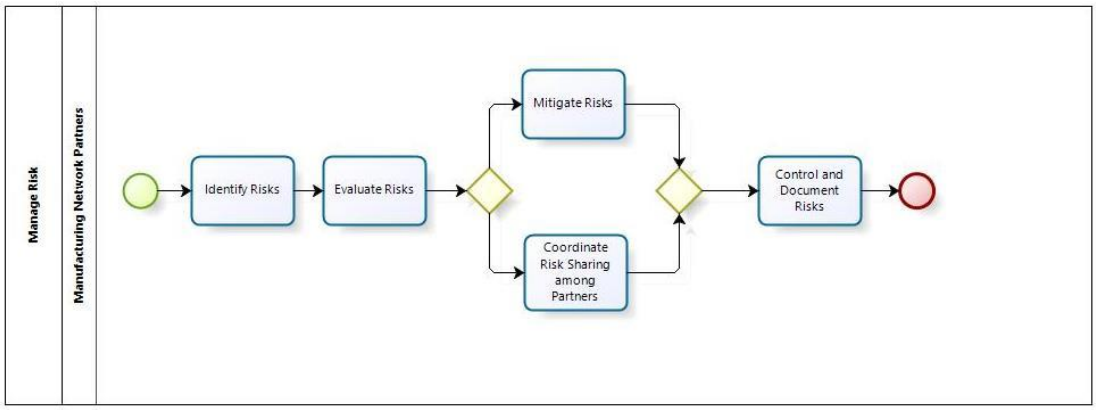




AP2.4. Negotiate Manufacturing Networks Agreements		
INPUTS	*Manufacturing Network business model description* Output of AP2.1	Document with the description of the business model elements for the virtual factory.
	Rights and responsibilities of each partner	Document with description of the rights and responsibilities of each partner.
	Operational plan Output of AP2.3	Plan of the manufacturing network operations covering the time period of the PLAY phase.
OUTPUTS	*Contracts and agreements among manufacturing network partners* Input of AP2.5	Set of contracts and agreements that define the rights and duties of each partner and the type of penalties to be applied in case of breach of the agreed conditions.

AP2.5. Manage risk





AP2.5. Manage Risk		
INPUTS	*Risk policies and procedures*	Set of risk procedures and policies to consider in developing the risk plan.
	Contracts and agreements among manufacturing networks partners Output of AP2.4	Set of contracts and agreements that define the rights and duties of each partner and the type of penalties to be applied in case of breach of the agreed conditions.

AP2.5. Manage Risk		
OUTPUTS	*Risk management plan*	Document with the identification of risks, its impact estimation, the definition of mitigation strategies for each risk and the plan of action that determine when the expected mitigation is to occur.
PRACTICES	*Exchange relevant and value-adding information in an accurate, timely and credible manner*	In order to improve operational performance, exchange only relevant and value-adding information and do it in an accurate, timely and credible manner.
	Solve problems jointly	Work together to solve problems, including their resolution and response planning.
	Maintain close contact with customers	Establish a system where customers can interact directly with the network partners for any update concerning to their expectations.
	Evaluate formal and informal complaints of customers and MN partners	Collect and scrutinize all types of complains (formal or informal) as received from actual and potential customers and partners with the objective to solve them properly.
	Respond quickly to complaints	Establish predefined risk responses in order to act promptly.
	Share risks	Evaluate possible risks and share them among the partners in order to reduce individual risk level.
Supporting Tools	*Smart Process Engine*	The Smart Process Engine is a state of the art workflow engine capable to interpret the process design language (BMPN) and execute the process while notifies the monitoring component about each event that occurs during the process execution. Therefore it supports the identification of events identified as risks.
	Process Monitoring	The monitoring component in the ADVENTURE platform is the component that provides the real time monitoring of ongoing processes, historical data relating to finished processes and instances and business analytics relating to process and activities types. Therefore, it supports the elaboration of the risk management plan.

PLAY

The Play phase is the beginning of the operational collaboration. After define the operational plan and processes, these are put into practice. Unlike the previous phases, these processes can run simultaneously and in different orders according to the type of collaboration or business opportunity. Besides that, during this phase there is a process running from the beginning to the end responsible for monitoring and continuous improvement of operational processes, while also allowing continuous adaptation to possible changes in the environment.

AP3.1. Design and develop product

Process Title: Design and Develop Product	**ID:** AP3.1
Mission: Design and develop a product according to customer needs	**Type:** Operational
Short Description: Define product requirements based on markets, technologies and customer needs. Integrate all partners in the development of strategies for sourcing, manufacturing and marketing. Produce prototypes in order to identify strengths, weaknesses, impact and acceptance. Plan Transportation and inventory.	

Process Initiator
Customer Order or Broker

INPUTS
- Customer order or market need
- Manufacturing network capabilities
- Manufacturing network design and capacity
- Operational processes
- Operational plan

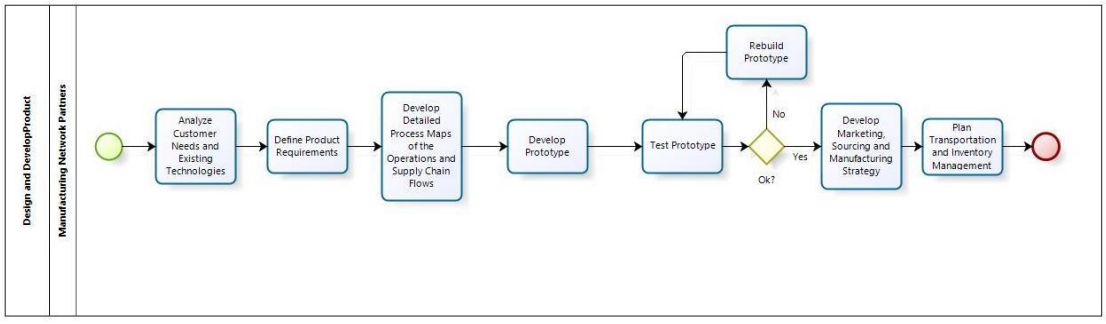
Process Activities:
APA3.1.1 Analyze Customer Needs and Existing Technologies
APA3.1.2 Define Product Requirements
APA3.1.3 Develop Detailed Process Maps of the Operations and Supply Chain Flows
APA3.1.4 Develop Prototype
APA3.1.5 Test Prototype
APA3.1.6 Rebuild Prototype
APA3.1.7 Develop Marketing, Sourcing and Manufacturing Strategy
APA3.1.8 Plan Transportation and Inventory Management
Practices:
APP3.1.1Involve customers/users, suppliers, product designers and manufacturers
APP3.1.2 Use modular design of parts
APP3.1.3 Use concurrent engineering
APP3.1.4 Simplify and standardize component parts
APP3.1.5 Use value analysis
APP3.1.6 Use Quality Function Deployment (House of Quality)
APP3.1.7 Formally evaluate the results of testing (concept, product, market)
APP3.1.8 Cleary pre-define Go/No-Go criteria for each review gate
APP3.1.9 Use design for manufacture and assembly
APP3.1.10 Use design for supply chain management

Supporting Tools: Process Monitoring, Smart Process Execution

Monitoring and Control: Time to market, Customer acceptance level, Time to profitability, Target cost

OUTPUTS
- Sourcing strategy
- Manufacturing strategy
- Marketing strategy
- Inventory management strategy
- Prototype
- Production process map
- Bill of materials

