A PROCESS MODEL FOR THE EXTENDED ENTERPRISE

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ABSTRACT
Models can be powerful tools for enabling understanding, consensus, communication and decision support in and between organizations regarding operations and structure in the Extended Enterprise. Models come in many variants and there exist some efforts for modeling and mapping Extended Enterprises. However there is a lack of holistic, consistent and comprehensive models that at the same time are simple, easy to use, time saving, intuitive and easily recognizable for the user. This paper will propose an Extended Enterprise Reference Process Model. The main focus in Extended Enterprise Process Model is on operations and particularly in manufacturing and logistics processes and those processes that manage and support these. The Extended Enterprise Model was developed according to the requirements in the Automotive Industry and is not yet a generic process model for all kinds of operations.

Keywords: Modeling, Visualization, Operational control

INTRODUCTION
In today's business environment companies are increasingly motivated and/or forced into more extensive interactions with its surroundings (e.g. suppliers and customers); they are establishing/joining Extended Enterprises. The formation of Extended Enterprises can be seen as a result of many factors; e.g. 1-2 decades of outsourcing, the global nature of business, increasing customer requirements regarding price (costs), quality, time and flexibility and motivated by new possibilities within (Information) Technology. Surviving and gaining competitive advantages in such a business environment requires skillful and powerful management, control and monitoring of operations not only within a company, but also throughout the value chain. It is essential to possess knowledge of the business processes in the Extended Enterprise and be able to control and monitoring these. Due to the complexity of these collaborations, it has become of utter importance to create models and/or maps of the operations in the Extended Enterprise. The purpose of these models is to provide common understanding among users about Extended Enterprise operations and structure, to support analysis or decision-making or to control operations of the Extended Enterprise (Vernadat, 1996). Such models are capable of assisting the managing task in the operations by providing decision support for long term and short term planning, as well as for exception handling (Kosanke and Zelm, 1999).
Throughout the last two decades several efforts and initiatives have been carried out within the development of enterprise models and modeling. Some of these efforts and initiatives resulted in well-known enterprise modeling frameworks (architectures, languages and methodologies) such as CIMOSA, PERA, GIM (see Vernadat (1996), Bernus and Nemes (1996) andersen and Rolstadås (2000) and Chalmenta et al. (2001) among others). Most of these modeling frameworks are

developed for Computer Integrated Manufacturing (CIM) enterprises in supporting their enterprise integration efforts (Delen and Benjamin, 2003). Other efforts and initiatives have approached a more narrow and specific aim and application. Examples of such efforts are process modeling for ERP implementation and BPR projects (see among others Hammer and Champy (1993), van der Aalst et al. (2000) and Becker et al. (2003)), the SCOR model (www.supply-chain.org) for supply chain modeling and performance measurement and Value Stream Mapping (VSM) (Rother and Shook, 1999) for eliminating waste and creating continuous flow within enterprises and Extended Enterprises. The latter approaches (e.g. SCOR and VSM) offers only a limited focus and do not attempt to give a holistic view of the (extended) enterprise, compared too the more complex and comprehensive enterprise modeling techniques.
This paper will address several issues of modeling in the Extended Enterprise. The assumption is that on one hand there is a need for holistic, consistent and comprehensive Extended Enterprise models and on the other hand these models needs to be simple, easy to use and time saving, intuitive and easily recognizable for the user. Unfortunately there is a lack of such models. As a response, this paper will present a reference Process Model for the Extended Enterprise.

MODELING IN THE EXTENDED ENTERPRISE

When addressing the topic of modeling in the Extended Enterprise it is important to underline that this is not equivalent to Enterprise Modeling. Enterprise Modeling is of course a prominent part of this domain, but there are other approaches as well; ranging from the primitive flowcharts, via various mapping initiatives (e.g. VSM), too more rigid and formal frameworks like the SCOR model and Business Process Modeling for ERP implementation (e.g. the SAP R/3 Blueprint).

