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## A solution for actors' viewpoints representation with collaborative product development

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**Abstract:** As product complexity and marketing competition increase, a collaborative product development is necessary for companies which develop high quality products in short lead-times. To support product actors from different fields, disciplines, and locations, wishing to exchange and share information, the representation of the actors' viewpoints is the underlying requirement of the collaborative product development. The actors' viewpoints approach was designed to provide an organisational framework following the actors' perspectives in the collaboration, and their relationships, could be explicitly gathered and formatted. The approach acknowledges the inevitability of multiple integration of product information as different views, promotes gathering of actors' interests, and encourages retrieved adequate information while providing support for integration through PLM and/or SCM collaboration. In this paper, a solution for neutral viewpoints representation is proposed. The product, process, and organisation information models are seriatim discussed. A series of issues referring to the viewpoints representation are discussed in detail. Based on XML standard, taking cyclone vessel as an example, an application case of part of product information modelling is stated.

**Key words:** Viewpoints, multidisciplinary collaboration, exchange information, product and process information, product lifecycle management.

### 1- Introduction

The development of a successful product is achieved through the cooperation of various actors' teams and utilization of an amount of different resources existing in various disciplines, organisation and locations. As the complexity of products and market competition increase, a collaborative product development framework is necessary for product engineers developing high-quality products in short lead-times [BW1, VT1]. In this logic, various actors coming from different fields, disciplines, and locations are required to collaboratively

develop a product efficiently. To support this collaborative work process, it is necessary to exchange and share information among product developers. The exchanged and shared information must be understood by various actors without any ambiguity even if they come from different industries or disciplines. Hence, common, neutral viewpoint/knowledge representation is required to help actors to capture/retrieve the adequate exchanged/shared information following their perspectives/objectives on the collaboration, because each actor depends on his own experiences/knowledge and interpret differently the same information on the product. To apply it, a universal information models are necessary to assure all actors within the whole collaborative product development process can clearly understand it.

In multidisciplinary collaboration, the actors express their interests (activity's focus) using a variety of conditions and/or representations, and follow different processes to deploy and extract those representations. Such multi-perspective product development embodies a number of characteristics that continue to be positioned in the core of organizing the product development activity. These characteristics include the need for gathering of actors' interests during product lifecycle phases following their points of view. The multiple comprehension of the information of processes and products, and the need to reason analytically over multiple views, permit to understand the properties and consequences of the multiple-viewpoint definitions of the actors. In other words, the viewpoints approach must define the specific information needed by each actor following his interests on the product/process.

To assure that the collaborative framework can be utilized by all actors, it must be based in two important layers: i) neutral base-level information that is independent of any application from respective collaborators, and ii) representation of the actors' viewpoints which represent their knowledge and can help them to retrieve the adequate information following their personal objectives in the collaboration.

In this paper, we focus on proposing the multiple viewpoints approach to organise and manage the exchange and sharing of product/process information between actors. The paper reviews two main viewpoint definitions (viewpoints on systems' specification, product design views). The paper presents the product-process-collaboration-organisation model as base-level modelling. The paper describes the use of explicit relationships between viewpoints to manage information extraction on the product development. An example has been given to illustrate the proposed approach.

## 2- Literature review

In the literature, a lot of studies focusing on knowledge representation and product modelling during collaborative development process have been investigated [K1, ST1, ZL1]. However, most of them emphatically address only a part of the entire issue of product modelling. And, up until now, few papers have synthetically investigated product information modelling based on the users' points of view on a large-system, from an application system in which the product information models are used to description of product information models.

Based-on existing literature, we can state that is difficult to find a general definition of "viewpoints" in the collaborative product development area; however, there are a lot of definitions related to the Requirements Engineering (RE) and Concurrent Engineering (CE).

One of the known viewpoints framework is the Reference Model Open Distributed Processing (RM-ODP) [I2]. The RM-ODP defines a holistic framework for the specification of all distributed systems. In order to deal with all aspects and complexities of such systems, the reference model defines five different abstractions – referred to as viewpoints – from which distributed systems may be modelled: *information, organizational, computational, engineering, and technology*. These viewpoints are sufficiently independent to simplify reasoning about the complete specification of the system; they are also generic and complementary. They enable different abstraction viewpoints, allowing actors to observe a system from different suitable perspectives [I3]. One of the main benefits of RM-ODP is that, as opposed to other approaches – as IEEE standard 1471 [I1], the "4+1" view model [K2], or the Zachman's framework [Z1] – it provides precise definitions of a system of interrelated concepts rather than some, often imprecise, description of isolated ones.

