INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN
ICED 03 STOCKHOLM, AUGUST 19-21, 2003

FROM DESIGN PROCESS SPECIFICATION TOWARDS PDM WORKFLOW CONFIGURATION

Pierre NOWAK, Christophe MERLO, Benoît EYNARD and Thomas GALLET

Abstract

One of the objectives of concurrent engineering is to manage design data among its life cycle. PDM systems allow the management of product data according to predefined process, but these processes have to be specified first in a more global and strategic approach. The goal of this paper is thus to link process data among the project life cycle.

This study is based on a meta-modelling approach and uses it for federating the IDEFØ diagram with Windchill and ENOVIAVPM workflows. The workflow defined by the WfMC is also studied as a possible interchange format.

It finally appears that the federation of models can ensure the consistency of most objects and information supported in the different process models.

Keywords: Process Modelling, Workflow Management, Product Data Management

1 Introduction

On one hand product data management (PDM) systems allow design engineers to share product data, documents, files, and to make them evolve according predefined processes [1]. In order to fulfil this need these systems use workflow functionalities. They also provide to users a complete or partial automated management of the information according to the activities and the roles of users in the project. On the other hand the objective of these systems is to support design project management in order to store design process history and to have information about what has been done to make the right decision. Thus activities managed by the workflow are basic activities and must be related to the detailed activities identified and scheduled by the project managers [2].

Our goal is then to obtain a dynamic and consistent link between design project management and PDM workflow. By the way, it could be possible to control the key steps of documents evolution based on the specification of the design process [3]. We also aim to clearly identify the possible relations between the specific process model and workflow implemented, in order to integrate the design process model with the PDM workflow functionality. For this study, the process modelling language chosen is IDEFØ, and the PDM software are Windchill (PTC) and ENOVIAVPM (Dassault Systèmes). The methodology chosen for identifying the data supported by each of the process models and for describing the relations between those models is the use of meta-modelling approach. We already use this approach in a similar case [4] for linking product models.

We will first present the research context, with the process modelling languages on which our work is based on, some works that have been carried out on the meta-modelling approach, and some languages we can use for meta-modelling. Section 3 will clarify the methodology used, the abstraction levels, the use of UML for meta-modelling, and the way to model the relations between models. The section 4 will finally describe the results we obtained by analysing the

IDEFØ diagram, comparing it with the workflow of the Workflow Management Coalition (WfMC), and carrying out the translation into PDM workflows. Finally, we conclude on the necessary steps to carry out before a real federation of project management and more clearly design planning into PDM systems.

2 Research context

The semantic field of our study deals with design process models and meta-modelling. This section aims at presenting the process models that we are working with and a general overview of our approach of federative models and meta-models.

2.1 Process modelling

In order to have a better understanding of the company's processes, it is often necessary to give details of their organisation, progress and behaviour through process modelling activities. Various methods exist regarding the aim of Business Process Reengineering (BPR) [5]. [2] present five modelling languages and detail a brief comparison. Those different modelling languages are relevant in different phases of the product design process. [6] show for example the differences between two modelling approaches IDEF and UML. The authors present the benefits arising from the combined use of IDEF for describing a very complex system, and the use of UML for strongly structuring it. In a similar approach, we present and assess in this paper the IDEFØ modelling, the reference workflow from the WfMC, the workflow of Windchill and the ActionFlow of ENOVIAVPM which are the PDM software we have chosen.

With IDEFØ [7], we get an efficient and simple use modelling language. It provides a good graphical representation of key elements of an activity. The activity is described with a box containing an active verb and a network of arrows links boxes representing the relationship between activities exchanging information or objects.

WfMC proposes a workflow modelling language described with a textual language XPDL (XML Process Definition Language) [8]. The aim of this workflow is to enable the interoperability and connectivity between workflow products. An activity is there surrounded by information or objects which are classified with their nature (transition information, data, participant…).