Process Customer
Customer or Broker

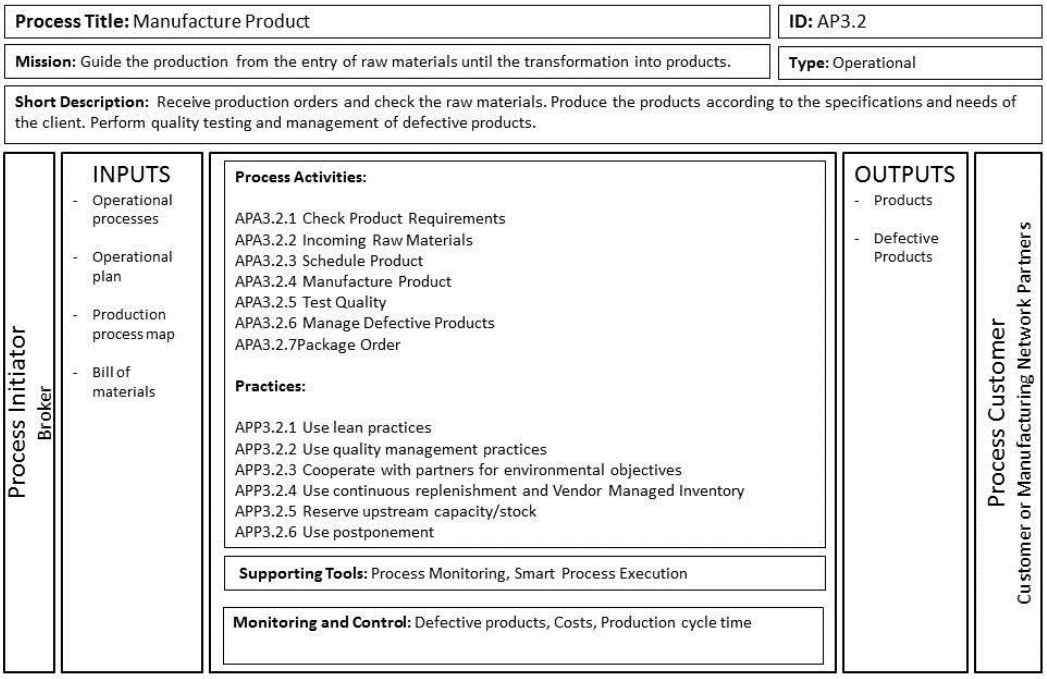


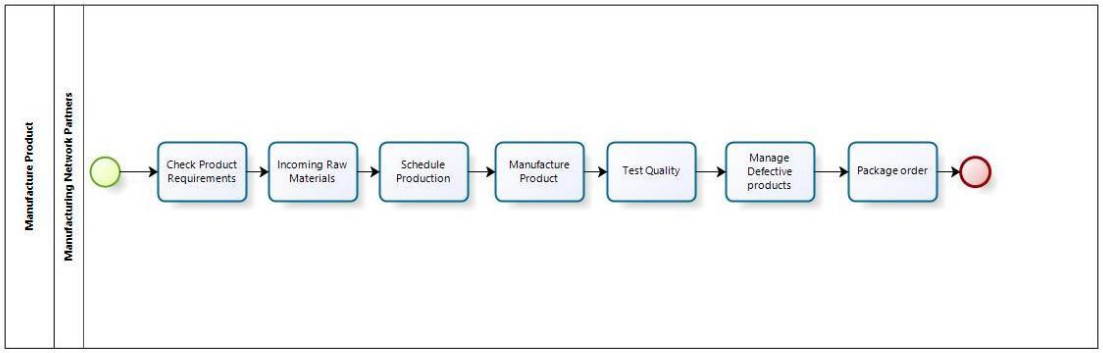
AP3.1. Design and Develop Product		
INPUTS	*Customer order or market needs*	Description of the product specifications provided by the customer or identified through market analysis.
	Manufacturing network capabilities	Capabilities of network partners
	Manufacturing network design and capacity	Geographical distribution and total production capacity of the network.
	Operational processes Output of AP2.3	Design and documentation of the manufacturing network processes for the PLAY phase.
	Operational plan Output of AP2.3	Plan of the manufacturing network operations covering the time period of the PLAY phase.
OUTPUTS	*Sourcing strategy*	Decision about what product components will be provided by partners and which have to be provided by external subcontractors. Definition of the tactics and actions to deal with subcontractors.
	Manufacturing strategy	Allocation of production volume of the different product components among the production sites of the manufacturing network.
	Marketing strategy	Definition of pricing policies and how the products will be distributed and promoted.
	Inventory management strategy	Decision about the quantity of stock to hold and its location.
	Prototype	Prototype of the product to be manufactured.
	Production process map Input of AP3.2	Set of detailed processes needed to manufacture the product within the manufacturing network.
	Bill of materials Input of AP3.2	List of materials needed to assemble one product.
PRACTICES	*Involve customers/users, suppliers, product designers and manufacturers*	Communicate with potential customers/users, suppliers, product designers, and manufacturers before conceptual design of the intended product(s).
	Use modular design of parts	Identify different modules as to be used to develop the customized product.

AP3.1. Design and Develop Product		
	Use concurrent engineering	Adopt concurrent engineering approach, in which activities in different development stages are allowed to overlap with one another, in order to shorten the total development time.
	Simplify and standardize component parts	Design and develop as much standard and/or common components/parts as possible.
	Use value analysis	Examine all elements of the product to make sure it fulfills its intended function at the lowest total cost.
	Use Quality Function Deployment (House of Quality)	Use QFD graphical tool to define specific engineering and operational requirements from the vague notions of what customers want.
	Formally evaluate the results of testing (concept, product, market)	Conduct necessary tests and experiments with the developed product(s) before launching to the market.
	Cleary pre-define Go/No-Go criteria for each review gate	Set up standard criterions for each Go/No-Go review gates.
	Use design for manufacture and assembly	Consider manufacturing issues in the design and development process, in order to achieve gains during the fabrication of the product's components and their assembly into the final product.
	Use design for supply chain management	Consider supply chain management issues in the design and development process, in order to achieve gains in the sourcing of materials, inventory management, distribution, and resources usage throughout the supply chain.
	Use eco-design of products	Design products that minimize consumption of materials and energy, that facilitate the reuse, recycle, and recovery of component materials and parts, and that avoid or reduce the use of hazardous products within the manufacturing process. Ultimately, the aim of eco-design is to reduce a product's environmental impact without creating a negative trade-off with other design criteria, such as costs and functionality.
Supporting Tools	*Process Monitoring*	The Real-time Monitoring component provides a live view of the ongoing processes using the process editor interface, so that manufacturing network brokers may decide to undertake flow adjustments and efficient decisions in order to improve the performance of the design processes. The Process Log component allows

AP3.1. Design and Develop Product		
		users to search for finished process instances and visualize its data in a graphical interface. The Process Analytics component provides the key performance indicators relating to the design processes. Finally, the alerts and notifications component allows the definition of rules based on process execution delays (e.g. if a process has 5 days to execute and it is now day 6) that are evaluated by the Rules Engine. This component throws alerts to the Dashboard, as well as performs action upon the Smart Process Engine.
	Smart Process Execution	The Smart Process Execution (SPE) component will orchestrate all interaction in a virtual factory. Its purpose is to execute Smart Processes, modelled in the Process Designer. SPE component will deal with Processes, Process Instances and the communication with gateways and logging.

AP3.2. Manufacture product





AP3.2. Manufacture Product		
INPUTS	*Operational processes* Output of AP2.3	Design and documentation of the manufacturing network processes for the PLAY phase.
	Operational plan Output of AP2.3	Plan of the manufacturing network operations covering the time period of the PLAY phase.
	Production process map Output of AP3.1	Set of detailed processes needed to manufacture the product within the manufacturing network.
	Bill of materials Output of AP3.1	List of materials needed to assemble one product.
OUTPUTS	*Products*	Finished products ready for delivery.
	Defective Products	Defective products for rework or disposal.
PRACTICES	*Use lean practices*	*Use lean practices such as reduced set-up times, small lot sizes, and pull-production.*
	Use quality management practices	*Ensure product quality by implementing practices such as supplier certification, inspection, statistical process control, continuous quality improvement programs, competitive benchmarking.*
	Cooperate with partners for environmental objectives	*Establish cross-partners communication infrastructure to create solutions for environmental friendly product manufacturing: reduce transportation, energy consumption, carbon and other emissions; implement cleaner production and green packaging.*
	Use continuous replenishment and Vendor Managed Inventory	By having visibility over the inventory levels via a real-time information system, partners may autonomously control the inventory of other partners and ensure its replenishment.

