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► To cite this version:

Farouk Belkadi, Nadège Troussier, Benoit Eynard, Eric Bonjour. Collaboration based on product lifecycles interoperability for extended enterprise. *International Journal on Interactive Design and Manufacturing*, 2010, 4 (3), pp.169-179. 10.1007/s12008-010-0099-z . hal-02390169

HAL Id: hal-02390169

<https://hal.science/hal-02390169>

Submitted on 17 Jan 2020

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Collaboration based on product lifecycles interoperability for extended enterprise

Farouk Belkadi · Nadège Troussier · Benoit Eynard · Eric Bonjour

Abstract The paper proposes a new approach for managing two products lifecycles in the context of collaboration between aircraft OEM and their equipment suppliers. The concept of entities and specific roles are used to improve the semantic interoperability between both aircraft and equipment projects' data. These concepts are also used to formalize the relation between various processes that guarantee the connection between the aircraft and the assembly equipment lifecycles. The aim of this integration approach is to enable the information sharing between OEM and suppliers. It intends to enlarge the role of suppliers in the development process of fixture equipment, which are used in the aircraft assembly process.

Keywords Product Lifecycle management · Semantic interoperability · Collaboration process · Extended enterprise · UML

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1 Introduction

Regarding aeronautic industry, the role of supplier is very important for the assembly process success of aircraft component. The Original Equipment manufacturers (OEM) have currently to adjust their design and engineering processes in order to deal with new market demands or to achieve some customizations in the aircraft structure.

When these variations occur, the supply chain is affected. If the corresponding information is not efficiently delivered to the concerned participants of the supply chain, it may cause huge waste of time and production resources.

Collaboration between OEM and suppliers should rather go into strategic partnership, covering the whole product lifecycle. Several PLM projects are developed to improve collaboration between OEM and suppliers in the aeronautic domain. For example, SEINE project is aimed to develop PLM standards that support the integration of French SME (Small and Medium Enterprises) in the extended enterprise [1]. The VIVACE project [2] aims to define the future European Aeronautical Collaborative Design Environment by providing methods and tools to enhance data sharing between OEM and suppliers [2,3].

The purpose of our research is to develop a new business partnership that enables efficient collaboration between OEM and suppliers and makes more important the role of suppliers in the design process of assembly tools. The case study concerns the equipment design and manufacturing process in the aeronautic industry. The construction of this business partnership is obtained according the following perspectives:

- The definition of its mission and organization,
- The identification of new methodologies to optimize its operating processes,

- The realization of a collaborative IT framework to support its activities.

This paper focuses on the last perspective and describes a conceptual framework to specify a new PLM-based approach. This framework is based on the concept of situation using the notion of interrelated entities. It mainly provides collaborative environment that enhances information sharing and coordination between both OEM's and supplier's design projects.

The first section presents a short literature survey about the role of the PLM concept to support the OEM—supplier partnership. Second, an overview of the context of our case study is presented. The third section discusses the conceptual meta-model of collaboration situation at the basis of the proposed approach. In the fourth section, two UML classes' models are developed to describe the relation between OEM and suppliers projects information. Using the UML activity diagram, the section five illustrates some functionalities of the future collaborative system to manage the equipment's design project. Finally, the structure of the Product Meta-model is presented as a kernel of the semantic interoperability between aircraft and equipment data.

2 Literature survey

2.1 Product lifecycle management

PLM is defined as a systematic concept for the integrated management of all product related information and processes through the entire lifecycle, from the initial idea to end-of-life [4]. PLM is considered as a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product information across the extended enterprise [5].

PLM for collaborative product development are well applied in many industries to improve product R&D quality and efficiency for achieving mass customization. Information technology (IT) plays a critical role in supply chain management activities as it permits the sharing of large amounts of information between supplier chain partners. Studies on the overall use of IT have found it to improve inter-organizational coordination [6]. Recently, the augmented reality technologies are integrated as novel interface to facilitate the access to PLM content and to display data in real time as 3D info spatially referenced to a tangible interface [7]. Thanks to the facilities of data navigation by physically handling the tangible marked drawing, the role of PLM system will better support real time interactivity between the work team members.

Such as in the automotive industry, the aeronautic industry is seen to adopt the supplier integration into the development

process. The new management culture considers necessary the PLM approach to get these goals [8]. Tang and Qian [9] present a literature review of PLM approaches used in automotive industry to improve collaboration between OEM and suppliers.

The life cycle currently supporting the OEM supplier partnership, can be grouped in collaborative environment with three main phases [10]:

- Designing the systems to be used in the OEM's product. In this phase, the collaborating partners need to exchange requirements on system and system structure, functional specifications and engineering results according to an agreed common project plan, with milestones, deliverables and measurable quality.
- Supply chain integration to produce and deliver the requested systems to the OEM. In this phase, electronic transfer and processing of orders, checking production and delivery status are essential to produce just in time the products on both side and drastically reduce stock costs.
- Provide services for the components. Having delivered the system to the OEM, the supplier must be enabled to react quickly in case of end customer requirements, which require tracking of products, information about actual state of operation and history of services performed.
- The IT solution to support PLM results from the integration between enterprise resource planning (ERP), product data management (PDM) and other related systems, such as computer aided design (CAD) and customer relationship management (CRM) [11].