Among ODP viewpoints, we are here interested in the information viewpoint which is related to the information modelling. An information specification defines the semantics of information and information processing in an ODP system, without having to worry about other system considerations, such as particular details of its implementation.

Rivière [R1] considers "Viewpoint" as a polysemous word, i.e. its definition depends on the context of use. She defines a viewpoint as "*a perspective of interest from which an expert examines the knowledge base*". It is a general definition that can take several interpretations in different domains of application. She proposes an extension of the conceptual graph formalism to integrate viewpoints in the support and in the building of conceptual graphs. Where the viewpoints allow her to define the context of use and the origin actor of concept

types introduced in a graph. The aim of her proposal is to define viewpoints to help knowledge representation with conceptual graphs for multi-expert knowledge acquisition and also to have an accessible and evolutive knowledge base of conceptual graphs through viewpoints.

Other viewpoints definitions have been given for Garlan [G1] *a viewpoint can be defined as a simplifying abstraction of a complex structure... suppressing information not relevant to the current focus*; and for Easterbrook [E1] *a viewpoint represents the context in which a role is performed*.

From the product views side, Hoffman [HJ1] proposes a mechanism for maintaining consistent product views in a distributed product information database. In his work, a single repository called a "master model" in which all-relevant product data resides was proposed for the integration of different product information domains, while the other views of the product must be updated to maintain consistency. Thus, Bronsvort [BN1] proposed a multiple viewpoints feature modelling approach to allow a designer to focus on the information that is relevant for a particular product development phase. His system supports conceptual and assembly design, part detail design and part manufacturing planning by providing their own view on a product for each of these applications.

The scope of the presented works mainly deals with the integration of a domain point of view (e.g. design) for all actors, and the generation of the product views according to the actor's objective. However their limitation is that none of them integrate the interests of the actors within different product lifecycle stages, such as the extraction/retrieve of adequate information. In multidisciplinary collaboration, the actors need to integrate their viewpoints on the product along its lifecycle stages, where they also need to retrieve important information within different stages according to their interests.

Among the previous definitions, we think that Rivière [R1] and Easterbrook [E1] are nearing adapted to the product lifecycle collaboration area. However, we need to improve viewpoint solution by adopting the adaptation of actors' knowledge/information within product lifecycle and supply-chain collaboration.

Based on previous studies on issues of collaborative product development process [GB1, GO1], this paper attempts to contribute to defining a solution for actors' viewpoints representation, where we propose an approach that makes connections with product, process, and organization information for a complete interaction between multidisciplinary actors. To give an appropriate definition of multiple viewpoints actors, we situate the actors under different views (product, process and collaborative supply chain organization). In the next section, we define our notion of viewpoints and its interactions with the product/process information within a collaborative supply chain organization.

## 3- Proposed approach

In multidisciplinary collaboration, the framework must be characterized with following features:

- a base-level information model should contain enough information for various needs of the product

collaborators, i.e., the product information model should be based on the whole lifecycle of the product to assure it contains complete information meeting the various demands of all actors in all product development stages.

- actors' viewpoint should represent the actors' knowledge and interests on the product collaboration which permit to help them to seek, extract, exchange, and share the adequate information. In a word, a whole-life-cycle product information model with neutral viewpoint representation is necessary to support collaborative product development.

### 3.1 – The information models

In a previous study [GB1, GO1], we defined an information model called PPCO (Product–Process–Collaboration–Organization information model) based, especially, on the collaborative and project options, this study is inspired 50% from [GR1] and [NR1] where they propose the Product–Process–Organization model (PPO). The PPCO provides a base-level information model that is open, extensible, independent from any product development process, aiming at capturing the engineering and business context commonly shared in product development (Fig. 1.).