AP3.2. Manufacture Product		
	Reserve upstream capacity /stock	Book capacity or stock of some of the partners to ensure the delivery of the MN products.
	Use postponement	*Move forward operations or activities (e.g. final assembly, delivery) to the later possible point in the supply chain.*
Supporting Tools	*Process Monitoring*	The Real-time Monitoring component provides a live view of the ongoing processes using the process editor interface, so that virtual factories brokers may decide to undertake flow adjustments and efficient decisions in order to improve the performance of the design processes. The Process Log component allows users to search for finished process instances and visualize its data in a graphical interface. The Process Analytics component provides the key performance indicators relating to the design processes. Finally, the alerts and notifications component allows the definition of rules based on process execution delays (e.g. if a process has 5 days to execute and it is now day 6) that are evaluated by the Rules Engine. This component throws alerts to the Dashboard, as well as performs action upon the Smart Process Engine.
	Smart Process Execution	The Smart Process Execution (SPE) component will orchestrate all interaction in a manufacturing network. Its purpose is to execute Smart Processes, modelled in the Process Designer. SPE component will deal with Processes, Process Instances and the communication with gateways and logging.

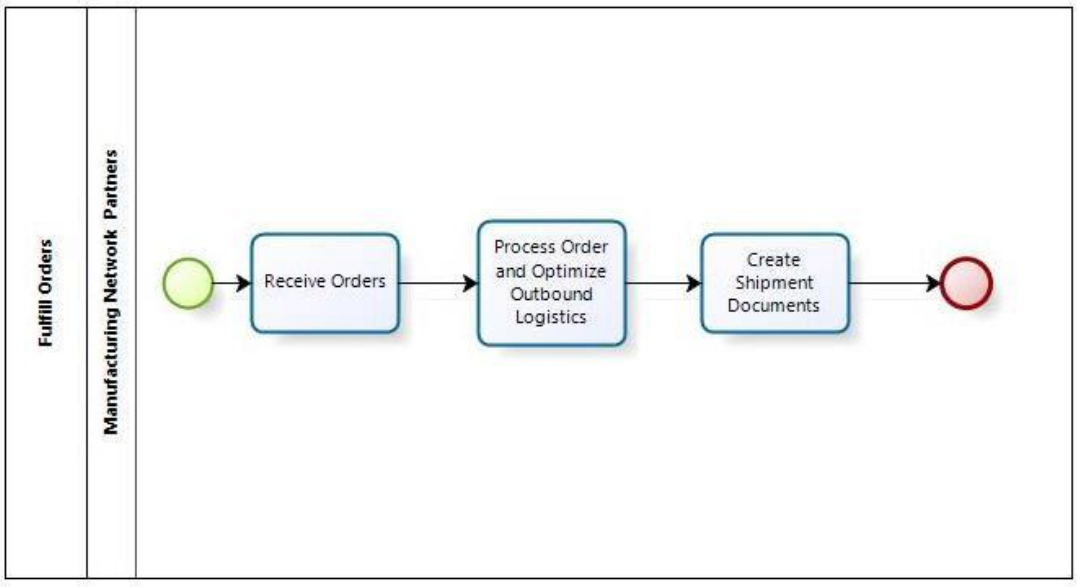
AP3.3. Fulfill Orders

Process Title: Fulfill Orders	**ID:** AP3.3
Mission: Fill and delivery customer orders according to customer requirements	**Type:** Operational
Short Description: Receive, process and deliver customer orders	

Process Initiator Customer Order or Broker	INPUTS	Process Activities :	OUTPUTS	Process Customer Customer
	- Customer order - Operational processes - Operational plan	APA3.3.1 Receive Orders APA3.3.2 Process Order and Optimize Outbound Logistics APA3.3.3 Create Shipment Documents	- Delivering schedule - Delivery route - Delivery documentation	

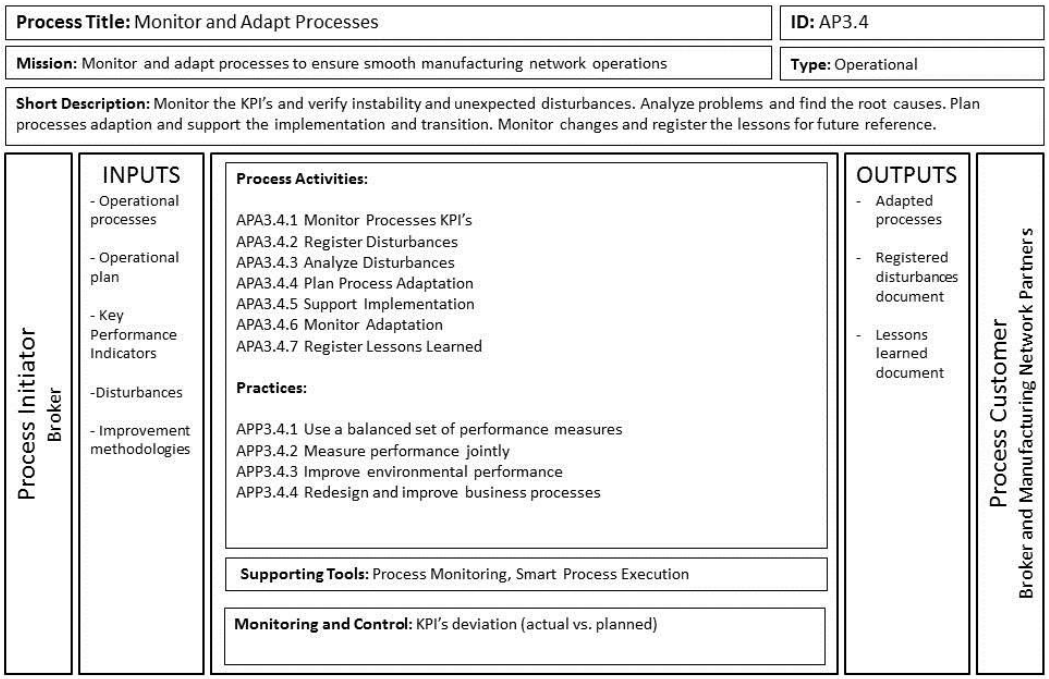
Supporting Tools: Process Monitoring, Smart Process Execution

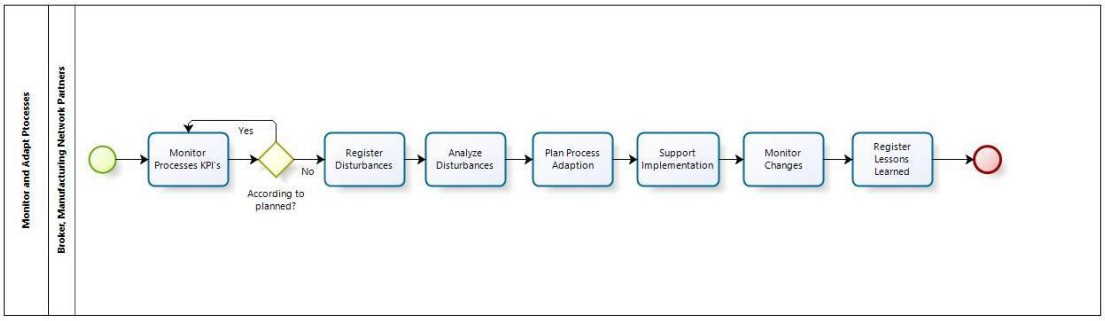
Monitoring and Control: Service level, Order fulfillment time



AP3.3. Fulfill Orders		
INPUTS	*Customer order*	Document with customer request that includes product description and specification, delivery quantity, schedule and conditions.
	Operational processes Output of AP2.3	Design and documentation of the manufacturing network processes for the PLAY phase.
	Operational plan Output of AP2.3	Plan of the manufacturing network operations covering the time period of the PLAY phase.
OUTPUTS	*Delivering schedule*	Scheduling of orders and their respective delivery
	Delivery route	Route to be used in the delivery of orders
	Delivery documentation	Documentation needed to follow the goods in transit.
Supporting Tools	*Process Monitoring*	The Real-time Monitoring component provides a live view of the ongoing processes using the process editor interface, so that virtual factories brokers may decide to undertake flow adjustments and efficient decisions in order to improve the performance of the design processes. The Process Log component allows users to search for finished process instances and visualize its data in a graphical interface. The Process Analytics component provides the key performance indicators relating to the design processes. Finally, the alerts and notifications component allows the definition of rules based on process execution delays (e.g. if a process has 5 days to execute and it is now day 6) that are evaluated by the Rules Engine. This component throws alerts to the Dashboard, as well as performs action upon the Smart Process Engine.
	Smart Process Execution	The Smart Process Execution (SPE) component will orchestrate all interaction in a virtual factory. Its purpose is to execute Smart Processes, modelled in the Process Designer. SPE component will deal with Processes, Process Instances and the communication with gateways and logging.