Models

When discussing modeling, it can be appropriate to start with defining the basic element: The model. A model is a simplified representation or abstraction of reality. It is usually simplified because reality is too complex to describe exactly and because much of the complexity is actually irrelevant in solving the specific problem (Turban and Aronson, 2001). The degree of simplification and abstraction depends on the interest of the targeted audience. A model is always expressed in terms of a language (mathematics, natural languages, symbols etc) (Vernadat, 1996). According to Turban and Aronson (2001) models can be classified into three categorizes according to the degree of abstraction: Ionic (e.g. prototypes), analog (charts, diagrams etc) and mathematical (e.g. algorithms). This paper will focus only on the analog models, which is a symbolic representation of reality. Sometimes the term conceptual is used instead of analog. According to Delen and Benjamin (2003), conceptual models are formal or informal abstractions of a system that are expressed using special-purpose modeling constructs. Typically part of a modeling language's syntax, these constructs include simple graphical elements such as circle, boxes and arrows
Some authors and practitioner use the term map instead of models. A map is a spatial representation of the environment. Representation in this sense means something that stands for the environment that it portrays and is both likeness and a simplified model (Muehrecke and Muehrecke, 1992 in Gardner and Cooper, 2003). From this definition we can conclude that maps are a sub-group of analog/conceptual model, where maps are those conceptual model which have a high degree of recognition (in the meaning of resemblance with the system is represent). When there is a need for complex and comprehensive models (e.g. high degree of details etc) of systems, it is in many cases not longer feasible to do this with maps and more traditional conceptual models are used (such as IDFO etc).
When models are used in Enterprise Modeling, they can be defined as (Vernadat, 1996): An Enterprise Model is one representation of a perception of an enterprise. It can be made of several sub models including (but not limited to) process models, data models, resource models and organization model. The content of an Enterprise Model is whatever the enterprise considers important for its operations. Delen and Benjamin (2003) use the term *enterprise model set* to refer

to a group of conceptual models built to obtain a coherent and comprehensive picture of an enterprise (the models within the model set are equivalent to the views used within enterprise modeling (functional, information, resource and organization view). This set includes models of various types and each type of model defines a "perspective or viewpoint from which the system is considered for a given purpose, concentrating on some aspects and hiding irrelevant ones to reduce complexity" (Vernadat, 1996). Within Enterprise Modeling there are three levels of generalization: Reference, partial and particular models. A particular model is a dedicated model for some aspects of a given enterprise or a system, whereas the partial model is a model which is not fully instantiated and which can be reused and customized by business users for building their particular models (Vernadat, 1996). A reference model is a (partial) model which can be used as a basis for particular model developments or evaluation of particular models (ibid). The rationale for developing reference and partial models are to provide standardization, user-friendliness and equally important save time and cost (due to the reuse of the model).

Benefits and pitfalls of modeling

Any Enterprise Model serves a purpose. There may be many different purposes, but fundamentally any Enterprise Model aims at making people understand, communicate, develop and cultivate solutions to business problems (Szegheo, 2000). An Enterprise Model can be created to serve one purpose, but it could as well be used for several purposes. Christensen et al. (1995) propose three categories of Enterprise Models:

1. Human sense making and communication, where the main purpose of Enterprise Modeling is to make sense of aspects of an enterprise and communicate with others.
2. Computer assisted analysis, where the main purpose of Enterprise Modeling is to gain knowledge about the enterprise through simulation or deduction.
3. Model deployment and activation, where the main purpose of enterprise modeling is to integrate the model in an enterprise-wide information system and thereby actively take part in the work performed by the organization.

Bernus (2001) point out that Models can be used throughout the life cycle of a systems – in concept development, specification, design, construction and operation – for experimentation, analysis, decision making, communication and learning. He further argues that enterprise models may be used to externalize (make explicit) individual understanding and to negotiate a shared one, alleviating the problem presented (ibid).

Delen and Benjamin (2003) group the benefits of use of enterprise models into three categories. First, conceptual models provide decisions makers with a consistent and coherent view of the current and future state of the Enterprise and enable managers to design and analyze operations at the macro level. Second, they can be used to transfer enterprise-specific knowledge among domain experts, system analysts and other stakeholders. The time and associated costs of knowledge transfer activities is significantly reduced. Third, high-level Enterprise models can be reused by a number of analysis method specialists to build a variety of analysis models.

Unfortunately, modeling of Enterprises is a complex, difficult, time-consuming process and prohibitively expensive (Reyneri, 1999) and have yet to make a significant impact on the decision-making of most companies and organizations (Delen and Benjamin, 2003). The primary reason for the limited success of these enterprise modeling and analysis methods on a large industrial base is that the methods are generally very elaborate and require acute expertise to be used effectively (ibid).

In line with this Szegheo (2000) points out that even though there are numerous enterprise modeling approaches and tools available, many organizations prefer to develop their own enterprise modeling approach or tool. She argue that there are at least three reasons for this (ibid)

- Existing solutions are developed for another purpose than the one in mind
- Existing solutions can not provide desired flexibility
- Reluctance in companies to use new tools and techniques

In the previous discussion the generic aspect of modeling in the enterprises has been discussed. The next section will however relate the discussion on modeling in the Extended Enterprise.