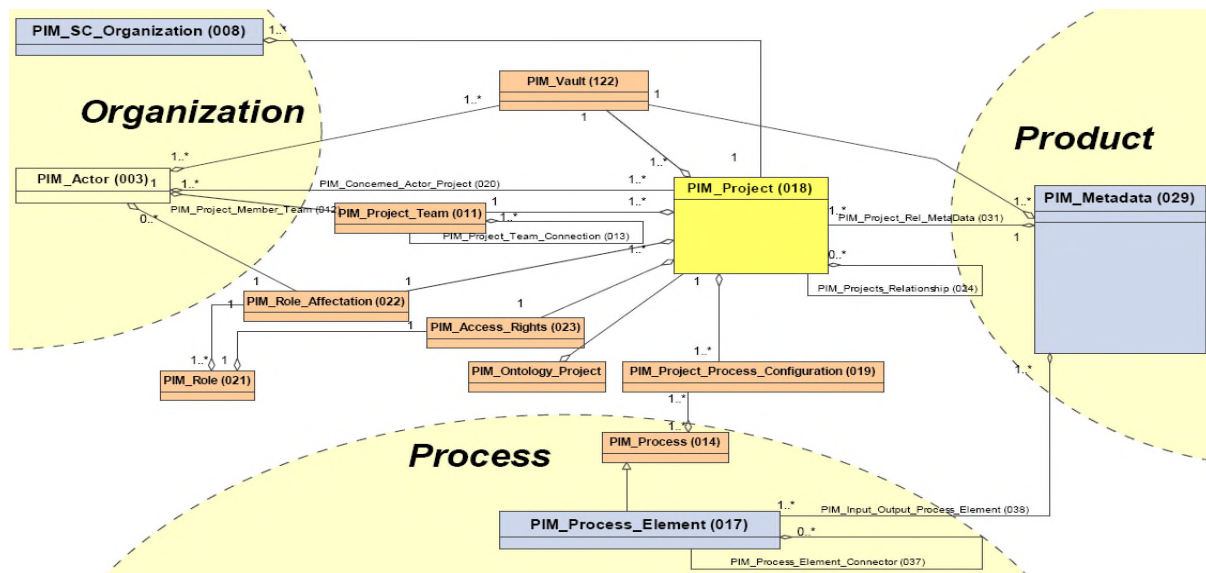


Figure 1: The PPCO Model.

The PPCO model is based on the four elements stated previously: product, process, collaboration and organization.

- Product:** the architecture of the product is defined not only by the decomposition of the final product into components, functions, behaviours, etc, but also by the interactions between all these components. The interactions may include well-specified interfaces and undesired or incidental interactions (Fig. 2).

- Organization:** the organization structure determines who works with whom and who reports to whom. However, in supply chains organization we are particularly interested in the study of the communication patterns between the actors conducting the technical development work, and the classification of the actor's competences following the integrated collaboration's domains (Fig. 3).

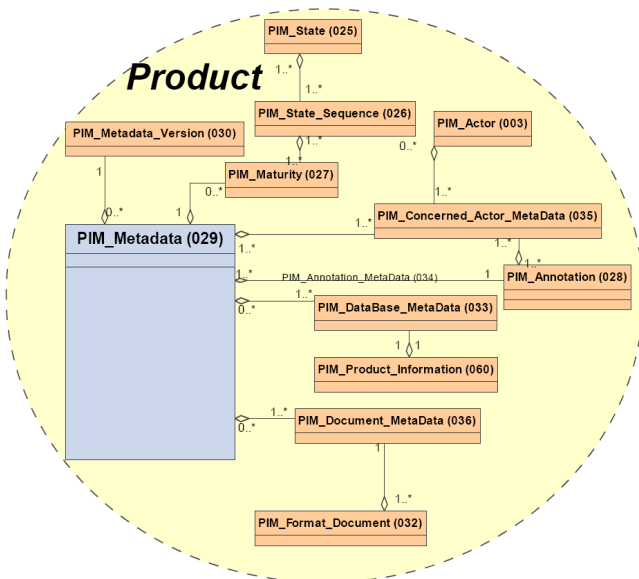


Figure 2: The Product Model.