AP3.4. Monitor and Adapt Processes





AP3.4. Monitor and Adapt Processes		
INPUTS	*Operational processes* Output of AP2.3	Design and documentation of the manufacturing network processes for the PLAY phase.
	Operational plan Output of AP2.3	Plan of the manufacturing network operations covering the time period of the PLAY phase.
	Key Performance Indicators	KPI of each operational process.

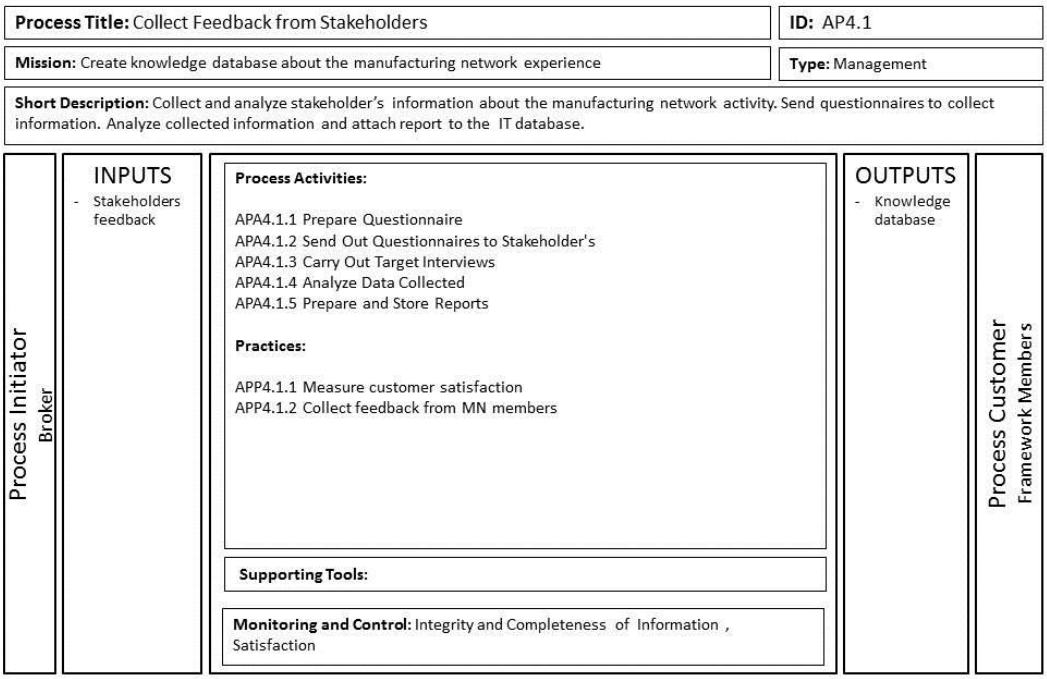
AP3.4. Monitor and Adapt Processes		
	Disturbances	Disturbances identified in the process or network
	Improvement methodologies	Methodologies to be used in process improvement.
OUTPUTS	*Adapted processes*	Processes after undergoing process redesign.
	Registered disturbances document	Document with description of disturbances recorded in the processes and network
	Lessons learned document	Document with the record of improvements implemented and problems to avoid in the future
PRACTICES	*Use a balanced set of performance measures*	Use performance measures of different nature: customer-related performance measures, softer performance measures, such as social responsibility and both efficiency- and effectiveness-based measures.
	Measure performance jointly	Select and implement common Key Performance Indicators (KPIs) to determine benefits to be shared among MN partners and also to identify performance gaps that need to be addressed.
	Improve environmental performance	Set up infrastructure to track environmental information (such as toxicity, energy used, water used, air pollution) and take action to reduce air emissions, effluent waste, and solid wastes and to decrease consumption of hazardous and toxic materials.
	Redesign and improve business processes	Take initiative to redesign business processes when necessary and elaborate plan for continuous process improvement.
Supporting Tools	*Process Monitoring*	The monitoring component in the ADVENTURE platform is the component that provides the real time monitoring of ongoing process, historical data relating to finished processes and instances and business analytics relating to process and activities types. The Process Monitoring component provides real time, log and performance data relating the virtual factory processes. it will contain 5 main sub-components: • Monitoring Engine • Real-time Monitoring • Process Log • Process Analytics • Monitoring Rules Engine

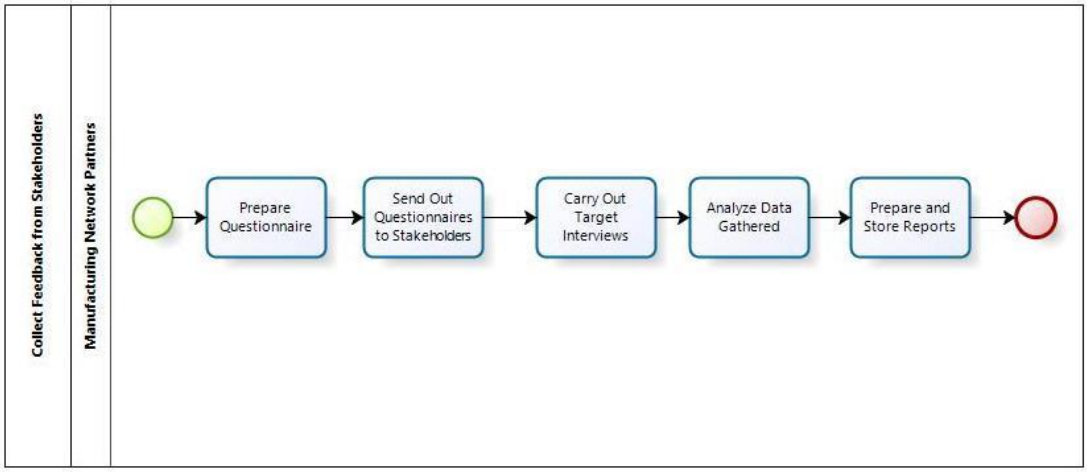
AP3.4. Monitor and Adapt Processes		
	Smart Process Execution	The Smart Process Execution (SPE) component will orchestrate all interaction in a virtual factory. Its purpose is to execute Smart Processes, modelled in the Process Designer.

DISSOLVE

Once the customer needs have been fulfilled, the proper network dissolution is essential to ensure the documentation of the knowledge acquired, the evaluation of the manufacturing network operations, and the distribution of benefits and responsibilities among partners based on the agreements previously signed. Gathering this information at this stage and sharing it in a semi-standard evaluation report in the platform is an essential vehicle to the successful creation and management of future manufacturing networks.