In Windchill, a workflow can be understood as “document oriented” [2] and a graphical editor functionality is available in the system. An activity is described by several parameters: its type (submission, promotion…), its nature (dedicated to human task or automatic), the access control rules that will dedicate it to a specific actor, and several criteria and conditions to realise it and to allow state transition. Activities are connected by sequential links but specific links can be defined: e.g. “AND” and “OR” conditions, back loops, synchronisation parameters and also triggering conditions.

In ENOVIAVPM there are no real workflow functionality. ENOVIAVPM supports the concept of action which is similar to activity. It provides a non prescriptive and notification workflow called ActionFLow which could be compared with an asynchronous collaborative workflow with a manual workflow engine [9]. Enlarge functionalities will be available by the future LCA system with build-time or run-time functionalities.

2.2 Meta-modelling

According to MetaModel Consortium (www.metamodel.com), a meta-model is mainly used as:

- A “schema” for semantic data that needs to be exchanged
- A “schema” for semantic data that needs to be stored
- A language that supports a particular methodology or process
- A language to express additional semantics of existing information

In our research work, we aim at creating a schema for semantic data that need to be exchanged and at enabling the interoperability between two process modelling languages. We have now to clarify the relations there are between objects, models, and meta-models. As currently considered a model is an abstraction view of a system built for being easier to handle, understand and communicate. The conventional four-level of abstraction architecture of modelling are M0 (User objects), M1 (Model), M2 (Meta-model) and M3 (Meta meta-model). In this study, we only use the levels M0, M1 and M2 (Figure 1).

In the same way [10] defines the meta-model aims as the representation of the concepts and relationships used in a particular model. Modelling a product model, aiming at meta-modelling, will then consist in specifying the structure of the product model and describing its entities based on a common modelling language.

A lot of research works dealing with the meta-modelling as an integration tool have already been carried out. For example [11] present a meta-model for activity based management. Their goal is then to use meta-model for defining a language for management of business process. The global meta-model is based on the assembly of elementary meta-models, each elementary meta-model describing a concept that have to be considered as the activity concept. It describes thus the entire concept used for managing the process.

2.3 Modelling languages

Various modelling languages could be used for meta-modelling. Each of those aims at representing some particular concepts. For example, a Petri-Nets meta-model describes concepts such as place nodes and transition nodes while an UML (Unified Modelling Language) meta-model describes concepts such as classes, associations, etc. [10].

UML [12] has been created for helping software development and is based on nine diagrams that also represent different static and dynamic views of an object-oriented system. UML is however the most frequently used language for meta-modelling. The main UML diagram used for meta-modelling is the class diagram. Indeed the formalism of this diagram contains many possibilities for describing models like aggregations or dependency relations.

Even if UML offers a lot of modelling possibilities, we will see that they are not always sufficient. Indeed, [13] propose an approach for the information integration of production system. Meta-modelling is then applied to expert models for enabling an information system to share common data. The authors give an example of an expert model "virtual machine tree" which is used for the management of the working modes of all the machines of a production system. In this case, UML is used but is not sufficient for specifying the system in an unambiguous way. So the authors propose to describe some additional constraints based on OCL (Object Constraint Language).

In our approach, the language we use for meta-modelling is the class diagram of UML, but we clearly want to underline that UML is used in our context as a static meta-model, and not as a process model.

3 Methods

3.1 Meta-modelling and abstraction levels

In order to have a better understanding of the business processes, it is often necessary to give details of their organisation, progress and behaviour through process modelling activities.

We use process models for enabling a better understanding of the company's processes (level M0 on Figure 1). As detailed in section 2.1, IDEFØ and workflows are relevant in different phases of the product design process. These process models have then to be represented at a M1 level. The formalism of these models has then to be modelled (level M2) for an easier identification of the relations existing between them. As shown in Figure 1, a federative meta-model is used for describing the relations based on the entities for pair of process meta-models. Our final goal is then to implement the link from IDEFØ to PDM workflows and also to ensure the best as possible consistency relation between instantiated models.