For instance, in order to get best integration of suppliers in the automotive design and manufacturing processes, Trappey et al. [12] develop and implement an information platform called advanced production quality planning (APQP) hub. The information hub mainly provides a collaborative environment that enhances the visibility of the supply chain operations and contributes in collecting and delivering APQP documents among all supply chain. This information hub is composed of three types of partners: Primary Manufacturing Enterprise; SMC (Small and Medium Companies) as first level supplier and SMC's suppliers as 2nd level suppliers. This information platform applies the concept of modularized assembly and consists of five major functions: Categorized part library, Project based collaborative design, real-time information exchange, on-line confirmation of modularized products, and on-line negotiation and ordering.

- The "Categorized part library" gives to all partners the possibility to upload and to share their product information concerning their needs and the needs of their partners.

- The “On-line combination of modularized parts” function gives help to the OEM to create new combined module from existing modules in the library.
- Through the function “On-line negotiation and ordering”, partners get helps to finish the product design confirmation and the order negotiating right after the confirmation.
- The function “Real-time information exchange” helps OEM to get real-time project progress information (project number, type, name, status, etc.) and to ensure the project status is under control.
- The function “Collaborative product design” provides a collaborative environment for the supply chain. It ensures that both OEM and SMC get project information and design changes synchronously.

Each one of the previous functions is implemented according to an interactive process. For example by means of the categorized part library, the SMC can upload its product category and specification to the APQP hub. Moreover, when SMC develops new system module (e.g., a new console box design), SMC goes to the hub to post the information and APQP hub also forwards this information simultaneously to keep OEM informed.

However, the successful of any PLM approach requires that the PLM system should guarantee the role of mediator and ensure the communication between different information systems (IS) used by different partners in the project.

2.2 Interoperability request

Collaboration between various partners required currently the sharing of common information that is stored in different information systems (IS). To insure the information sharing request, interoperability mechanisms are needed to support the IS communication and guarantee the coherency between data structures. The interoperability mechanisms are also solicited to support communication between novel generations of digital devices [13].

In a general point of view, the global term “Interoperability” could have many meanings and concerns various application fields. The number of interoperability definitions for this term in literature is also a strong proof of this. Affirmation [14]. Among all these definitions, the most cited is the definition from IEEE, which give general bases of interoperability: “The ability of two or more systems of elements to exchange information and to use the information that has been exchanged”. Other definitions were proposed to add the concepts of services exchange between organizations to this definition.

Regarding the large variety of interoperability definitions and their domain of application, several classifications of interoperability levels are proposed in the literature. Three

main kinds are generally identified, with different nominations:

- Organization and business interoperability support enterprises to factually co-operate with other external organizations. It focuses on the definition of common rules and the synchronization of the interconnected processes.
- Semantic and model interoperability focuses on the correspondence between the different concepts meanings and the linking between the data models. The definition of common semantic references and the mapping between concepts and models ensure the semantic translation between different IS.
- Syntactical and technical interoperability is usually associated with data formats, standards and hardware/software components that enable machine-to-machine communication to take place.

Data and processes modeling is a kernel aspect of interoperability. In this work, we intend to develop a modeling based framework that supports the product lifecycles interoperability in context of OEM and suppliers collaboration. The next subsection presents a literature survey relating data modeling in PLM field.

2.3 Data modeling for PLM

A critical aspect of PLM systems is their product information modelling architecture. In the literature, several representations of the product data are presented [15]. The majority of these systems is limited to the representation of geometric data and other information related to geometry. The unified representation of the product knowledge can favor semantic interoperability of CAD/CAE/CAM systems at the conceptual level [16]. UML is currently used to support product models [17]. STEP and XML are used to obtain interoperability at the implementation level [18].

Sudarsan et al. [19] propose a product information-modelling framework aimed to support PLM information needs. It intended to capture product data, design rationale, assembly, tolerance information, product evolution and, product families. This framework is based on the NIST Core Product Model (CPM) and its extensions (Fig. 1), the Open Assembly Model (OAM), the Design-Analysis Integration Model (DAIM) and the Product Family Evolution Model (PFEM). CPM represents the product’s function, form and behavior, its physical and functional decompositions, and the relationships among these concepts. An extension of CPM provides a way to associate design rationale with the product. OAM defines a system level conceptual model and the associated hierarchical assembly relationships. DAIM defines a Master Model of the product and a series of abstractions called Functional Models related to domain-specific aspects

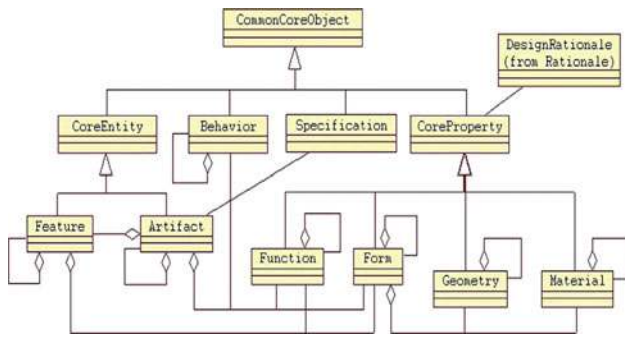


Fig. 1 Example of product model [19]

of the product. PFEM extends the representation to families of products and their components; it also extends design rationale to the capture of the rationale for the evolution of the families.

