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INTEGRATING LCA WITH DESIGN TOOLS (PLM, CAD)

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ABSTRACT

One of the barriers to green product design remains the cost to collect or to share data between Design and Environmental Design tools. The proposal is to favor sharing data between Environmental Design and Design activities, integrating the Life Cycle Assessment [LCA] tools with the Product Life Cycle Management [PLM] tools.

Three software prototypes will be presented based on the ENOVIA v6 PLM platform (by Dassault Systèmes) and Simapro, openLCA and the ReSICLED recycling tool. The options for the interface implementation, the data pattern mapping and the materials and processes reconciliation between PLM and LCA databases will be detailed with the benefits to support "Design for Environment" use cases and business scenarios. Perspectives of that work will be discussed.

INTRODUCTION

Current acute environmental challenges require that preventative approaches to environmental pollution be urgently deployed into day-to-day practices within manufacturing industries. Interconnecting Environmental Assessment tools with design tools, such as Computer Aided Design (CAD) and Product Lifecycle Management (PLM) tools, used for designing products based on "Life Cycle Thinking" is one of the emerging challenges that design software companies like Dassault Systèmes have to face.

The crux of this problem is not as simple as extracting the product CAD digital structure from a CAD Tool, i.e. the product "Bill of Materials" with all the Materials of the Parts, the corresponding weights, and other properties like Surface (for coating treatment) or the associated packaging, in order to send them as inputs into environmental assessment tools.

Efficient product stewardship requires that product and environmental information is shared among the design stakeholders and along the product design process. To address this issue, new concepts for design tools have been defined. A new product data model based on the triplet Product-Process-Resource (PPR) linked to the Product Lifecycle Phases has been proposed and is used to facilitate data mapping and exchange.

Different levels of Information and Communication Technology (ICT) interconnections between design tools and environmental assessment tools are proposed to support various business scenarios and the tool capabilities.

This paper describes three software prototypes implemented in the context of the GIPIE2.0 project, started in September 2010 and ended in November 2012, by Dassault Systèmes, BIO Intelligence Service, G-SCOP laboratory, Pernexas and Green Delta, and funded by the Department for the Competitiveness of Industries and Services of the French Ministry of Economy (DGCIS), following the GIPIE project (2008-2010) whose first results have been described in (Jean-Pierre Theret, 2010).

METHODS

Environmental Design starts with the collection of the product features along its lifecycle: Material Weights, Chemical Substances and Recycling properties of Materials, Energy and Raw Materials flows, Waste scenarios, corporate or suppliers' Assembly/Dismantling scenarios. Many of these data are available in PLM or CAD systems and may be shared with Environmental Design tools. This data sharing may be implemented along two ways:

- Either Environmental Design modules are **integrated** into CAD or PLM tools;
- Or Environmental Design tools are **interfaced** with CAD and PLM tools to exchange the data and to return the results.

SolidWorks Sustainability was the first proposal by Dassault Systèmes on 2010 of an integrated solution with an environmental dashboard of four indicators (CML 2001 method) to be available real-time and on demand in the SolidWorks CAD tool.

Because many other Manufacturers have started their Environmental Design studies with professional tools, like SimaPro, GaBi or EIME, the “interface” way between the ENOVIA PLM system and those tools was investigated. Here, the mapping of Materials & Processes from different tools is the main issue. Two methods have been tested:

- An **inclusive mapping** (or one-to-many) has been implemented for the Materials between the ENOVIA PDM tool and the ReSICLED recyclability tool for Electrical and Electronic Equipment (EEE). This is feasible because the ReSiCLED Materials database contains a small count of Material Families grouped in Categories: Polymers (PE, PP, ABS…), Metal (Steel, Aluminum, Copper…), Components (cables, screens, batteries, PWBs…).
- An **extensive mapping** (or one-to-one) has been implemented for the Materials and Processes between the ENOVIA PDM tool and the PPR extension, and the EcoInvent2 database using the mapping file of the EcoSpold1 XML format.