Modeling in the Extended Enterprise

According to Szegho (2000) many of the Enterprise Modeling approaches are directly applicable to modeling in the Extended Enterprise. This is in line with Vernadat (2001) who claims that enterprise modeling is concerned with representing the structure, organization and behavior of a business entity, i.e a part of an enterprise (or enterprise domain), or of a group of enterprises (extended enterprise, virtual enterprise, networked enterprise), to evaluate its performance or reengineer its material, information or control flows in order to make it more efficient.

Gardner and Cooper (2003) suggest that not only is there a need to visualize (create models of) the supply chain, there needs to be a well-established process for building the map so that knowledge is easily transferable and exchangeable among managers and organizations as appropriate; *supply chain mapping*. They point out that there is not yet a universal set of mapping convention to represent a supply chain (ibid).

Accordingly to the work of Gardner and Cooper a supply chain map is a representation of the linkages and members of a supply chain along with some information about the overall nature of the entire map (2003). And they propose that a supply chain map has the following attributes (ibid):

- Geometry – embodies aspects of generalization, particularly aggregation issues and the shape of the map of supply chain members
  - Tiers – the number of sequential business units performing transactions leading to the final consumer
  - Aggregations – the degree of specificity within a tier
  - Spatial – a map is geographically representative
- Perspective – address the focus and the scope of the map
  - Focal point – firm-centric view or an industry-centric view
  - Scope – the scope of the perspective (product, supply chain, process, cycle)
- Implementation issues – include information density and database linkage to make the map useful for managing the supply chain
  - Information density – the amount of information integrated into the visual display
  - Live link to database – linked to preexisting corporate or supply chain database(s)
  - Delivery mode – how the map is made available to the users

Accordingly to this work there are no established mapping (or modeling) approach available today who comprise all the attributes. Gardner and Cooper use several different mapping and modeling approaches (like VSM, SCOR etc) to illustrate this (ibid).

Discussion

Throughout this chapter various models have been introduced and discussed, together with several issues of modeling in enterprises and Extended Enterprises. On one hand we have the rigid, standardized, comprehensive and expert-based methods from Enterprise Modeling, which have not yet made a significant impact on the decision-making in enterprises, because they are found elaborate and require acute expertise to be used. On the other hand there are various informal, simple, not standardized and practitioner–based supply chain/enterprise mapping/modeling initiatives, which have gained popularity.

The remaining part of this paper will be devoted to a reference process model that can be seen as an attempt to develop a modeling method in between the domains of enterprise modeling and various supply chain mapping/modeling approaches. It seeks to take advantages from the benefits of both approaches and at the same time to avoid the respectively pitfalls.

THE EXTENDED ENTERPRISE PROCESS MODEL

The Extended Enterprise (EE) Process Model is developed at SINTEF over the past years and as a part of the European Union funded project MOMENT (the Mobile Extended Manufacturing ENTerprise, see http://moment.nuigalway.ie/content/members.asp for more information). The EE Process Model where developed due to the shortcomings of the existing models (see the prior discussion) and to the requirements of suppliers to the automotive industry. Further it was developed with a particular focus on manufacturing and logistics processes and on those processes managing and supporting these. Hence, the EE Process Model is not yet generic and able to support all kind of process in the processes within the Extended Enterprise. However, the EE Process Model has been tested and modified through several cases in the Automotive Industry and to some degree in other industries (e.g. furniture, food and pharmaceutical).

The EE Process Model will enable Extended Enterprises to build up their operation based on standard processes. The EE Process Model will allow mapping of all actors, processes and activities in the Extended Enterprise and thereby have a complete and corresponding description of the Extended Enterprise. In addition, the EE Process Model will be used to measure and evaluate the Extended Enterprise.

Purpose and functionality of the EE Process Model

The purposes for developing the model can be split into five categories. Firstly, it seeks to be an efficient tool for *mapping processes in engineering and re-engineering projects*, both in enterprises and along the value chain in the Extended Enterprise. Secondly, the model will provide *visualization of material and information flow* as a decision support in the planning, control and monitoring of operations in the Extended Enterprise. Thirdly, it will represent a *common language* for the Extended Enterprise. Fourthly, it will provide extended enterprises with a set of *pre-defined state-of-the-art processes*. And finally, it will propose *standard symbols* for process modeling in the Extended Enterprise.