The concept of product model is closed to the concept of Product representation, which is used in interactive design to support the management of various product views. For example, in [20] and [21], the authors propose the interfacing of product views through a mixed shape representation that integrates different data representations, basically CAD geometry and faceted geometry, in order to bring the design and the analysis model closer together. Representation in a structured way, and can have semantics associated with them.

However, product information is not the unique element affecting the product lifecycle. The inherent imperfections of manufacturing processes and resources might involve a degradation of some product characteristics. In order to ensure a certain level of quality and to assess the manufacturability, Dantan et al. [22] propose a generic information model that aims to formalize and to capitalize the causality between the manufacturing process key characteristics (MPKCs) and the corresponding product key characteristics (PKCs)

In the same idea, Nowak et al. [23] present the architecture of a collaborative aided design framework integrating Product, Process and Organization models for engineering performance improvement. Danesi et al. [24] propose the P4LM methodology which allows the management of Projects, Products, Processes, and procedures in collaborative design and that aims to allow the integration of information coming from different partners which are involved in a PLM application. This framework allows a top-down approach through four functional modules. Each one of these modules is described in a specific model:

- Project module represents all the entities related to the organization, the resources (human and equipment)

- Product module represents all the entities related to the organization, the resources.
- Procedure represents abstracted definitions related to a sequence of physical steps which lead to the modifications of the product
- Operational Process represents a succession of tasks whose realization contributes to the modification of the product.

Generally, each PLM model aims at covering a particular point of view of the collaborative task in a specific industrial case. As synthesis of the presented literature, this work deals with the integration of Product, Process, and Organization dimensions of a design project. Several models are developed to support, at the conceptual level, this integration.

3 Description of the case study

The case study of our research work concerns the design and manufacturing processes of fixture equipment used in the aeronautic industry. The equipment supplier is a basic manufacturer of the assembly tools. The design and manufacturing processes of these tools are considered as a sequential one. First the design department delivers the engineering documents (CAD or CAE files) of the different aircraft parts; the production engineering department specifies and designs the detailed assembly processes and needed tools to carry out the assembly operations. Then, the production engineering department sends the detailed specifications to the supplier for tools manufacturing.

Figure 2 shows this configuration. On the one hand, three departments are engaged in the global process of assembly tools purchasing: production service specifies the assembly needs, the tooling R&D designs the tooling structure and the purchase service negotiates and sends the order to supplier. On the other hand, several suppliers located in different geographical locations are involved to produce the various parts of the tool. After the completion of the tool, it is sent directly to the production shop for use.

During manufacturing process of the assembly tool, some modifications may occur to the initial configuration of aircraft components. These modifications imply changes on the

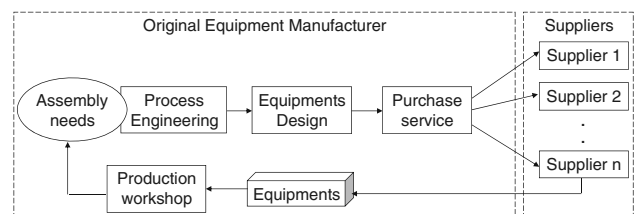


Fig. 2 The current organization of the OEM-Supplier partnership

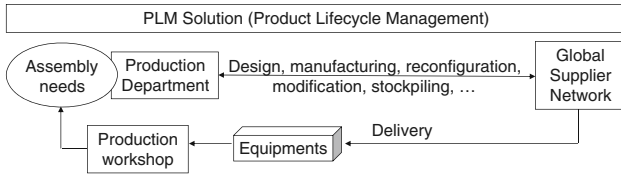


Fig. 3 Future organization of OEM-Supplier partnership

specification of the assembly process and thus of the assembly tool. The whole cycle of the assembly tool ordering is then repeated to cope with the new specifications.

In the future configuration, a new PLM-based approach is proposed to support the new perspectives of the business partnership. PLM is used for the seamlessly integration of all the information specified throughout all phases of the equipment's life cycle to everyone in the new organization (OEM and a new global supplier network GSN) at every management and technical levels. Figure 3 shows the proposed configuration of the new business partnership. In this configuration, tasks of design, configuration and fabrication of the assembly tool are performed collaboratively with the new global supplier network. Suppliers are already informed by new modifications of the assembly operations and design themselves the new tool.

