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INTEGRATION OF PLM AND ERP SYSTEMS AT KONČAR – INSTRUMENT TRANSFORMERS

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1. Introduction

The primary driver for integrating Enterprise Resource Planning (ERP) and Product Life-Cycle Management (PLM) in most companies is productivity. It reflects on reduced redundant work, streamlined processes, eliminated quality problems because data is incorrectly represented, efficiency and speed [Brown 2009]. On the market exists suppliers which offer out-of-the-box integrate PLM and ERP solution (Oracle Agile PLM, SAP PLM, Infor PLM) or tools for an integration between several ERP and PLM solutions (IBM Web Sphere, Windchill Enterprise System Integration (ESI), **ENOVIA SmarTeam's Engineering Express (SNE) etc.).**

Such solutions require an encroachment into the structure of the system that is closed and therefore this method can not be implemented without the original manufacturer of software tools that enable the integration. Another drawback is that manufacturers themselves did not standardize interfaces for integration, making it very difficult process of integration. While these solutions are suitable for large companies because of high costs of implementation, small and medium enterprises (SMEs) can not justify such an investment in an integrated solution. Therefore, small and medium enterprises, as Končar - Instrument transformers, should take an individual integration between ERP and PLM systems.

Ninety percent (90%) of the companies that have integrated ERP and PLM exchange Bill of Materials (BOMs) from PLM to ERP [Jackson and Houlihan 2008]. Several BOMs are created during the product life-cycle: engineering BOMs (eBOM), commercial BOMs (cBOM), manufacturing BOMs (mBOM), service BOMs (sBOM) etc. The prerequisite for exchange BOMs from one system to another (data exchange) is to define key attributes that are identical in both systems. If values of key parameters are not identical, the errors that occur due to the inconsistent data exchange are often hidden deeply in the system and hardly recognized. Therefore the consequents of an inconsistent data exchange have far-reaching effects for a company.

To avoid errors before data exchange from one system to another, it is necessary to control a data. Data control should be performed on the parameters that will be exchanged from one system to another. While some parameters can be automatically controlled by the ERP and PLM systems, certain parameters can only be controlled by the creator of a parameter and that is a designer. The control of data only at the level of value is unreliable and requires huge attention of a designer. It is therefore necessary to provide quick and easy data control to a designer in order to avoid errors before data exchange. This leads that the integration between the systems-level is replaced with integration at the process level of data exchange between systems.

This paper describes the process of exchanging data from the PDM system to the ERP system as one way of ERP - PLM integration. Research questions that guided this study were: what are the minimum data required for integration, and how data can exchanged accurately and quickly?

2. Functional roles of PLM and ERP systems

Research on integration between PLM and other systems took a significant focus among academics. [Huet at al. 2011] conducted studies on the interaction between the PDM and Manufacturing Process Management (MPM) modules of a PLM strategy. [Ćatić and Malmqvist 2007] addressed the issue of integrating knowledge based engineering (KBE) and product lifecycle management. [Xu et al. 2007] proposed an algorithm of automatically transforming eBOM into mBOM. However, the basic prerequisite for achieving the PLM strategy is linking PLM and ERP systems.

The area of PLM is a vast area embracing many disciplines. CIMdata [Ćatić and Malmqvist 2007], [CIMdata 2006] provides the following definition of PLM: Product Lifecycle management is a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life – integrating people, process and information.

ERP is developed as a response to the islands of automation problems: companies have deployed a variety of independent software that was not integrated. This lack of integration caused major inefficiency in business, especially in the areas of supply chain management, which depends on the smooth and reliable flow of materials data from one functional area to the next. Without this integration, organizations can not plan and schedule resources correctly, leading to the over- and under- inventory parts and finished products, supply problems, production scheduling issues, order fulfilment and distribution problems, and so on through the supply chain [PTC White Paper 2011].