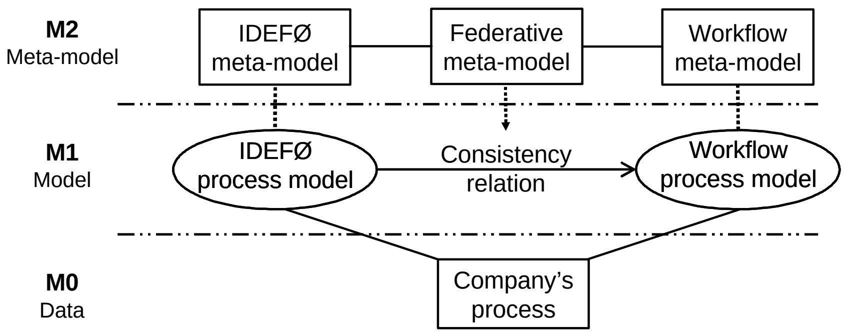

Figure 1 Mapping of the model levels, links, and data in relation

3.2 Use of UML

The language chosen for meta-modelling is the UML class diagram. Thus we have to map the formalism of each process model into UML classes and associations. Meta-models of the WfMC and Windchill workflows already exists in their description documents [8][14]. We thus present here the IDEFØ meta-model.

The IDEFØ diagram supports some concepts that we have to model. Some of these concepts remain to entities like the activity box, while others are expressing the relationship between entities. In fact, a flow arrow can be at the same time connected to more than two activities and have different relations with them. This is why our meta-model is made of some classes representing the entities, and some virtual classes like “ToLink” used for representing the concepts which are not entities (Figure 2). Other classes like “VerbPhrase” are used for representing some data types.

We can notice that the UML meta-model is not able to represent concepts like tunnelled links. A tunnelled link is a flow arrow connected to an activity that can not exist in the level detailing this activity. Such a concept could be modelled using the object constraint language (OCL) [13] but this will not help us in reaching our goal.

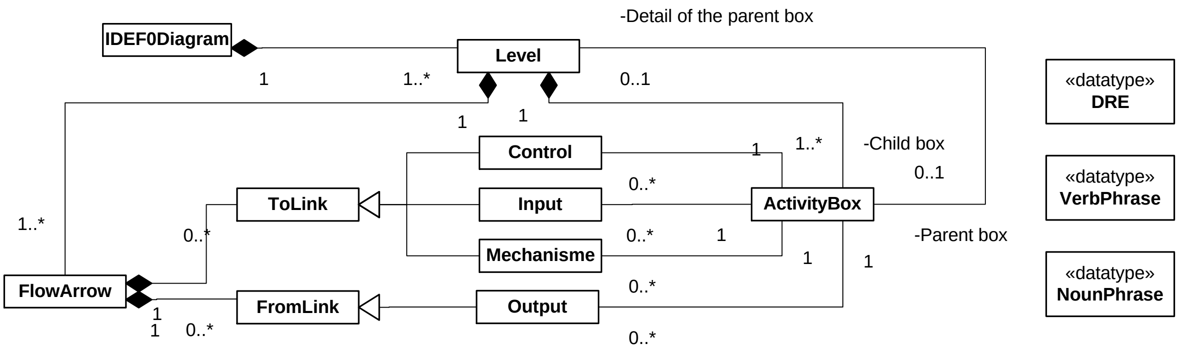

Figure 2 IDEFØ meta-model (without attributes and operations)

3.3 Federation of meta-models

The goal of the federative meta-model is to describe the existing relation between items of two process meta-models. According to Figure 1, the federative meta-model is considered at the abstraction level M2. It specifies some association classes linking classes from both considered meta-models. Figure 3 shows the association class between ActivityBox from the IDEFØ meta-model and WorkflowProcessActivity from the WfMC workflow meta-model. Association classes handle the rules used for the translation of attributes as some operations. Those rules are launched each time an operation of a class of the IDEFØ meta-model is launched. Then the rules launch equivalent operations for the class of the WfMC meta-model.

Instantiated process models considered at the abstraction level M1 are composed of some objects describing both models, and some objects of the association classes controlling the consistency between objects of both models. Thus, relations modelled at the level M2 with some association classes insure the consistency between entities from different models.