One can consider that the assembly equipment is an intermediate artifact since it is simultaneously a support of the assembly tasks (that are performed in the OEM Assembly Workshop) and, the main object of the equipment development process (that are realized by the new trade organization). Figure 4 illustrates the complexity of the studied case. The development process of the equipment aims at the definition of the functions, the structure, the geometry and the parameters of the equipment, which is used in the aircraft assembly process. To fulfill the equipment project goals, designers need to manage some relevant information that is coming from the aircraft assembly process. This information concerns: the goals of the related activities, the geometry of the concerned aircraft part and the assembly environment.

The process data concerns both the assembly process of aircraft parts and design process of the equipment. Saved information is used to recognize the activities evolution of each partner (new requirement of the OEM, new kind of assembly tools proposed by suppliers,...). In such a context, PLM architecture is proposed to connect the two products lifecycles (aircraft and equipment) (Fig. 5).

The paper contribution is focused on the definition of a PLM platform to be used for the seamlessly integration of all the information specified throughout different phases of the equipment's life cycle. The proposed approach is based on the concept of working situation [25] to describe different relations between supplier network (and assembly tool) and OEM (and aircraft part).

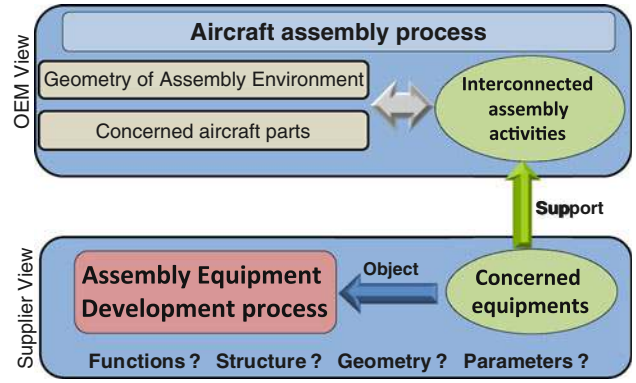


Fig. 4 Relation between equipment development process and aircraft assembly process

4 Meta-model of the situation

At the conceptual level, the proposed approach is based on the concept of working situation proposed in [25]. The situation model is based on the concept of interaction and has some similarities with the concept of environment model such as it is currently discussed in interactive design [26]. In our context, the collaborative project between the OEM and the supplier network might be considered as a global situation within different organizational, operational and collaborative views.

The meta-model of the situation framework is described in an UML class diagram (Fig. 6) by a set of entities and roles. Any object of the class entity may be related to any other object of the class "interactional entity", according to a specific role.

4.1 Basic entities (BE) or concrete entities

These entities bring together the different physical elements in a situation which includes all material resources. For example: product models, drawings, specification documents, CAD tools, planning tools, etc.

4.2 Interactional entities (IE) or abstract entities

Noted "IE", these entities refer to links between entities in a given situation. We define four forms of interactional entities as follows:

- "Operational IE" informs of all the possible transformations in a situation. They refer to specifications which have an effect on objectives and also, to the activities that are performed.
- "Community IE" describes a link of affiliation between parent and child entities. Generally speaking, the notion of belonging to a community is expressed through shared

Fig. 5 Relation between equipment and aircraft lifecycles

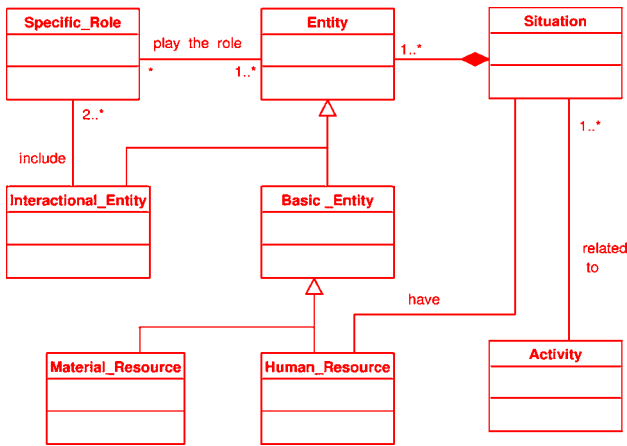
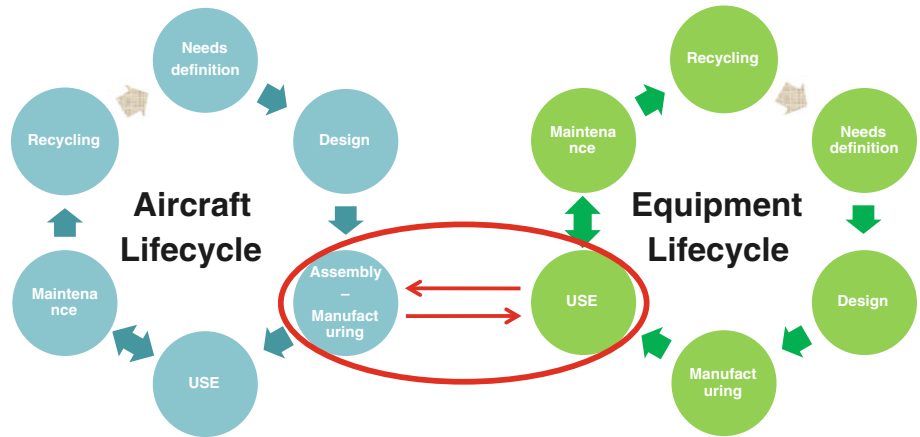


Fig. 6 The Meta model of situation [25]

rules. (e.g., a supplier network is a community IE that puts together different human resources that share the same goals).