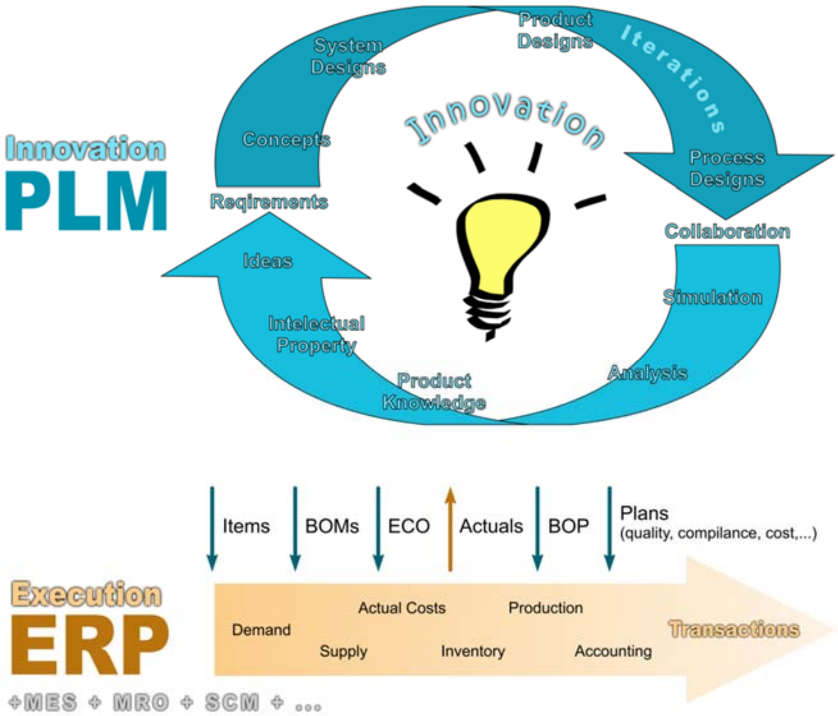

Figure 1. Innovation and execution cycle adopted from [Brown 2009]

The primary value of PLM comes from integrated business process and information. The flow of work and data required to manage a product through its lifecycle, however, are by their nature not as linear and structured as those addressed by ERP which focuses on transactions [Brown 2004]. PLM focuses on defining the intent of the product – both technically and commercially. ERP then helps plan production resources at a high level, accounts for material usage, plans inventory, manages orders, and accounts for the physical delivery of the product. In essence, PLM is the innovation cycle and ERP is the backbone for the execution cycle (Figure 1) [Brown 2009]. Since PLM fundamentally defines bills of materials it influences the efficiency of ERP and supply chain activities [PTC White Paper 2011]. eBOM as the end result of design process is the beginning for transactions in the ERP. Therefore eBOM contains the minimum data required for integration between PLM and ERP.

3. Bridging the gap between ERP and PLM integration

Why is it beneficial to integrate ERP and PLM system? [PTC White Paper 2011] stated it is because integration links together the critical upstream and downstream process and data between classically disparate user groups who work in different systems. Therefore the main questions are: What are the critical processes and which data is needed to exchange between these two systems?
The data which is exchanged between PLM and ERP systems are listed in the engineering bill of materials (eBOMs). A bill of material is a formally structured list for an object (semi-finished or finished product) which lists all the component parts of the object with the name, reference number, quantity and unit of measure of each component. The eBOM contains a list of components according to their relationships with parent product as represented on assembly drawing. [Xu et al. 2008] Reference number, name and unit of measure representing the basic attributes of the components because they represent a minimum set of data that uniquely defines each component.
The first question posed at the beginning of integration is: in which the system is the basic attributes first recorded? Are they recorded in the ERP or PLM system? ERP systems need to ensure uniformity of data and should not allow the redundancy of existing or new attributes of components. Unlike ERP, design process within the PLM system does not require capturing basic attributes of the components at the beginning of the process. Therefore the basic attributes is first recorded in the ERP system and afterward used in the PLM system.
During the design process in PLM system, basic attributes are augmented with additional attributes that describe in more detail components. These additional attributes are:

- characteristics
- raw material
- standard
- size
- mass
- description

The aim of integration is to obtain an identical eBOM in both systems. This can be achieved by the integration carried out on the data level or at the level of data exchange (process level).

3.1 Integration at the data level

Integration at the data level means that the eBOMs in both systems are synchronized. Synchronization implies that changes in one eBOM automatically trigger changes in other eBOM regardless of the information system in which the change first occurred. Creation of eBOM in the design process within the PLM system is not a linear process. It is rather an iterative process in which the deletion and insertion of parts or changes in the amount of material is a continuous process [Brown 2009]. As long as the components are not fully completed in the PLM, the existence of unfinished components in ERP does not mean the beginning of activity in the ERP. Therefore, the existence of unfinished components in the ERP is the first lack of integration at the data level.
Depending on experience of designers, pedantic and self-control, but also on subsequent requests from the customer, eBOM is possible to change until the product is in production. If there is a change in eBOM within the PLM same changes can not be automatically applied to eBOM in ERP because it is possible that certain ERP transactions already underway. An example of such changes which cannot be automatically implemented in ERP is the order cancellation. It can not be automatically implemented because it depends at what stage is the order. Some orders cannot be reversed because the supplier is almost finished with the order and cancellation is no longer possible. The scope of these changes is not always the same and therefore is left to manually implement the necessary changes.
The aforementioned disadvantages of integration at the data level contributed to the integration of Končar - Instrument transformers conducted at the process level.