The overall requirement for the EE Process Model was that it must be capable to model all manufacturing and logistics processes in the Extended Enterprise and all those processes managing and supporting these. Further, the model should be easy and simple to use and in a format were it is interpretable, recognizable and easy-to-disseminate. The following six categories summarize the functionality of the EE Process Model:

- *Give the overall structure of the Extended Enterprise* – identify all actors in the Extended Enterprise, geographical location of actors and links between the actors
- *Visualize material and information flow in the Extended Enterprise* - both internal in actor as well as external in the Extended Enterprise (including reverse logistics)
- *Contain all relevant information regarding actors, processes and activities in the Extended Enterprise* – top level information of each actor, as well as input and output of all processes and activities, resource and performance information for all processes and activities
- *Mapping types*– support various scenarios for mapping; drag&drop, manual (typing) mapping and automated mapping based on data from ERP/legacy systems
- *Model mode* – support paper, electronic and web usage
- *Easy and not time efficient usage* – the model should be based on standard modules (reference models) and the usage should be plain and intuitive

If these functionalities of the EE Process Model are compared to the attributes of a supply chain map by Gardner and Cooper, we can conclude that there is a high degree of concurrence. The EE Process Model fulfills the proposed attributes; geometry, perspective and implementation.

Conceptual reference model

The EE Process Model can be viewed from various perspectives and classified accordingly to the several model definitions given earlier. First of all, the EE Process Model is an analog model. This implies that there are no simulation and/or optimization functionality provided and physical replica

of the system. However with time it could be desirable to include for example some sort of "what if" functionality.
At a high level (basically at the actor level) the EE Process Model can be interpreted as a map, which basically means an interpretable and recognizable analog/conceptual model. However, when more information are added and the structure and processes of the Extended Enterprise is detailed, the model loose it resemblance with maps and can be viewed only as a conceptual model.
And finally, the EE Process model can also be classified as a reference model. The EE process Model provides a standard structure and hierarchy of the Extended Enterprise, a set of predefined actors and state-of-the-art processes and a standard notation for modeling the Extended Enterprise. Therefore the user can rapidly create new models and be able to communicate and evaluate the process model with others. When the EE Process Model is applied for modeling, a particular model is created in each case.

Overview of the EE Process Model
The EE Process Model is developed for and gives particular focus on operations in the Extended Enterprise. The model is developed according to the requirements and purposes highlighted previous in this paper.
The EE Process Model has four levels of details:

- Level 0 - Actors (with attributes) and group of actors
- Level 1 - Processes (Operate, Manage and Support)
- Level 2 - Sub-Processes
- Level 3 - Activities

Figure 1 illustrates the four levels of detail in the EE Process Model. Figure 1 shows how the Operate process at a Manufacturer (one of five actors) consists of several sub-processes and activities.

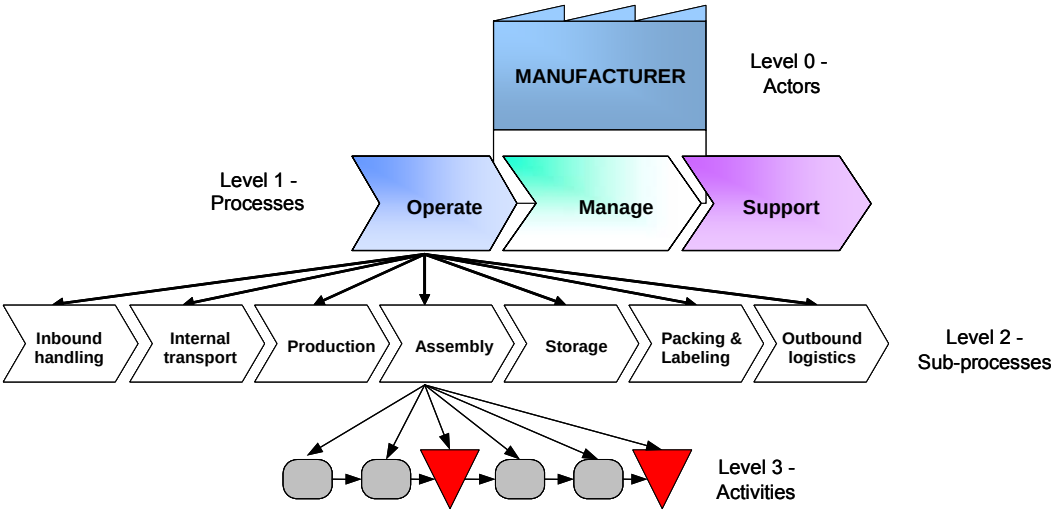

Figure 1 - The EE Process Model levels

An alternative view of the EE Process Model is given in figure 2 (this view is inspired by the Supply Chain Management Model presented by Lambert et al. (1998), but the content of model is different). In figure 2, three of the actors are illustrated (the two others are omitted due to space issues) and operate, manage, support processes are indicated.