- “Transactional IE” denotes various mechanisms of information exchange or the exchange of material resources between human resources or community entities during the carrying out of their collective tasks (e.g., a project review meeting concerning the reconfiguration of the assembly tools).
- “Constraints” express, requirements and limits on the realization of an activity or on a given interaction.

The scope of the paper is the operational IE, which will be used to describe the integration of the two products lifecycles through the different connections between their main projects and related processes.

4.3 Specific role

The definition of a work situation should not only take into account the enumeration of its different elements and the

relations between them, but also the nature of the contribution made by each entity to the interactions. The concept of role has been the subject of many definitions and studies, depending on the discipline (sociology, organization theory and information sciences are some examples). Sübmilch-Walther [27] refers globally to a set of behaviors used by an individual relative to his position in the organization. Uschold et al. [28] define the concept of role as the way in which an entity participates in a relationship with one or more entities.

In the original approach proposed by [25], five types of specific roles are proposed as a systemic adaptation of the concept of role. Regarding to the specificity of the studied context, some semantic modifications are introduced in the original typology:

- The “core” processes are the main processes in a project or the main sub processes in a process.
- The “customer” processes (or projects) concern the processes (or projects) that are going to receive the end result of the interaction.
- The “control” processes concern the sub processes that regulate the fulfilling of a process (or project) with a set of constraints.
- The “support” processes are affected to the processes that contribute indirectly to the main goal of the sup-process (or project).
- The “object” entity answers the question “About what?” It concerns every entity on whom/which the operational interaction acts.

5 Data models for products lifecycles integration

The concepts of project and process are two kinds of operational interaction including a set of processes in order to obtain specific goals. The project structure consists in a system breakdown into different sub-projects according to the product complexity.

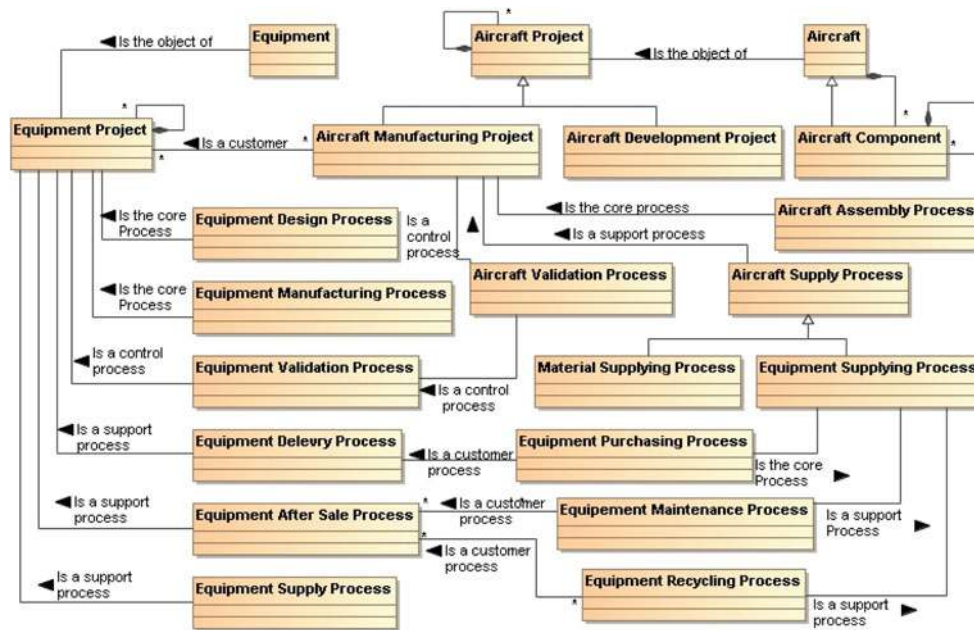


Fig. 7 Relations between OEM and suppliers processes

In the proposed approach, the integration between aircraft and equipment lifecycles is defined according to two complementary views: relation between processes and relation between product and processes data. In addition, a unified representation on both Equipment and Aircraft data is developed to ensure the semantic interoperability.