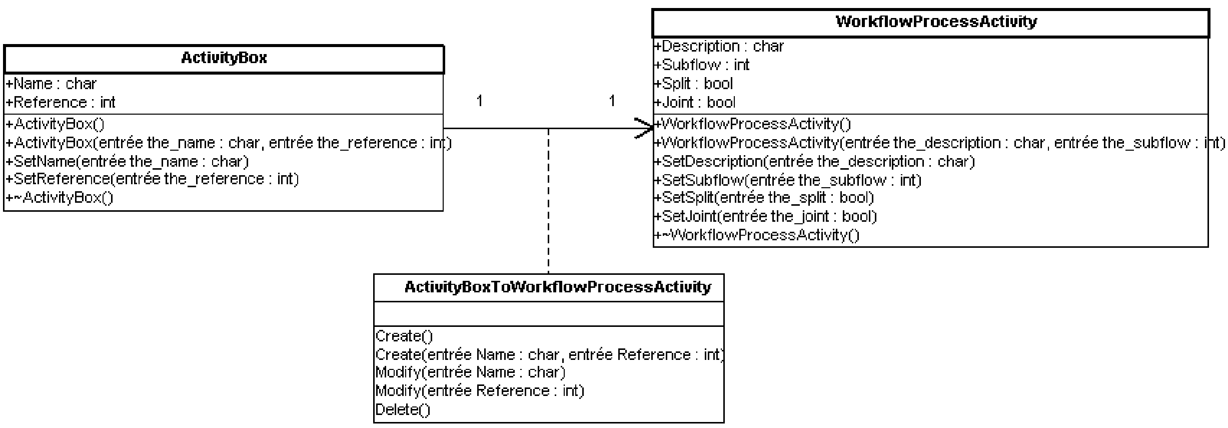

Figure 3 Association class between ActivityBox and WorkflowProcessActivity

4 Results

In this section we focus on the results of the federation of models. We thus use a process example described in IDEFØ (Figure 4), and compare it with the models we can establish using WfMC workflow, Windchill workflow, and ENOVIAVPM ActionFLow languages.

4.1 WfMC workflow specifications

The WfMC workflow model supports quite different concepts than IDEFØ. As an example, while objects and information in relation with an IDEFØ activity are classified by the type of relation (Input, Output, Control, Mechanism), objects in relation with a WfMC workflow activity are classified by the type of the objects (data, participant, application…). We are thus able to get in the WfMC workflow the way the process should run, with the activity, the split and joint fork, and the objects and information relating to each activity. Nevertheless, a human intervention is necessary for identifying the objects types. We can also notice that in the WfMC workflow, a loop can only been done over an inline block: e.g. a loop over the activities "Embodiment of sub assembly 1" and "Integrate sub assemblies" could not be done because of the joint fork that appear in WfMC at the input of "Integrate sub assemblies" (Figure 4).