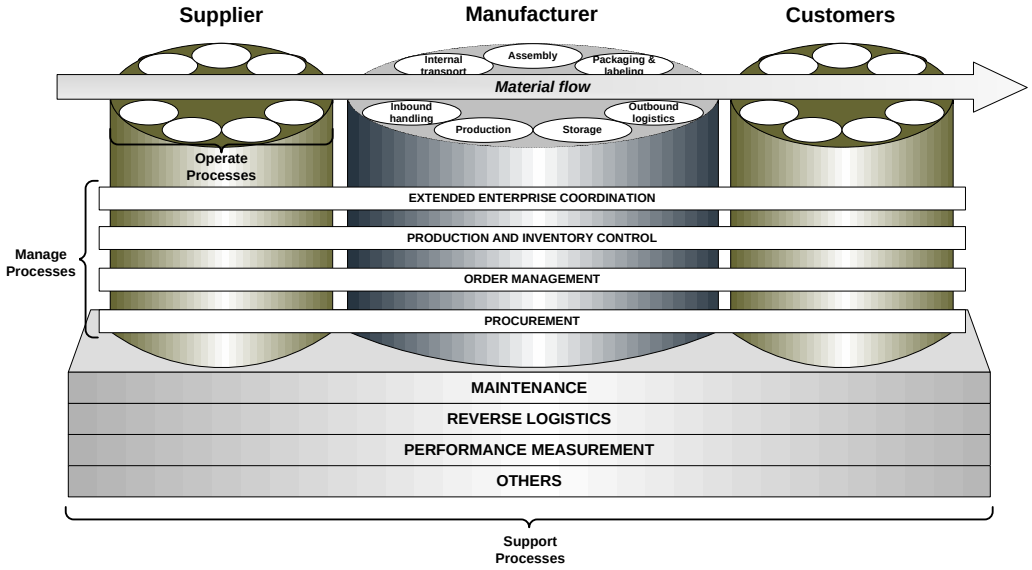

Figure 2 - Overview of the EE Process Model

The next paragraph will give a brief introduction to the EE Process Model and the four levels of detail.

The EE Process Model have five different types of actors: *Suppliers*, *Transporters*, *Warehouse*, (distribution centers), *Manufacturer* (focal company), *Customers*. Each actor has attributes assigned to it. The actor attributes are high-level information that gives the reader/user practical, general and informative information about the actor. The attributes are assigned to the actor independently of the processes. The attributes should give the reader/user value information about the actor, without going into detail with the processes. Each actor can be described using several predefined set of attributes, e.g. Warehouses have attributes such as normal-, clean- or cold- environment.

In the EE Process Model the actors perform Manage processes, Operate Processes and Support processes. The *Operate Processes* are defined as those concerning the physical material flow in the value chain. Each actor will therefore always contain one or more out of the operate processes. *Manage Processes* are defined as those concerning the management activities undertaken to support the operate processes. *Support Processes* are those processes not directly associated with the operation, but will have an indirect influence on the operation.

Each of the operate, manage and support processes can be broken down into slightly more detailed, but still generic, sub-processes. The sub-process provides us with a more accurate view of what is "going on" in the company. The suppliers, focal company and the customers are all considered manufacturing companies and therefore these actors perform similar sub-processes.

Activities are the lowest and most detailed level in the EE Process Model. Activities are attached to organizations (the actors) that operate, manage and support them. Activities more than organizations are the building blocks of the extended enterprise. The activities can be outsourced, shifted between organizations, consolidated for the system as a whole or combined into new forms of enterprises (Schary and Skjøtt-Larsen, 2001). Whereas the processes and mostly also the sub-processes, are generic for all kinds of manufacturing companies, the activities are more particular and specific. Every manufacturing company is conducting operate, manage and support processes. Similarly it is possible to model nearly all manufacturing companies by the sub-processes. All manufacturing companies receive material/components, transform these (production, assembly and/or packaging) and send them further down the value chain. However, activities depend more on industrial sector (e.g. food & drink, furniture, automobile etc), type of manufacturing (process,

discrete and project) and kind of manufacturing (batch, mass, job production etc). This implies that there are a considerable amount of activities that have to be identified, defined and described. The activities described in EE Process Model are within the flow oriented mass production in the automotive industry.