5.1 Relation between OEM and suppliers processes

The coordination between projects and the synchronization between processes requires the identification of different relations between OEM and suppliers processes. Two questions must be answered to build the conceptual models: (1) what is the contribution of each process (OEM and suppliers processes) to different phases of the fixtures' lifecycle? (2) What connection is needed between the OEM's processes and the Suppliers processes? (Fig. 7)

In Fig. 7, according to the situation Meta model, the goals of equipment project are reached by two core processes: design and manufacturing. In the same idea, the aircraft assembly process is the core process in the OEM manufacturing project since it is one of the main processes in this project. The equipment process is a support in the same project since it is used to fulfill the manufacturing activities.

Similarly, the aircraft manufacturing project is a customer of the equipment project until the result of the equipment project is used in some manufacturing activities. Otherwise, the beginning of an equipment project depends of a purchasing order delivered during the aircraft's project. Therefore, the equipment purchasing process plays at the same time,

the role of core process in the equipment supplying process (Aircraft project) and the role of customer for the equipment delivery process (Equipment project).

The OEM gets more visibility about the suppliers workload and might take into account their constraints when it defines the manufacturing planning. It will also be useful when the OEM will decide the re-scheduling of its activities. In this case, the suppliers are automatically notified by these modifications to ensure their possible reactivity.

The triggering of the equipment delivery process depends, at least, on supplying activities that are managed in the OEM organization. Thanks to the PLM system, the partners might considerably reduce the number of iterations for the cost estimates and negotiation since it is based on common procedures and will be fulfilled through a collaborative process.

5.2 Relation between products and processes information

To ensure the integration between the two products lifecycles, the PLM meta-model must manage relevant information concerning the relation between processes (for OEM and supplier network) and the concerned products (equipment and aircraft parts). This meta-model gives also a schema for semantic data that need to be exchanged between different software during the equipment lifecycle. It may give, at the conceptual level, the first responses to the interoperability problems, by answering the four key questions below:

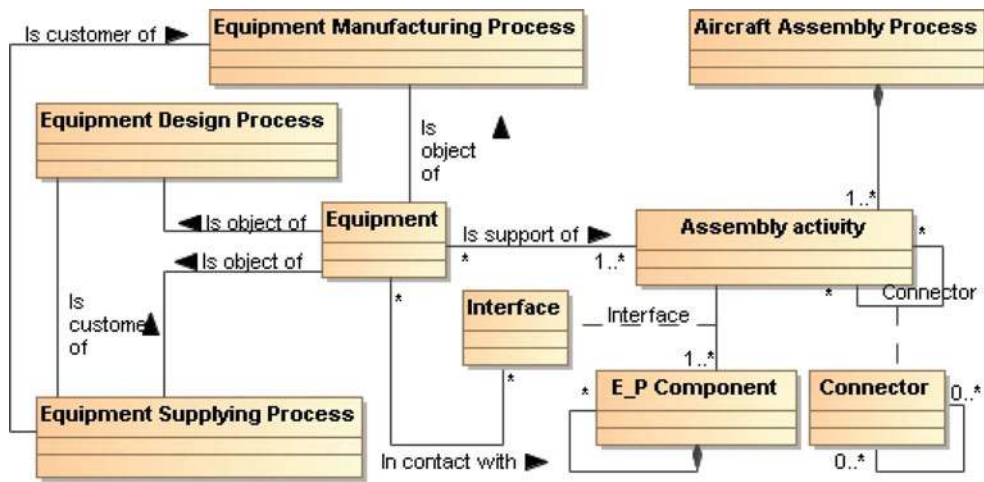


Fig. 8 Relations between processes and products

- What kind of product information (concerning both equipment and aircraft part) are needed to fulfill each activity of the aircraft project and the aircraft project?
- And, what is the relation between equipment information and aircraft part information that is necessary to consider in each process?

These previous considerations make easier the data flow organization by importing only the necessary product information from the good sources and submit it only to the concerned persons in the organization in the context of multi-firms partnerships.

In the present approach, the concept of specific role is used to integrate the response of the two first questions in the Meta-models. Figure 8 presents a partial view of the generic meta-model structuring the relations between processes and products. It focuses on three processes and on the relation between the assembly process and products definition.

The aircraft assembly process is composed of numerous assembly activities. Each activity acts, at least, on one aircraft part by transforming their properties (drilling, stamping, etc.) or by bringing together two or more parts. According to the situation concept, the assembly equipment plays the role of support in the fulfilling of these activities. The relation between the assembly activities, the assembly tool and the aircraft part is described through the association class “interface”. The aircraft assembly process is composed of a set of assembly activities.