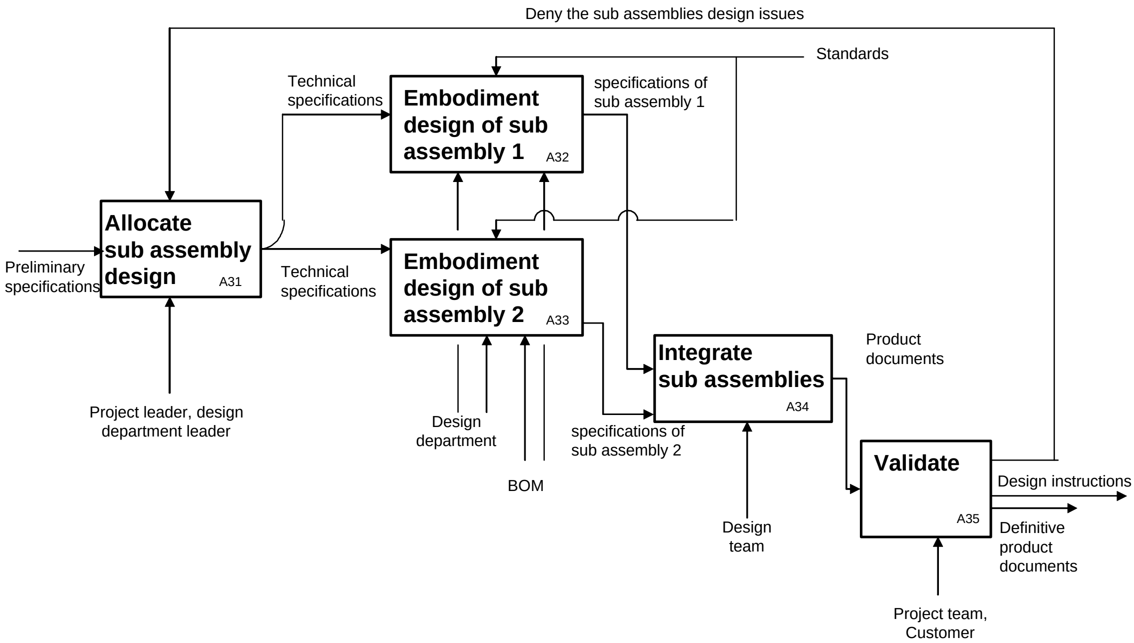

Figure 4 Example of en embodiment design process model with IDEFØ

4.2 Windchill workflow specifications

Windchill workflow and IDEFØ modelling have different domain application: IDEFØ is used to describe processes such as design project breakdown while Windchill workflow describes tasks related to document management. With IDEFØ, an activity produces or transforms documents and with Windchill workflow an activity participates to this transformation. We consider that the two kinds of such processes can be federated but not integrated in a full bijection way.

Considering the example of IDEFØ process modelling, several documents are managed, such as the "product document": it is created in the "Integrate sub assemblies" activity, then transformed in the "Validate" activity before being used into later activities. These different activities can be associated to corresponding states of a life cycle and the transformations to specific workflow. The transformation can be described at a more detailed level of the IDEFØ model in order to fit with the activities and the transition conditions of Windchill workflow. Human resources linked to an IDEFØ activity characterise part of access control rules specified in the life cycle (state, workflow or activity).

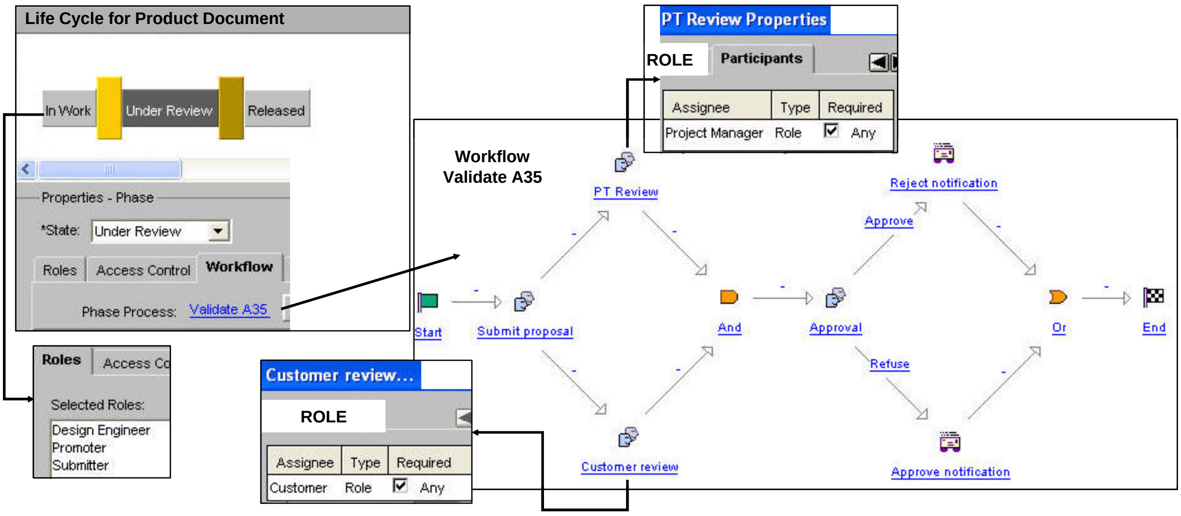

Figure 5 Synthesis of Windchill configuration

As a conclusion, the specification of Windchill workflow based on IDEFØ models is possible but it requires that:

- a document considered as one object into the PDM must have a unique name into the IDEFØ model,
- the activities concerning the document management must be described at the adequate IDEFØ detailed level.