Due to the complexity of the EE Process Model, a software tool has been developed in order to improve the comprehensibility and user-friendliness. The Software tool is a Web-Browser (a set of hyperlinked web pages), which let the user play, explore and learn the EE Process Model in a perspicuous way. The application of the EE Process Model Browser is mainly for training and demonstration of the concept and content of the EE Process Model. It is suitable for students, researcher, academics and practitioner from industry. A draft version of the EE Process Model Browser is available online, www.produksjonslogistikk.no/browser/browser.htm. The Browser provides quick access to all levels of details in the EE Process Model. All figures are hyperlinked and make the user able to quickly and precisely manoeuvre through the EE Process Model. By clicking any figure the user get access to all processes, process attributes, cost drivers, performance indicators, definitions etc. It is also possible to use a menu for easy manoeuvres through the Process Model.

Standard symbols

A final important aspect of the EE Process Model as a reference model is a set of predefined (standard) symbols. Figure 3 illustrate a high-level template of these symbols. This template will provide a standard notation for describing processes and the relations between processes in the Extended Enterprise. This basically means a template for how to visualize actors, processes, sub-processes, activities and the relationships between them.

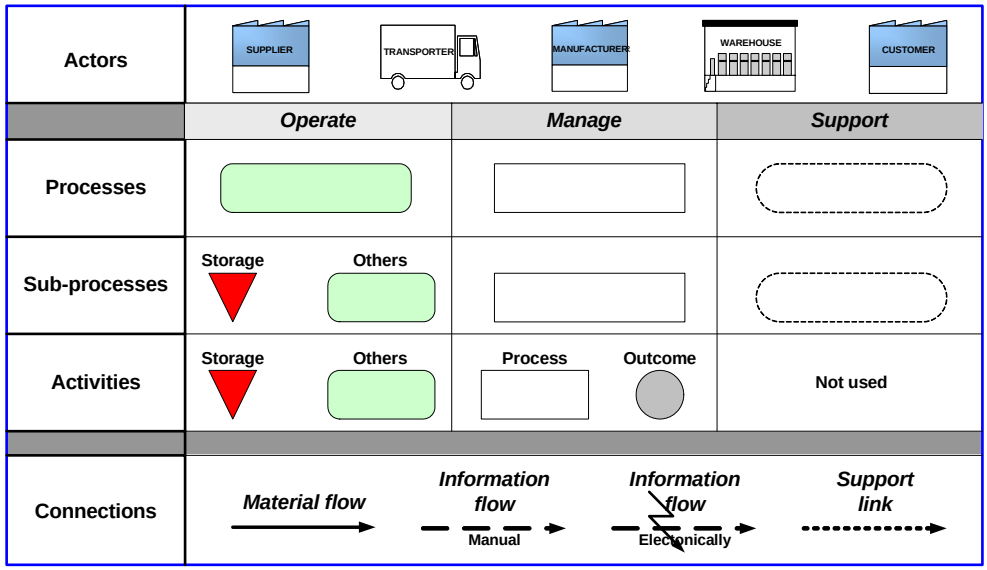

Figure 3 - Template for symbols used within the EE Process Model

The template has been tested successful in various cases in the Automotive Industry. However, when the span of the model increase (more actors and pre-defined processes) and/or when the area of application also will include other types of industry than the Automotive, the symbols have to be modified and enlarged.

CONCLUSION

This paper has introduced a reference Process Model for the Extended Enterprise. The EE Process model serves several purposes, among other supporting improvements through Enterprise Engineering projects and visualization of processes as support for planning, control and monitoring of operations in the Extended Enterprise.

The main motivation for developing the EE Process Model was due to the shortcoming of available modeling approaches for modeling enterprises, extended enterprise, supply chain etc. On one hand we have the rigid, standardized, comprehensive and expert-based methods from Enterprise Modeling, which have not yet made a significant impact on the decision-making in enterprises, because they are found very elaborate and require acute expertise to be used. On the other hand there are various informal, simple, not standardized and practitioner–based supply chain/enterprise mapping/modeling initiatives, which have gain popularity.

The EE Process Model is however not generic in the sense that it support modeling of all kind of operations and processes in the Extended Enterprise. So fare it has been developed, tested, modified and verified within the Automotive Industry, with a particularly focus on manufacturing and logistics processes.

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