6 The process view

The following activity diagram (Fig. 9) describes the interaction process during the creation of a new project. At the

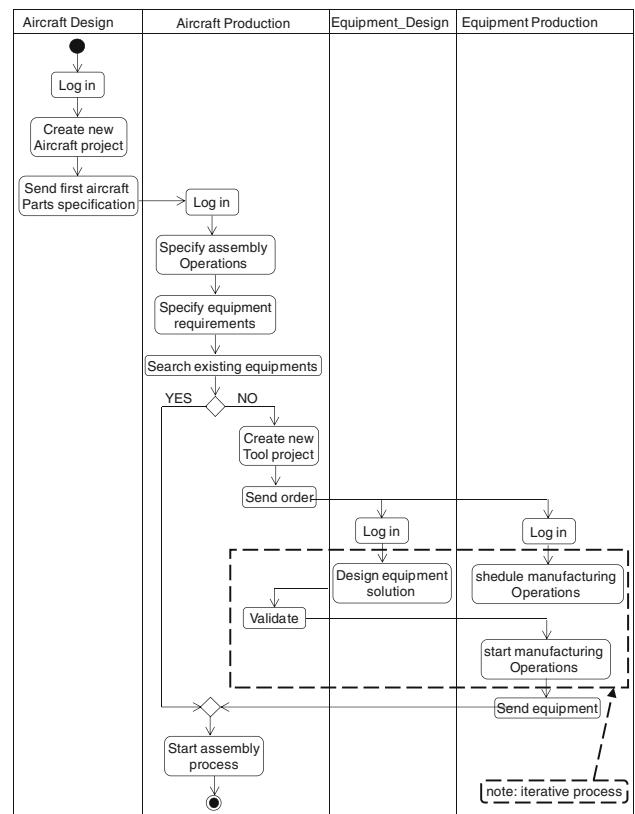


Fig. 9 Scenario of creating new equipment project

beginning, Aircraft R&D creates a new project and sends initial specifications to the production department. It defines the different operations of the assembly process and specifies the functions of the assembly tool to be performed. If no tool is founded, production department creates new equipment sub project through the situation framework and sends

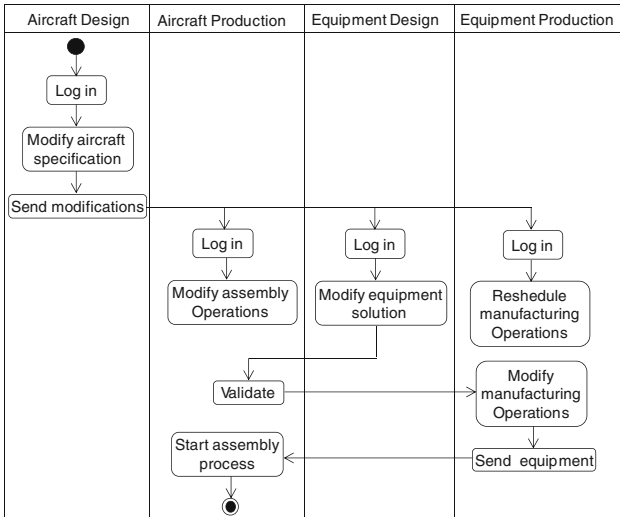


Fig. 10 Scenario of modifying requirement

information to the supplier network (equipment R&D and equipment manufacturing).

In fact, the real process is established in concurrent way. When, the equipment R&D starts the design process, manufacturing service simultaneously schedules the manufacturing operations and researches the available technological solutions.

When a definition change in the aircraft structure occurs, the system notifies the members of the business partnership and sends him the new requirement to consider in the specification of the related assembly tool. Figure 10 presents the interaction process for this case.

7 The product view

At the methods and process level, the product model is a core discipline of PLM as it structurally connects items and information of the product. It ensures the semantic interoperability and facilitates the connection between PDM systems (of both aircraft part at the OEM level and the equipment at the supplier level). The state evolution of this product and the technical solution adopted for the studied product are saved in the product model (Fig. 11).

According to the integration strategy, the interface between products data (Aircraft and equipment) is based on a common product meta-model. This meta-model is based on the “Function–Behaviour–Structure” (FBS) modelling approach [29,30]. The FBS approach gives a global framework to describe the product through its functions, structure and behaviour. The aim is to integrate all product data throughout its lifecycle.

Figure 11 shows the proposed structure of the product model that might be available for both the aircraft and the equipment. The product state evolves according to various life situations. Each situation exploits specific product data (structural data for the design, etc.) and generates some constraints to be resolved in the final solution.

In the proposed model, the product data are structured according six sub-models covering different phases of the product lifecycle (development, production, delivery, etc.). Each kind of data is stored in a specific form of documents (drawings for the structural model, etc.):

- *Functional model*: includes the different functions of the product (service and technical functions).