4.3 ENOVIAVPM ActionFlow specifications

ENOVIAVPM ActionFlow also focuses on the processing of documents. The ActionFlow does not provide a real workflow schema and not ensure the description of the whole process, but each activity can be identified and is described with its related documents, owner, memo (text description) and methodology description (Figure 6). Thus, the methodology field allows us to complete the input/output identification of the related documents type in identifying input, control and mechanism documents.

Nevertheless, the evolution of an activity and the sequence of activities have to be carried out by humans using the “transfer” and “generate” functionalities.

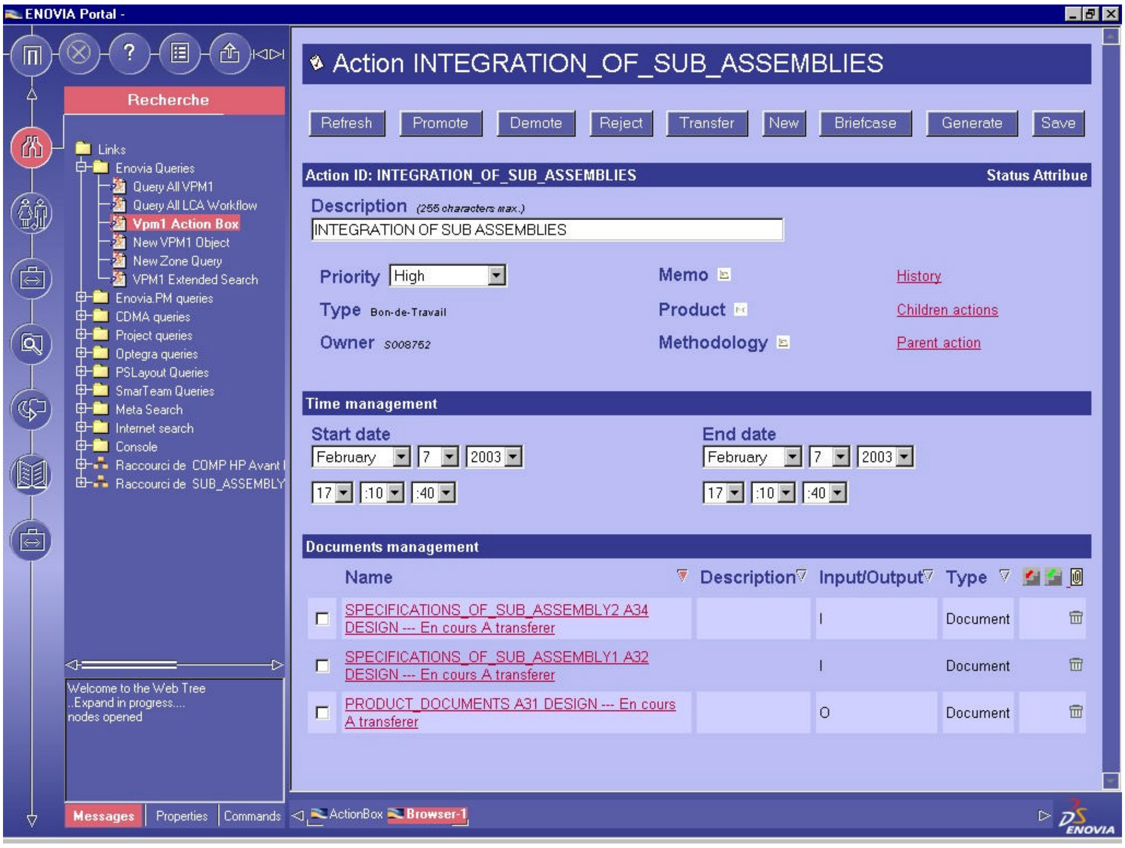

Figure 6 ENOVIAVPM action “Integration of sub assemblies”

5 Conclusion and prospects

In this paper, we show how we use the meta-modelling approach for pointing out the data supported by several process models. This allows us to formalise the relation between these models, and so to point out the problems we encounter in configuring a PDM workflow by using a design project planning. We have also shown that each of our studied four process models supports its own concepts, but even if we need a human intervention for carrying out the link between two instantiated models, the federation of models can ensure the consistency of most objects and information.