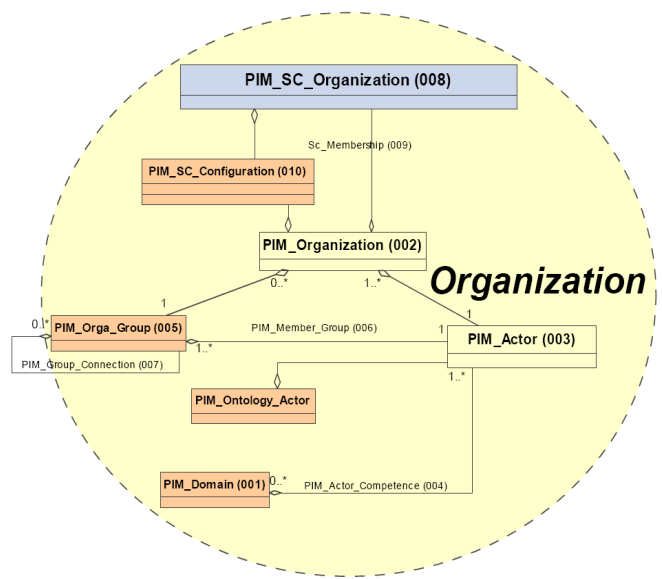


Figure 3: The Organization Model.



situation; *iii*) the **Viewpoint\_Relationship** concept indicates the different interactions between actor's viewpoints, where the viewpoint information will be compared and gathered in one global information-set, and will be used for filtering actions; *iv*) the **Viewpoint\_Objective** concept is described by a focus which defines the actor's objective according to it's activity objective and the viewpoint domain of the objective's activity. Figure 5 shows the different relationships between the four concepts of viewpoint.

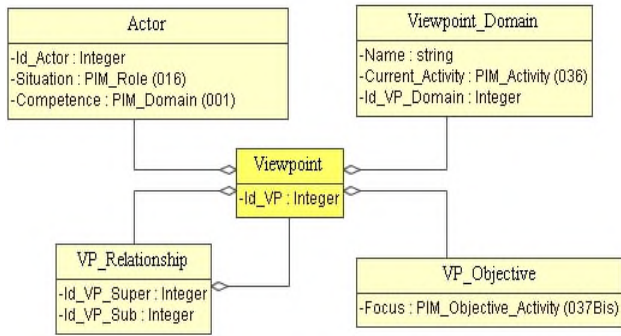


Figure 5: Viewpoint definition.

3.1.2 –Algorithm for the criteria filtering

In the table 1, we present one of the main information filtering algorithms. The filtering action consists in retrieving the appropriate information for a particular actor, according to his "viewpoint" on the product. Also it permits to combine all viewpoints and adapt the found information. However, the actors can carry out modifications, according to their rights, on the recorded information. For each modification, the actor submits his update which will be temporarily saved in the database of the PPCO model, and annotated to all actors concerned by this change. This update will take effect after approval of these concerned actors.

```

Program filtering_info_artifact (In: Artific#, Actor#,
                                Out: List_connexion_batch_info)
Begin
// 1st step: Restitution of all actor's viewpoints
Restitution_list_viewpoint(In: Actor#; Out: List_vp_actor);
// 2nd step: Filtering of viewpoint on current artifact
Filtering_list_vp_artifact(In: List_vp_actor, Artific#; Out: List_vp_actor_prod);
// 3rd step: Viewpoints classification by level of competence
              (decreasing classification)
Classification_vp(In: List_vp_actor_prod; Out: List_vp_class);
For i = 1 to size(List_vp_class) Do
// 4th step: Restitution of information batches and the expertise level for
              each viewpoint using the focus activity and level competency.
Restitution_list_connexion_level(In: List_vp_class;
                                   Out: List_connexion_level_vp);
// 5th step: Update of the list of information batches and its level of use
If (i>1) Then
    Optimize_list_connexion_level(In: List_connexion_level_vp;
                                   Out: List_lev_vp_prebious);
Else
    List_con_lev_vp_previous = List_connexion_level_vp
End_If
End_For
List_connexion_batch_info = List_connexion_level_vp;
End
    
```

Table 1: Algorithm of information by actor's viewpoints.

4- Example

To illustrate the proposed approach, we present an example about a closed pack cyclone vessel. In the next sections, we present the three models, product structure (or decomposition), process development, and the development of the supply-chain organization. Figure 9 shows examples of two viewpoints of the same actor of the information restitution.

4.1 – Product structure example

Figure 6 shows a model representing the decomposition of a closed pack cyclone vessel into 18 components. The product architecture and the interactions between the components are documented and detailed in this model (not presented in this paper). 38 interactions were identified according to a classification related to space, energy, material, and other information.