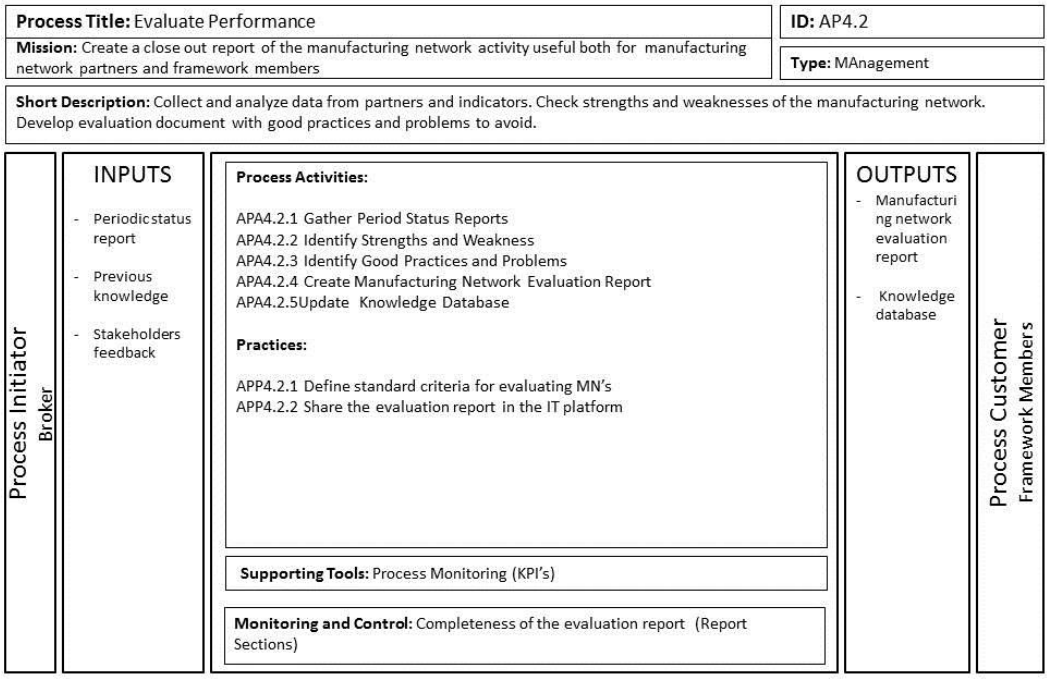
AP4.1. Collect feedback from stakeholders

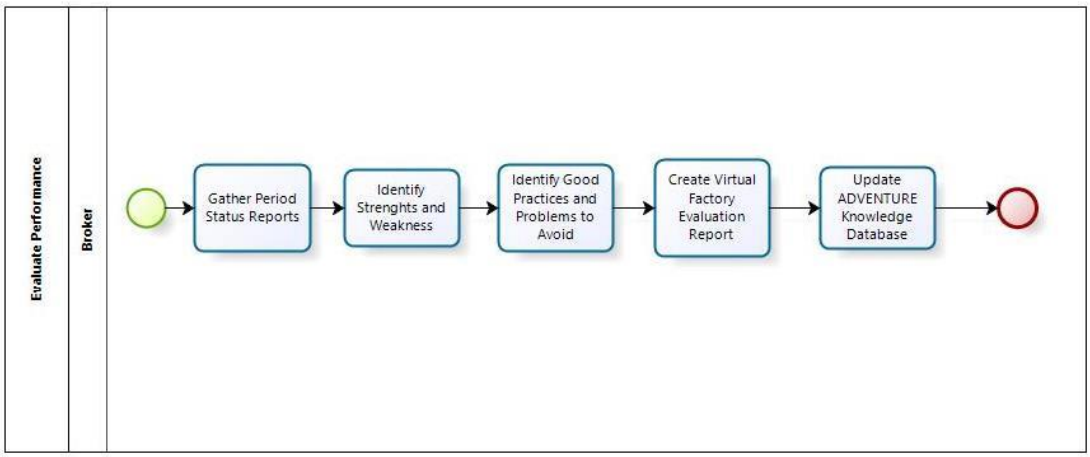




AP4.1. Collect feedback from stakeholders		
INPUTS	*Stakeholders feedback*	Document on the assessment of the collaboration established by each partner.
OUTPUTS	*Knowledge database* Input of AP1.3	Create knowledge about previous collaborations undertaken by introducing the feedback collected from the stakeholders of each manufacturing network in the database.
PRACTICES	*Measure customer satisfaction*	Document customer satisfaction indexes and implement them to measure customer satisfaction.
	Collect feedback from MN members	Prepare questionnaires to collect feedbacks from MN partners.

AP4.2. Evaluate performance

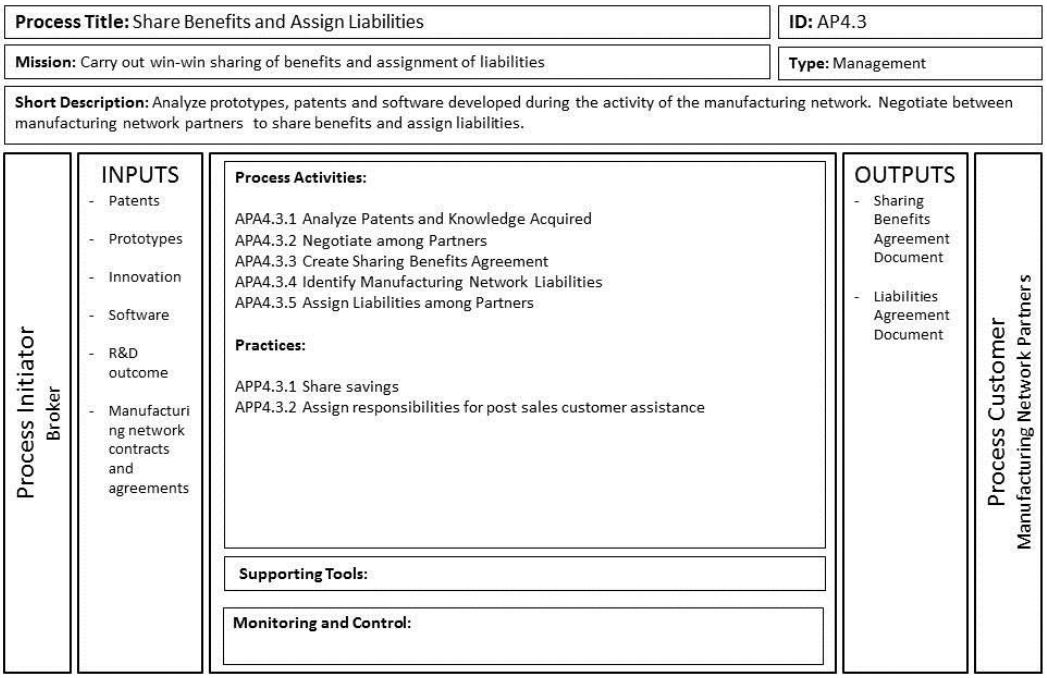


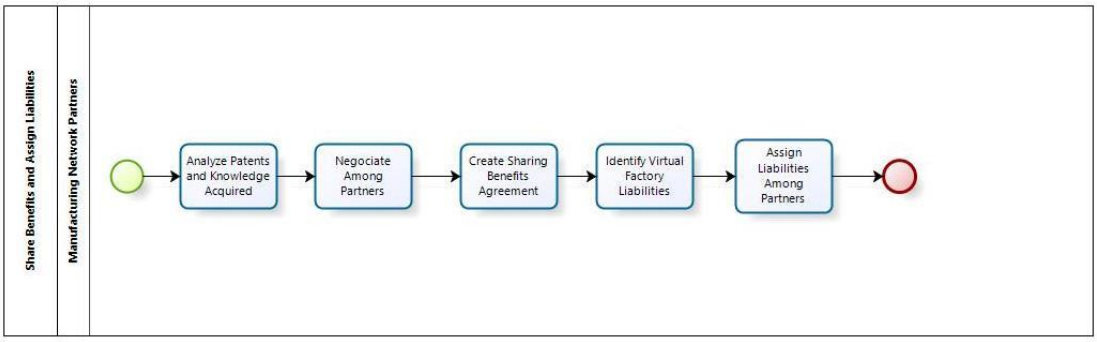


AP4.2. Evaluate Performance		
INPUTS	*Periodic status report*	Monitoring and Control Reports compiled during the PLAY phase.
	Previous knowledge	Knowledge already acquired in other similar collaborations important for performance evaluation of this network

AP4.2. Evaluate Performance		
	Stakeholders feedback	Document on the assessment of the collaboration established by each partner
OUTPUTS	*Manufacturing network evaluation report*	Final report on the evaluation of the manufacturing network.
	Knowledge database Input of AP1.3	Introduction of the evaluation report of the network in the database in order to collect the information of all collaborations undertaken.
PRACTICES	*Define standard criteria for evaluating MN's*	Design and implement performance metrics to evaluate MN network.
	Share the evaluation report in the IT platform	Make MN network's evaluation report available to the platform with the objective to share the outcomes among MN members.
Supporting Tools	*Process Monitoring*	The monitoring component in the platform is the component that provides the real time monitoring of ongoing process, historical data relating to finished processes and instances and business analytics relating to process and activities types.