This work is a preliminary step in the integration of design process specification and PDM workflows configuration. It has to be followed by a software implementation with Windchill and perhaps in the future LCA System.

This work also aims at providing a basis for the integration of other models dealing with the product definition or design alternatives management. Such a base will be developed and carried out within the IPPOP project (Intégration Produit – Processus – Organisation pour l’amélioration de la Performance en ingénierie) founded within a French government research program. This project aims at integrating the product process and organization dimensions (http://www.opencascade.org/IPPOP).

Finally, the WfMC workflow without additional customisation does not appear as a really interesting gateway, nevertheless we can look at the Process Specification Language (PSL) to get closer to an international standard. About the PDM software, we could expect some better results with the arrival of Project Link (PTC) which involves the project phases and the Windchill workflow.

References

[1] CIMdata Inc., “Collaborative Product Definition management (cPDm): An Overview of a Collaborative Approach to Managing the Product Definition Lifecycle”, CIMdata Report, August 2001, http://www.CIMdata.com

[2] Eynard B., Merlo C. and Carratt B., “Aeronautics Product Development and Certification Workflow based on Process Modelling”, Proceedings ICE’02, Rome, Italy, June 2002, pp.439-442.

[3] Kovacks Z., Le Gof J.M. and McClatchey R., “Support for product data from design to production”, Computer Integrated Manufacturing Systems, Vol. 11, n°4, 1998, pp.285-290.

[4] Nowak P., Roucoules L. and Eynard B., “Product Meta-Modelling : an approach for linking product models”, Proceedings of IEEE SMC’02, Hammamet, October 2002.

[5] Vernadat F.B., “Enterprise modelling and integration : Principles and applications”, Chapman & Hall, London, 1996.

[6] Cheol-Han Kim, Weston R.H., Hodgson A. and Kyung-Huy Lee, “The complementary use of IDEF and UML modelling approaches”, Computers in Industry, Vol. 50, 2003, pp.35-56.

[7] Colquhoun G.J., Baines R.W. and Crossley R., “A state of the art review of IDEFØ”, International Journal of Computer Integrated Manufacturing, Vol. 6, n°4, 1993, pp.252-264.

[8] Workflow Management Coalition, “Workflow Process Definition Interface - XML process definition language”, Workflow standard, document number WFMC-TC-1025, October 2002, http://www.wfmc.org/standards/docs/TC-1025_10_xpdl_102502.pdf

[9] Gzara L., “Les patterns pour l’ingénierie des systèmes d’information produit”, PhD Thesis of INP de Grenoble, 2000.

[10] Lemesle R., “Transformation rules Based on Meta-Modeling”, Proceedings EDOC’98, San Diego, California, November 1998.

[11] Breton E. and Bézivin J., “Un méta-modèle de gestion par les activités : Définition et intégration”, Proceedings CITE 2001, Troyes, France, November 2001.

[12] Booch G., Rumbaugh J. and Jacobson I., “The unified modeling language user guide”, Addison-Wesley, Boston, 1999.

[13] Ndiaye D., Bigand M., Corbeel D. and Bourey J.P., “Information system for production engineering: contribution to maintaining consistency of composite data using an object-oriented approach”, International Journal of Computer Integrated Manufacturing, Vol. 15, n°3, March 2002, pp.233-241.

[14] Windchill Business Administrator’s Guide, Release 6.2, Parametric Technology Corporation, December 2001.

Corresponding author’s : Benoît EYNARD

Lab. of Mechanical Systems and Concurrent Engineering (LASMIS), Troyes University of technology, 12 rue Marie Curie, BP 2060, F-10010 TROYES CEDEX, FRANCE, Tel : +33 3.25.71.58.28, Fax : +33 3.25.71.56.75, e-mail : benoit.eynard@utt.fr, URL : http://www-lasmis.utt.fr