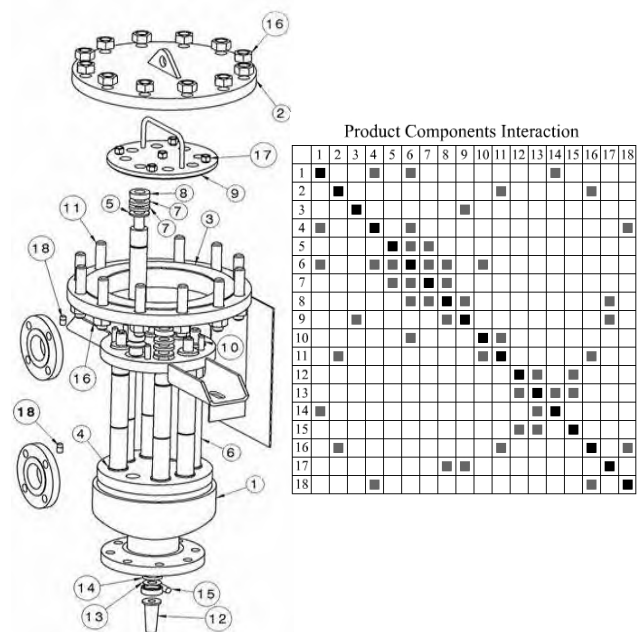


Figure 6: Cyclone vessel structure.

4.2 – Development process example

Figure 7 shows a tree illustrating the procedure followed by a vessel manufacturer to determine the feasible layout of the customer requirements of the closed pack cyclone vessel. This is based on a digital model using CAD solid models. Interactions in this type of model represent flows of information and data between the tasks of the activities (in this example, we consider that every process has only one activity).

4.3 – Supply-chain organisation example

Figure 8 shows the decomposition of the supply-chain organization used to develop a new cyclone vessel project. The organization involves 3 teams; each team has a responsibility for a major component. The given matrix depicts the interactions across the 3 teams in terms of frequency of their required collaboration.

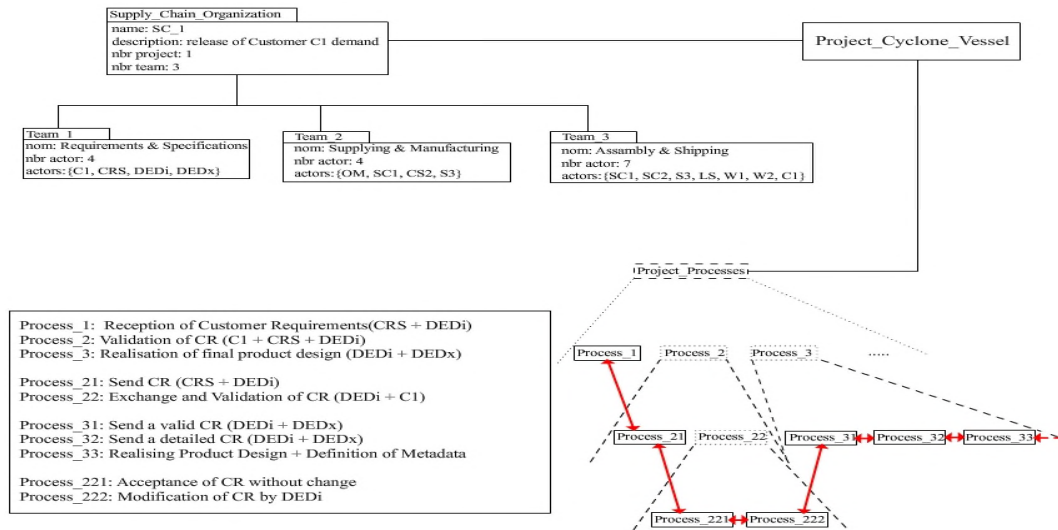


Figure 7: Part of the process development.