AP4.3. Share the benefits and assign liabilities





AP4.3. Share Benefits and Assign Liabilities		
INPUTS	*R&D outcome*	Research results subject to be published in academic journals.
	Manufacturing network contracts and agreements	Set of contracts and agreements that define the rights and duties of each partner and the type of penalties to be applied in case of breach of the agreed conditions.
OUTPUTS	*Sharing Benefits Agreement Document*	Document with the division of the profits earned during the collaboration (e.g. Patents, Software)
	Liabilities Agreement Document	Document with the division of obligations to be complied after collaboration(e.g. after sales support)
PRACTICES	*Share savings*	Distribute profits and liabilities among the MN partners once the network is dissolved after fulfilling the business opportunity.
	Assign responsibilities for post sales customer assistance	Select partner(s) to assign responsibilities for after sales services to the customer.

5 th Chapter

Conclusions

5.1 Summary of the thesis

The identification and description of business processes and practices for manufacturing networks as proposed was achieved as well as their empirical validation.

As expected literature review was carried out and through this it was possible to develop the business processes and practices best suited to use in manufacturing networks. At the end it was possible to get a set of business processes, practices and their characterization suitable to be applied to manufacturing networks in order to ensure the management and adaptation of the network quickly and effectively to market changes. Beyond that, in the second part of the work an empirical validation was carried out to bring the work to an industrial and collaborative reality of the today's enterprises.

The validation of the processes by the ADVENTURE project collaborators had two major advantages. First, it enabled to receive feedback from a group of experienced and qualified personnel in this field of research. Second, it was then possible to adjust the processes according to a real and running project, the ADVENTURE project.

The companies had an important contribution in the link of the work with the industrial reality, through the ADVENTURE workshops among companies was possible to simulate and organize a real manufacturing network. During these workshops it was possible to understand how businesses operate and organize their networks and build knowledge together, on one hand they can experience new ways to develop their networks using this work and on the other shared their knowledge in this field.

Through the work performed has been written a paper to be submitted to a conference. (E. Annexes)

5.2 Future Work

Analyzing the work is possible to verify the possibility to continue what has been developed so far. The next steps of the work could be done by implementing the processes

and practices to real contexts in order to test them. One possibility is the test in the short term, during the ADVENTURE project, by using industrial cases that are already taken place at the moment with some members of the advisory board. Another possibility would be the realization of workshops in companies to test the framework in a real situation and see the flaws found in the framework.

Another option that should be implemented would be the incorporation of these processes in an information system to make it automatic and intuitive, including for example templates to help write contracts.

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Annexes

A. Business Processes Table

Table A.1 - Business Processes Table from Literature

			Romero & Molina (2009)[17]	Huan et al. (2004)[35]	Amaravadi & Lee (2005)[6]	Croxton et al. (2001)[5]	Cancian et al. (2012) [2]	Shamsuzzoha et al. (2012)[3]	Harland et al (2004)[19]	Gunasekaran & Ngai(2004)[36]	Verdouw et al. (2011)[4]
Phase	Sub phase	Process Name									
JOIN	Adoption	Manage Membership and structure	X								
		P0 - Plan ICT infrastructure		X							
		S0 - Source ICT infrastructure		X							
		M0 -Make infrastructure		X							
		D0 – Deliver Infrastructure		X							
		Manage information technology and knowledge			X						
	Provisioning	Manage profiling and competency	X								
		Manage account				X					
PLUG	Business Opportunity analysis	Identifiy collaboration opportunity	X								
		Characterize collaboration opportunity and plan VO rough	X				X				
		Develop vision and strategy			X						
		Define requirements				X					
		Analyse costumer profitability				X					
		Market and sell products			X						

		Manage customer service			X						
	Partners search and selection	Search and select Partners	X				X	X	X		
		e-Procurement,								X	
	Negotiation	Agreement/contract negotiation wizard	X				X				
		Analize risk and negociate					X				
		VO initiation: Register , set-up & launch	X								
	Processes definition and planning	Design collaboration based on a list of shared components among partners.						X			
		Plan collaboration (aggregate and detailed)					X	X		X	
		Plan supply chain		X							
		Plan Source		X		X					
		Plan Make		X							
		Plan Deliver		X							
		Plan Network								X	
		Mine Data								X	
		Forecast Demand		X						X	
		Define Strategic alliances								X	
		Web-based Design								X	
		Define manufacturing strategy				X					
		Define sourcing strategy				X					
		Specify Performance				X					
		Plan demand				X					
		Plan capability				X					
		Select performance indicators					X				
		E-contracting					X				
		Manage IPR					X				
PLAY	Execution and delivery	VO operation: Execute & Manage delivery	X								
		Design and develop products			X						
		Deliver products and services			X						
		Deliver MTS		X							X
		Deliver MTO		X							X
		Deliver ETO		X							X
		Deliver retail product									X
		Make to stock		X							X
		Make to order		X							X
		Engineer to order		X							X
		Source Stocked Products		X							
		Source MTO Products		X							
		Source ETO Products		X							
		Simulate					X				

		Manage project quantitatively					X				
	Monitoring and controlling	VO evolution: Manage exceptions	X								
		Manage performance					X	X			
		Monitor operations						X			
		Manage environmental health and safety			X						
		Manage improvement and change			X						
		Coordinate execution				X					
		Monitor supplier				X					
		Manage governance					X				
		Manage partnership project					X				
		Manage quantitative project					X				
		Measure and analyze					X				
		Decision support management and optimization					X				
		Manage collaborative project					X				
		Manage requirements					X				
		Manage risk					X				
DISSOLVE	Dissolution	VO Dissolution: Inheritance information management	X				X				
		Partners Assessment					X				
		Finalize contract					X				

B. Case Studies

B.1 – Case from the aerospace industry: Aerospace Wales Forum

Interview Date	July 4th, 2013, 9:30-11:00
Interviewee	John Whalley | Chief Executive Aerospace Wales Forum Bridgend, UK
Interviewers	INESC PORTO - Ana Barros - David Costa UVA - Ahm Shamsuzzoha
Goals	Apply the Virtual Factory Business Model Framework to a future VF in the UK aerospace industry.

Context and Case Description

One of the major supply chain trends of the aerospace industry is that OEM's (Original Equipment Manufacturers) have been focusing on their core competences (aircraft overall design, architecture, integration, and final assembly and delivery to end customers) and though becoming large scale integrators and co-coordinators of aircraft production (Clearwater Corporate Finance, 2010). Furthermore, OEM's have become more integrated with Tier I suppliers, increasing the share of risk in the supply chain.

Currently, the aerospace industry is facing a surge in demand for civil aircraft. Consequently, Tier 1 suppliers are also facing the need to integrate and collaborate with Tier 2 suppliers, due to their capacity constraints in dealing with this demand increase. This report provides the data gathered during the application of the Virtual Factory Business Model Framework to define the business model of a Virtual Factory aiming at delivering aero structures (e.g. skins, stringers, spars) to an aircraft OEM. The Virtual Factory Business Model Framework is the first part of the Conceptual Manufacturing Reference Model developed under the ADVENTURE - ADaptive Virtual ENTerprise manufacTURing Environment - FP7 European Project.

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EFQM (2013). http://www.efqm.org/en/tabid/108/default.aspx, accessed on 11.07.2013.

B.2 - Case from the machinery industry: Azevedos Indústria S.A.

Interview Date	July 19th, 2013, 10:00-13:00
Interviewee	Tiago Gomes, R&D Project Manager
Interviewers	INESC PORTO - Ana Barros - David Costa - Filipe Ferreira
Goal	Validate the Conceptual Manufacturing Reference Model by applying it to a future Virtual Factory coordinated by Azevedos Indústria, Portugal.

Context and Case Description

Azevedos Indústria S.A. is a Portuguese company founded in 1964, which focuses its activities in the equipment and machinery design, manufacturing, and commercialisation mainly for the cork transformation industry. The company's activities cover all areas of the preparation, transformation, finishing and laboratorial control sectors of the cork industry.