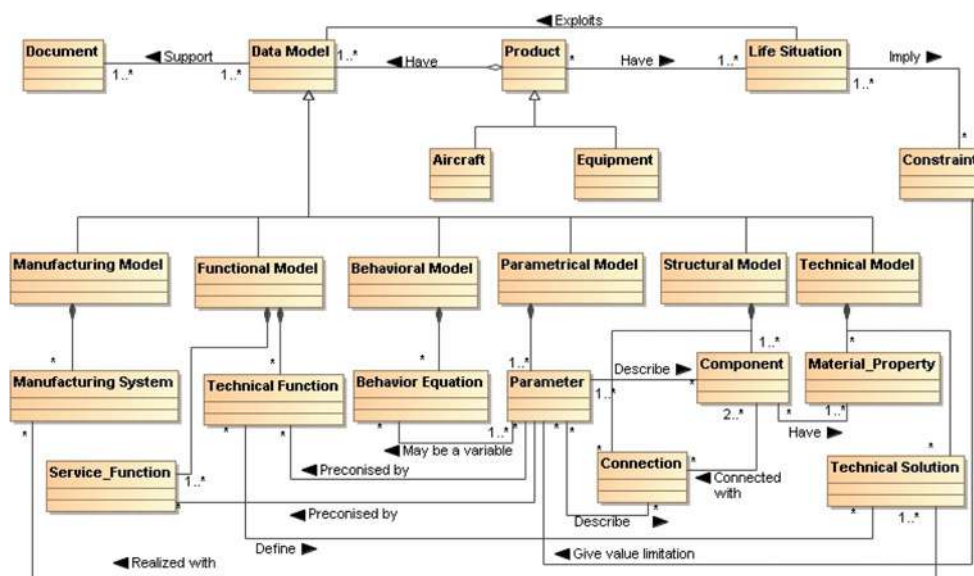


Fig. 11 The Assembly tool model

- *Behavioural model*: provides a formal definition of the required solution regarding the technical function needs and, allows simulating the system functioning.
- *Structural model*: Describes the structure of the equipment. It is composed of a set of components related by a set of physical connections.
- *Technical model*: is composed of a set of possible technical solutions that can satisfy functions and various constraints generated by different life situations.
- *Parametric model*: completes the definition of the product architecture. The class “parameter” can be a variable of the behavioural model (input or output).
- Manufacturing model includes information about methods, technology and type of systems that are necessary to manufacture the favourite solutions.

8 Conclusion

This paper has presented a modelling framework to support, at the conceptual level, a new PLM-based approach that improves information sharing in collaborative design. This approach aims at enhancing the integration of the supplier in the design and manufacturing processes. The new business partnership implies to establish new collaboration strategy between OEM and supplier.

The developed framework deals with the integration of Product, Process and Organization dimensions of a design project, and, in future works, the corresponding extension of existing CAD/CAM and PDM systems. The proposed Product model gives the structure of the product data base. It uses a generic semantic that can favour, in our sense, the conceptual interoperability between different product data coming from different partners.

The proposed approach may imply important evolutions in the current configuration of the development process that can be summarized by considering the shift from a linear and sequential process to a much more “collaborative” one. This reconfiguration should lead to significant improvement in cost and time saved in association with a greater innovative potential. This leads to consider the new role of the suppliers, not only as an efficient manufacturer, but more as partner, collaborating in different product development project stages.

On one hand, horizontal collaboration will be more improved by the mean of a “back office” interface that gives to suppliers the possibility to share their knowledge and to get a common representation about the project evolutions. Thanks to the collaborative back office, the specification and manufacturing of the assembly equipment are performed progressively and jointly by different departments of the global supplier Network (GSN). For instance, when, the engineering department starts the design process of the fixture equipment,

manufacturing department might simultaneously schedule the manufacturing operations in order to optimize the production process. Furthermore, during the whole development process, engineering department can inform progressively the production department and other furniture suppliers about the bill of material structuring the equipment, in order to reduce the purchasing time.

The use of a modeling framework based on the generic concepts of entities and interactions in the working situation may give more interests. It may favor applicability of the approach to deal with various problematic which concern the integration of the supplier by the means of the PLM systems.

Further research work will be performed to improve and validate these different issues. The interoperability mechanism based on the proposed conceptual approach ensures the communication between PLM, OEM and suppliers IS. Based on the proposed conceptual specifications, various functions are proposed by the PLM and might be reached through interactive processes. For example:

- *Track the project progress*: The project coordinator gets more visibility about the GSN Workload and the OEM assembly planning. He can take into account these constraints when he schedules the equipment project. For this function, the PLM system extracts planning information from different partners’ IS and aid coordinator to schedule the equipment project.
- *Product data interfacing*: the OEM defines on his own system the assembly activities and the references of concerned product components. However, to fulfill the equipment developments operations, the GSN members should get some information about the OEM product (structure, geometry, materials, etc.). Based on the meta-model structuring the relations between processes and products, the PLM system extracts from the OEM system only the relevant and authorized aircraft data.
- *Collaborative project management*: The PLM system might also play the role of mediator between different partners. GSN users download the equipment order with their associated requirements, and upload the different documents defining the corresponding equipment. The PLM system notifies the partners about the evolutions of both aircraft and equipment projects. At the end of the project, OEM validates the reception of the equipment.

Acknowledgments This work is partly supported by the Picardie Regional Council (France), the Regional Direction of Industry, Research and Environment and the European Regional Development Fund for European territorial cooperation. The research project involves the ESIEE Amiens, the Université de Technologie de Compiègne and three French SMEs (PRODESS, STIM-SUPEC and DeltaCAD). Particular thanks are addressed to these companies for their professional implication in the research project and for their contribution to a great part of the project costs.

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