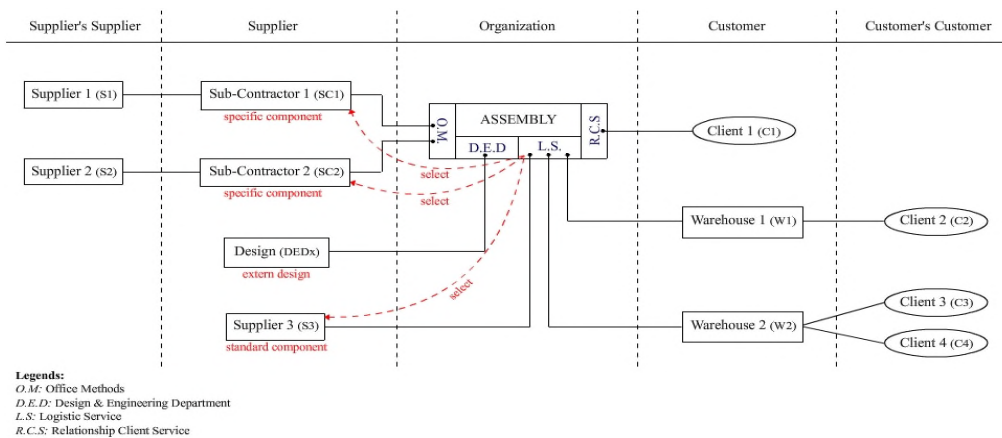


Figure 8: Development of the supply-chain organization.

4.4 – Information restitution by viewpoint approach

Let's take the example of an actor "ActorX" integrating the supply chain organization into the team 1 as an external designer. He has two focuses on the product "cyclone vessel", the first as **shape global design**, and the second as **mechanical design** (Fig. 9). The actor's objectives are related respectively to the activity on geometry and mechanic tasks. To retrieve the adequate information for the actor "ActorX", we need to filter and classify the information following his interests. After this step, the framework compares the information of each

viewpoint (Tab. 2) and gives the sets of adequate information to the actor following his focuses on the product and his activities in the project. Based on the level's batch definition, the system regroups the batches with high-level hierarchy, and retrieves the information which is more adequate to the actor according to his focuses and activities [GB1]. Figure 10 shows part of the generated XML file of the retrieved information, the actor "ActorX" can use/reuse this information.

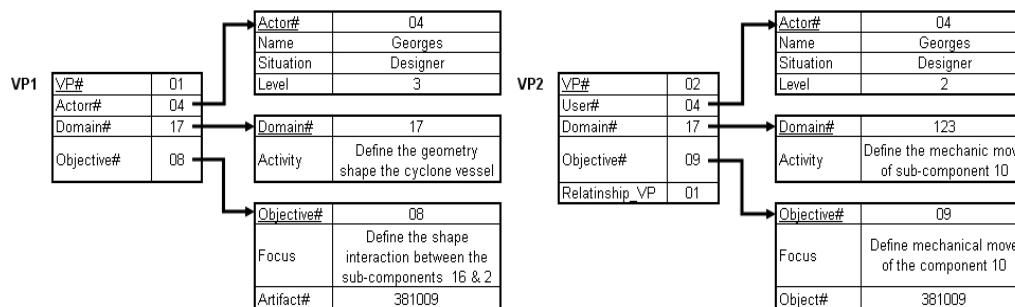


Figure 9: ActorX viewpoints.

<p>VP# = 01</p> <p><u>Batch (Level):</u></p> <p>Artifact (1) : Standard Information about the product                  Function (2) : Different function of the final-product and sub-artifact                  Behavior (2) : Different behaviors of the final-product and sub-artifact in relation with their respective functions                  Flows (2) : Different flows of the final-product functions                  Geometry-Form (1) : All information about the detailed-geometry with a CAD model                  Sub-Artifact (2) : Different information about the second level of direct-component assembly                  Assembly (2) : The relationship with Sub-Artifacts                  Constraints (1): All constraints of the product (design, assembly...)                  Requirements (2) : Requirements about the product and different phases of its lifecycle                  Group (1) : All information about actors of collaboration-team                  ...</p>	<p>VP# = 02</p> <p><u>Batch (Level):</u></p> <p>Mechanic (1) : All information about the mechanic application of the product (see activity of VP09 and VP08)                  Artifact (2) : Standard Information about the product                  Function (2) : Different function of the final-product and sub-artifact                  Behavior (2) : Different behaviors of the final-product and sub-artifact in relation with their respective functions                  Flows (3) : Different flows of the final-product functions                  Geometry-Form (2) : Different information about the geometry with a CAD model                  Sub-Artifact (3) : Different information about the first level of direct-component assembly                  Assembly (3) The relationship with Sub-Artifacts                  Constraints (1) : All constraints design of the product                  Requirements (3) : Requirements about the product and different phases of its lifecycle                  Group (1) : All information about the actors in the group                  ...</p>
---	--