When customers have special equipment requirements, Azevedos Indústria collaborates with other companies in order to be able to coordinate the production of the machine according to the customer needs.

Using the Conceptual Manufacturing Reference Model

Phase	Business Process	Management Practices	Adopt?
JOIN	Set-up the ADVENTURE framework	Have an IT infrastructure with appropriate hardware, software, and technical support available to all VF personnel	Yes
		Create a compatible communication/ information system within the VF	Yes
	Provide information about products, services, competencies and capacity	Share information about products, services, competencies and capacity	Yes
	Leverage networking to find new business opportunities	Find networking partners and manage networking relationships	Yes
		Build networking activities in order to leverage partner's resources, capacity, skills, knowledge, and specialization	Yes
PLUG	Define the Virtual Factory business model	Use the business model framework for Virtual Factories	Yes
		Create a core cross-functional team which remains on the project from beginning to end	Yes
		Nominate a project leader	Yes
	Search and assign partners	Vision the network architecture and identify the right individuals or organizations for the VF	Yes
		Build strategic partnerships with VF members	Yes
	Design network's governance and operational plan and processes (incl. simulation and optimization)	Share information: Costs, Customer demand, Materials requirement, Price changes, Production capacity and scheduling, Supply disruptions, Order status, Delivery schedules	Yes
		Design facilities network and transportation	Yes
		Leverage partner's resources, capacity, skills, knowledge, and specialization	Yes
		Develop and clearly communicate VF goals and needs	Yes
		Document operational processes	Yes
		Design flexible and adaptable processes	Yes
		Plan collaboratively	No

Phase	Business Process	Management Practices	Adopt?
		Make decisions jointly concerning sourcing, manufacturing, logistics, marketing, and sales.	Yes
	Negotiate Virtual Factory agreements		
	Manage risk	Exchange relevant and value-adding information in an accurate, timely and credible manner	Yes
		Solve problems jointly	Yes
		Maintain close contact with customers	Yes
		Evaluate formal and informal complaints of customers and VF partners	Yes
		Respond quickly to complaints	Yes
		Share risks	Yes
PLAY	Design and develop product	Involve customers/users, suppliers, product designers and manufacturers	Yes
		Use modular design of parts	Yes
		Use concurrent engineering	Yes
		Simplify and standardize component parts	Yes
		Use value analysis	Yes
		Use Quality Function Deployment (House of Quality)	No
		Formally evaluate the results of testing (concept, product, market)	Yes
		Cleary pre-define Go/No-Go criteria for each review gate	Yes
		Use design for manufacture and assembly	Yes
		Use design for SCM	Yes
		Use eco-design of products: design of products for reduced consumption of material and energy, for reuse, recycle, recovery of material and/or component parts, and to avoid or reduce the use of hazardous products within the manufacturing process	Yes
	Manufacture product	Use lean practices: reduced set-up times, small lot sizes, and pull-production	Yes

Phase	Business Process	Management Practices	Adopt?
		Use quality management practices: supplier certification, inspection, statistical process control, continuous quality improvement programs, competitive benchmarking	Yes
		Cooperate with partners for environmental objectives: reduce transportation, energy consumption, carbon and other emissions; implement cleaner production and green packaging	Yes
		Use continuous replenishment and VMI	No
		Reserve upstream capacity /stock	Yes
		Use postponement	Yes
	Monitor and adapt processes	Use a balanced set of performance measures	Yes
		Measure performance jointly	Yes
		Improve environmental performance	Yes
		Redesign and improve business processes	Yes
DISSOLVE	Collect feedback from stakeholders	Measure customer satisfaction	Yes
		Collect feedback from VF members	Yes
	Evaluate performance	Define standard criteria for evaluating VF's	Yes
		Share the evaluation report in the ADVENTURE platform	Yes
	Share the benefits and assign liabilities	Share savings	No
		Assign responsibilities for post sales customer assistance	Yes

B.3 - Case from the energy industry: Oy Merinova Ab

Interview Date	August 22nd, 2013; 17:00 – 20:00
Interviewee	Timo Kankaanpää, Managing Director
Interviewers	UVA - Ahm Shamsuzzoha
Goal	Validate the Conceptual Manufacturing Reference Model by applying it in to a future Virtual Factory coordinated by Oy Merinova Ab, Finland.

Context and Case Description

Oy Merinova Ab, Finland is a technology centre that promotes utilisation of new technologies and the growth and success of companies by offering development services together with its partners especially for companies in the energy technology sector. This company is responsible for the technology centre services in the Vaasa region in Finland in the co-operation with its associated company Oy Vaasa Parks Ab.

Merinova is a member of the Finnish Science Park Association TEKEL. TEKEL is a nationwide co-operation network of Finnish science parks and technology centers, containing 30 members in Finland's university cities. Together with its partners, TEKEL develops internationally attractive environments for innovation as well as implements national projects and programs.

Using the Conceptual Manufacturing Reference Model

Phase	Business Process	Management Practices	Adopt?
JOIN	Set-up the ADVENTURE framework	Have an IT infrastructure with appropriate hardware, software, and technical support available to all VF personnel	Yes
		Create a compatible communication/ information system within the VF	Yes
	Provide information about products, services, competencies and capacity	Share information about products, services, competencies and capacity	Yes
	Leverage networking to find new business opportunities	Find networking partners and manage networking relationships	Yes
		Build networking activities in order to leverage partner's resources, capacity, skills, knowledge, and specialization	Yes
PLUG	Define the Virtual Factory business model	Use the business model framework for Virtual Factories	Yes
		Create a core cross-functional team which remains on the project from beginning to end	No
		Nominate a project leader	Yes

Phase	Business Process	Management Practices	Adopt?
	Search and assign partners	Vision the network architecture and identify the right individuals or organizations for the VF	Yes
		Build strategic partnerships with VF members	Yes
	Design network's governance and operational plan and processes (incl. simulation and optimization)	Share information: Costs, Customer demand, Materials requirement, Price changes, Production capacity and scheduling, Supply disruptions, Order status, Delivery schedules	Yes
		Design facilities network and transportation	Yes
		Leverage partner's resources, capacity, skills, knowledge, and specialization	Yes
		Develop and clearly communicate VF goals and needs	Yes
		Document operational processes	No
		Design flexible and adaptable processes	Yes
		Plan collaboratively	Yes
		Make decisions jointly concerning sourcing, manufacturing, logistics, marketing, and sales.	Yes
	Manage risk	Exchange relevant and value-adding information in an accurate, timely and credible manner	Yes
		Solve problems jointly	Yes
		Maintain close contact with customers	No
		Evaluate formal and informal complaints of customers and VF partners	Yes
		Respond quickly to complaints	Yes
		Share risks	Yes
PLAY	Design and develop product	Involve customers/users, suppliers, product designers and manufacturers	Yes
		Use modular design of parts	No
		Use concurrent engineering	No
		Simplify and standardize component parts	Yes
		Use value analysis	No
		Use Quality Function Deployment (House of Quality)	No

Phase	Business Process	Management Practices	Adopt?
		Formally evaluate the results of testing (concept, product, market)	Yes
		Cleary pre-define Go/No-Go criteria for each review gate	Yes
		Use design for manufacture and assembly	Yes
		Use design for SCM	Yes
		Use eco-design of products: design of products for reduced consumption of material and energy, for reuse, recycle, recovery of material and/or component parts, and to avoid or reduce the use of hazardous products within the manufacturing process	Yes
	Manufacture product	Use lean practices: reduced set-up times, small lot sizes, and pull-production	Yes
		Use quality management practices: supplier certification, inspection, statistical process control, continuous quality improvement programs, competitive benchmarking	Yes
		Cooperate with partners for environmental objectives: reduce transportation, energy consumption, carbon and other emissions; implement cleaner production and green packaging	Yes
		Use continuous replenishment and VMI	No
		Reserve upstream capacity /stock	No
		Use postponement	Yes
	Monitor and adapt processes	Use a balanced set of performance measures	Yes
		Measure performance jointly	Yes
		Improve environmental performance	Yes
		Redesign and improve business processes	Yes
DISSOLVE	Collect feedback from stakeholders	Measure customer satisfaction	Yes
		Collect feedback from VF members	Yes
	Evaluate performance	Use standard criteria defined for evaluating VF's	Yes
		Share the evaluation report in the ADVENTURE platform	Yes
	Share the benefits	Share benefits	Yes

Phase	Business Process	Management Practices	Adopt?
	and assign liabilities	Assign responsibilities for post sales customer assistance	Yes

References

Merinova (Innovation with Energy) (2013). http://www.merinova.fi/en/merinova/, accessed on 26.08.2013.