Another issue comes when designing complex products with a large number of Parts: addressing all the Parts individually is not possible, because it would be very time-consuming. Two approaches have been implemented:

- **Part Family** and automatic inheritance of LCA model from the Family to the Part. This solution is based on the existing concept, Part Family, in PDM system; that means the Part classification is not an additional work.
- **Material Family**, in accordance with the inclusive mapping described above; here the Material classification is an additional work, but it is done only once and can be reused for several usages of the Materials.

RESULTS

Three prototypes have been implemented based on these methods:

1 - Easing data collection from PLM to LCA with ENOVIA to Ecospold1 export

Based on the ENOVIA Product-Process-Resource data pattern, a mapping between the ENOVIA and EcoSpold1 concepts have been established:

- All ENOVIA Products, Processes and Resources map with a Process in the dataset;
- Resources are used as Input and may be associated to an Input Group;
- Parts and Processes are used as Output and may be associated to an Output Group;
- Quantities are managed using the Part Quantity and Unit of Measure from the Product BOM, taking into account the Functional Unit ratio of the Processes and Resources.

Categories for Simapro 7.3 have also to be defined, to locate the imported data in the targeted folders. Possible choices depend on: the Product network for LCI: either BOM oriented, or lifecycle oriented; and the type of Categorization: close to the network, or a single Category per SimaPro process type.

A prototype with a lifecycle oriented network and a single category for imported datasets was implemented. The EcoSpold1 mapping file was not generated and had to be built manually. It should be enriched when new Materials or Processes are established in ENOVIA to find out the matching in the EcoInvent2 database. This eventually becomes a problem because the declaration sections have to be written manually. Future work should include a way to generate this file.

2 - Run LCA from PLM with the eLCA interface between ENOVIA and openLCA

Even LCA models available within LCA tools (SimaPro, GaBi, EIME…), may be difficult to use for complex products because the data exchange activity is time-consuming. A direct connection between the PDM system and the LCA tool may ease that.

The eLCA interface between ENOVIA v6 and openLCA 1.2.8 (Michael Srocka, 2012) was implemented based on Part Family and Material Family existing information in the PDM side:

- The LCA Product Systems are built in the LCA tools; here openLCA is considered. They are defined for a given dimension: weight, surface, energy, volume, length.
- Then in ENOVIA, using the eLCA connector, LCA Containers are created and refers one or several Product Systems for a given Part Family; one is the default. A Life Cycle Impact Assessment (LCIA) method is assigned to the Product System.
- Parts are assigned a Part Family according to business rules (supposed existing).

- LCA Containers are assigned to Part Families; then, their default product System is assigned to the Part; it can be changed for another one from the Container.
- Then an LCA calculation is run for all Parts with a Product System: according to their dimension, the relevant attribute are applied to the Functional Unit. The result is an environmental footprint with indicators according to the LCIA method.

The ENOVIA-openLCA interface was implemented by Pernexas using native Java API and new ones implemented by Green Delta in the context of the open source openLCA project.

3 - Compute recycling & recovery rates with ENOVIA-ReSICLED interface

The ReSICLED Material Classification was created using the ENOVIA format and applied to the Bill of Materials (BOM) of our test case: the "IDevice" cell phone.

The Out-of-the-box XML export capability of the ENOVIA PDM platform was customized to flatten the BOM tree structure (ReSICLED uses only flat BOM – two levels), to include the Material Classification for each Material using the ReSICLED Family Name and to comply with the custom XSD pattern defined by Dassault Systèmes and G-SCOP Laboratory.

This new XML export capability for the Part BOM has been successfully tested with the online version of ReSICLED (Damien Evrard, 2011) based on XML file. The web services were not yet ready for use with a direct connection between ENOVIA and ReSICLED.

DISCUSSIONS AND PERSPECTIVES

The prototypes were implemented at the end of the GIPIE2.0 project and were not yet tested by manufacturers. Deploying a new data model like ENOVIA PPR requires a data migration activity that is not always possible for former version of Information System. In this case, PDM tool may be connected to professional search engine dedicated to Environmental Data that can also solve the issue of the data collection activity required by the Environmental Design activity.

In addition to the Environmental Design tools, new collaborative practices and associated tools are needed to enable stakeholders from various organizations (Designers, Engineering Experts, Project Managers, etc.) to share their knowledge and to collaborate during the design and review of new Products / Processes / Resources with both a holistic view and different levels of details for each expertise.

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