Table 2: Results after the information filtering by the actor's viewpoints.

```

<?xml version="1.0" ?>
<DRP xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="C:
<Artifact>
  <One-Artifact>
    <id_artifact>381009</id_artifact>
    <name>Cyclone Vessel</name>
    <class_name>ARTIFACT</class_name>
    <properties>See Properties N° PR012</properties>
    <methods>See Methods N°MT002</methods>
    <documentation>See Documentation N°DOC055</documentation>
    <description>Industrial Closed Cyclone vessel</description>
    <created_by>Michel</created_by>
    <creation_date>Sat Nov 12 07:34:44 EET 2005</creation_date>
    <last_update_by>Michel</last_update_by>
    <last_update_date>Sat Nov 12 07:34:44 EET 2005</last_update_date>
    <type>-732469182</type>
    <is_complete>No</is_complete>
  </One-Artifact>
  <Sub-artifact>
    <id_sub_artifact>3011010</id_sub_artifact>
    <name>CP Vessel Body</name>
    <class_name>ARTIFACT</class_name>
    <properties>316L Stainless Steel</properties>
    <methods>No methods</methods>
    <documentation>No documentation</documentation>
    <description>Gudgeon Pin Group 1 debug</description>
    <created_by>Jean</created_by>
    <creation_date>Sat Nov 12 07:32:27 EET 2005</creation_date>
    <last_update_by>Jean</last_update_by>
    <last_update_date>Sat Nov 12 07:32:27 EET 2005</last_update_date>
    <type>-732469187</type>
  </Sub-artifact>
  <Sub-artifact>
    <id_sub_artifact>5010120</id_sub_artifact>
    <name>CP Vessel Cover</name>
    <class_name>ARTIFACT</class_name>
    <properties>316L Stainless Steel with Lifting Eye</properties>
    <methods>No methods</methods>
    <documentation>No documentation</documentation>
    <description>Piston Ring Set</description>
    <created_by>Jean</created_by>
    <creation_date>Sat Nov 12 07:26:12 EET 2005</creation_date>
    <last_update_by>Jean</last_update_by>
    <last_update_date>Sat Nov 12 07:26:12 EET 2005</last_update_date>
    <type>-732469183</type>
  </Sub-artifact>
  <Sub-artifact>
    <id_sub_artifact>30141280</id_sub_artifact>
    <name>Casket 14" </name>
    <class_name>ARTIFACT</class_name>
    <properties>Thick Custom cut for 10" (250 mm) 150# ANSI Flange, Gylon Blue 3504</properties>
    <methods>No methods</methods>
  </Sub-artifact>

```

Figure 10: Part of the generated XML file.

**5- Conclusion**

Multidisciplinary collaboration is a complex domain, in which all the actors need to exchange and share product and process information. In fact, product information generated by each actor is communicated to all actors in order to integrate them in a shared representation. Knowledge about actors' preferences, methods, etc. and about actors' focuses, constraints, objectives, etc. must be taken into account to manage information extraction.

In Multidisciplinary collaboration, the use of viewpoint in the structured collaborative product development shows how the viewpoint notion can provide real help in the extraction, treatment and consulting of adequate product/process information. The proposed viewpoint description and multi-level management approach aim to structure the actor's focuses in multidisciplinary collaboration thanks to a more accurate characterization of the viewpoints, which allows an intelligent indexation of the product/process information.

In this paper, we have presented our Product, Process and Organisation Models, from the PPCO model, developed in previous studies, the Collaboration Model, is not presented in this paper, but it defines the different strategies/methods of collaboration between the actors in-side the Supply Chain and in the different activities of Project Processes. The originalities of the PPCO model are: i) the integration of the Supply Chain world into the creation of the collaborative product information during the product lifecycle, ii) the opening of the product metadata model, which can integrate any existing product data model, like as the Core Product Model [SF1], and iii) the inter-connection of the model with the viewpoint approach to facilitate the information extraction and exchange between actors.

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