B.4 - Case from the semiconductor industry: Nanium S.A.

Interview Date	August 23rd, 2013, 14:30-16:30
Interviewees	Alexandra Castro, Director of Planning and Logistics Pedro Vasconcelos, Customer Logistics Manager
Interviewers	INESC PORTO - Ana Barros - David Costa
Goals	Validate the Conceptual Manufacturing Reference Model by applying it to a future Virtual Factory coordinated by Nanium S.A, Portugal.

Context and Case Description

The semiconductor industry is a highly evolving industry that has to constantly update its supply and production to the emergent technologies, developed in order to respond to the very demanding market needs. Therefore, customers look for suppliers that have both the engineering and operations skills needed to coordinate the development and industrialization of new technologies in collaboration with other suppliers.

Nanium S.A. is based in Vila do Conde, Portugal, and has been providing advanced assembly and test services to a global customer base of semiconductor companies for more than 15 years. Their services include package design to prototyping, wafer-level packaging (WLP), wafer probe, assembly and test, supply-chain management and drop shipping.

Using the Conceptual Manufacturing Reference Model

Phase	Business Process	Management Practices	Adopt?
JOIN	Set-up the ADVENTURE framework	Have an IT infrastructure with appropriate hardware, software, and technical support available to all VF personnel	Yes
		Create a compatible communication/ information system within the VF	Yes
	Provide information about products, services, competencies and capacity	Share information about products, services, competencies and capacity	Yes
	Leverage networking to find new business opportunities	Find networking partners and manage networking relationships	Yes
		Build networking activities in order to leverage partner's resources, capacity, skills, knowledge, and specialization	Yes
PLUG	Define the Virtual Factory business model	Use the business model framework for Virtual Factories	Yes
		Create a core cross-functional team which remains on the project from beginning to end	Yes
		Nominate a project leader	Yes
	Search and assign partners	Vision the network architecture and identify the right individuals or organizations for the VF	Yes
		Build strategic partnerships with VF members	Yes
	Design network's governance and operational plan and processes (incl. simulation and optimization)	Share information: Costs, Customer demand, Materials requirement, Production capacity and scheduling, On hand inventory levels, Supply disruptions, Order status, Delivery schedules	Yes
		Design facilities network and transportation	Yes
		Leverage partner's resources, capacity, skills, knowledge, and specialization	No
		Develop and clearly communicate VF goals and needs	Yes
		Document operational processes	Yes
		Design flexible and adaptable processes	Yes
		Plan collaboratively	Yes

Phase	Business Process	Management Practices	Adopt?
		Make decisions jointly concerning sourcing, manufacturing, logistics, marketing, and sales.	Yes
	Manage risk	Exchange relevant and value-adding information in an accurate, timely and credible manner	Yes
		Solve problems jointly	Yes
		Maintain close contact with customers	Yes
		Evaluate formal and informal complaints of customers and VF partners	Yes
		Respond quickly to complaints	Yes
		Share risks	No
PLAY	Design and develop product	Involve customers/users, suppliers, product designers and manufacturers	Yes
		Use modular design of parts	Yes
		Use concurrent engineering	No
		Simplify and standardize component parts	Yes
		Use value analysis	No
		Use Quality Function Deployment (House of Quality)	No
		Formally evaluate the results of testing (concept, product, market)	Yes
		Cleary pre-define Go/No-Go criteria for each review gate	Yes
		Use design for manufacture and assembly	Yes
		Use design for SCM	Yes
		Use eco-design of products: design of products for reduced consumption of material and energy, for reuse, recycle, recovery of material and/or component parts, and to avoid or reduce the use of hazardous products within the manufacturing process	Yes
	Manufacture product	Use lean practices: reduced set-up times, small lot sizes, and pull-production	Yes

Phase	Business Process	Management Practices	Adopt?
		Use quality management practices: supplier certification, inspection, statistical process control, continuous quality improvement programs, competitive benchmarking	Yes
		Cooperate with partners for environmental objectives: reduce transportation, energy consumption, carbon and other emissions; implement cleaner production and green packaging	Yes
		Use continuous replenishment and VMI	Yes
		Reserve upstream capacity /stock	Yes
		Use postponement	No
	Monitor and adapt processes	Use a balanced set of performance measures	Yes
		Measure performance jointly	Yes
		Improve environmental performance	Yes
		Redesign and improve business processes	Yes
DISSOLVE	Collect feedback from stakeholders	Measure customer satisfaction	No
		Collect feedback from VF members	Yes
	Evaluate performance	Use standard criteria defined for evaluating VF's	Yes
		Share the evaluation report in the ADVENTURE platform	Yes
	Share the benefits and assign liabilities	Share savings	No
		Assign responsibilities for post sales customer assistance	Yes

References

Nanium S.A. (2013). http://www.nanium.com

C. Azevedos Hands On Workshop Photos

Figure C4 - Azevedos Workshop Photo

Figure 5 - Azevedos Workshop Photo 2

D. Practices Scheme for Workshop

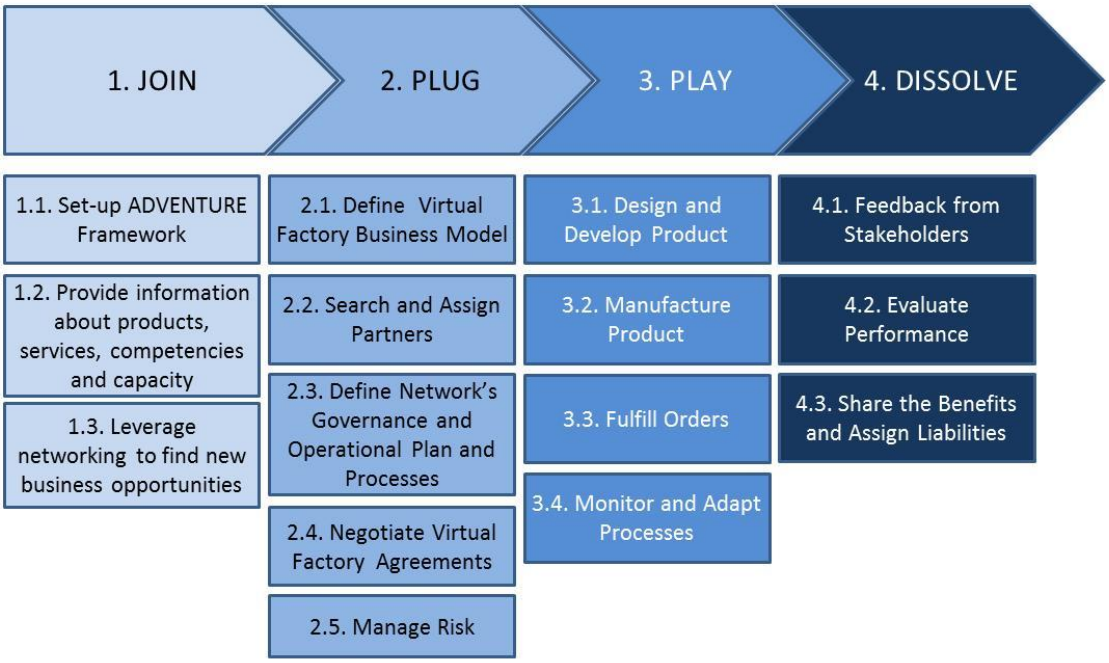

Figure 6 - Processes Scheme for Workshop

E. FAIM 2014 Paper

The paper to be submitted for the 24th FAIM conference (The International Conference on Flexible Automation and Intelligent Manufacturing, http://www.faim.eu/) is in a pdf file on the cd submitted with this thesis.