3.2 Integration at the process level

After designer has finished creating the eBOM in PLM follows a verification of the component attributes in the eBOM with attributes stored in ERPu. Verification of the components is completed when the data from both components are compatible and followed by data exchange. Integration at the level of the process allows the designer to:

- Quick and easy comparison of data between two systems,
- If the data are not identical, rapid detection of inconsistent data
- Automatically exchange data from the PLM to ERP system after data verifications.

Exchange of information between PLM and ERP systems is carried out in the following steps:

- Verify whether all the basic attributes of the components used in the PLM eBOM are recorded in ERP
- Verify whether all the additional attributes of the components used in the PLM eBOM correctly completed
- Check the assembly version used in the PLM eBOM with the assembly version previously recorded in ERP
- Data exchange between the two systems after matching eBOMs

3.2.1 Verification of the basic components' attributes

Verification of the basic attributes occurs when eBOM from PLM is loaded and possible scenarios are:

- Basic attributes are not recorded into the PLM
- Basic attributes are recorded into the PLM, but are not recorded in the ERP
- Basic attributes are recorded into the PLM and ERP.

If the basic attributes are not recorded in the eBOM, then they should first record in PLM. This case happens when the designer forgets to enter basic attributes. Therefore, these data are shown in red in order to be immediately detectable. If attributes are recorded in PLM but not recorded in the ERP, they will be shown in yellow. Yellow color is used for incomplete data. The green color represents the attributes that are identical in the ERP and PLM systems. Using color to identify the level of incompleteness of the attributes in the eBOM allows designer a quick detection of the data (Figure 2). The designer does not need to pay attention to the value of the data but visually searches the colors which are used for the detection of data completeness.

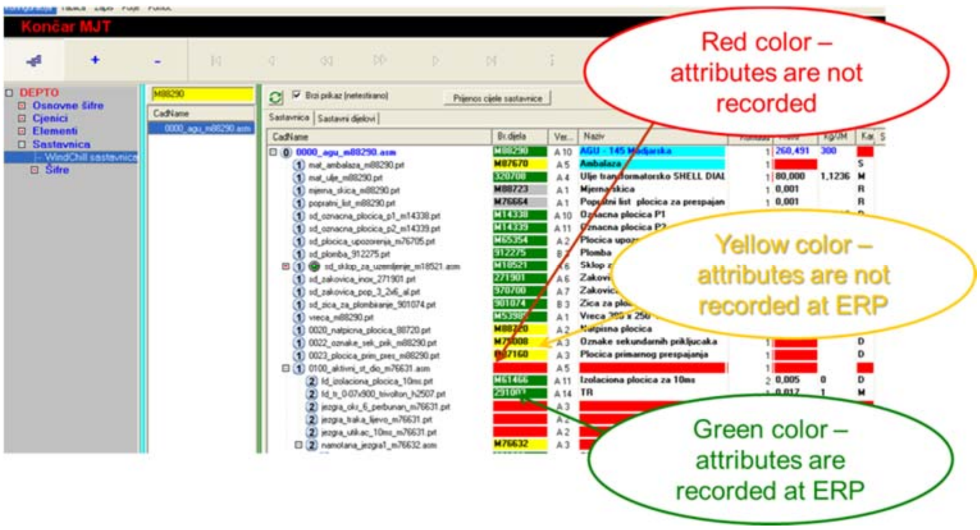

Figure 2. Visualization the completeness of basic attributes

In addition to these colors, additional gray color is used for visual detection. Components highlighted in gray are sub-components of an assembly which makes a supplier. Considering that suppliers deliver manufacturing companies assembly that is manufactured from components, manufacturing company receives in warehouse manufactured assembly, not the components of which the product is assembled. Because the ERP does not require information about the components of which the assembly is produced, these components are highlighted in gray, and they are not exchanged to the ERP.

3.2.2 Checking the additional attributes

After all the basic attributes of PLM identified and adjusted with the attributes in the ERP, it is necessary to verify whether the additional attributes are correctly entered in PLM. If additional attributes not entered, they must first be entered, and if they are already entered it is necessary to verify the compatibility of attributes between PLM and ERP. At this level color is used to identify the level of completeness of the additional attributes, too (Figure 3.). The red color is used to highlight data that are not entered in eBOM and yellow color identifies data that is not consistent between the PLM and ERP. Example of inconsistency of data is when the component is entered with one unit of measure in one system and in another system is the same component entered under a different unit of measure. These two units are compatible if there is a converter from one unit to another unit. However, if the converter does not exist, the value of the unit in which the component is entered in the PLM can not be converted into the unit under which the component is entered in the ERP, so we say that the data are not consistent. It is therefore necessary before data exchange to type converters in the ERP or change the measurement unit in eBOM.

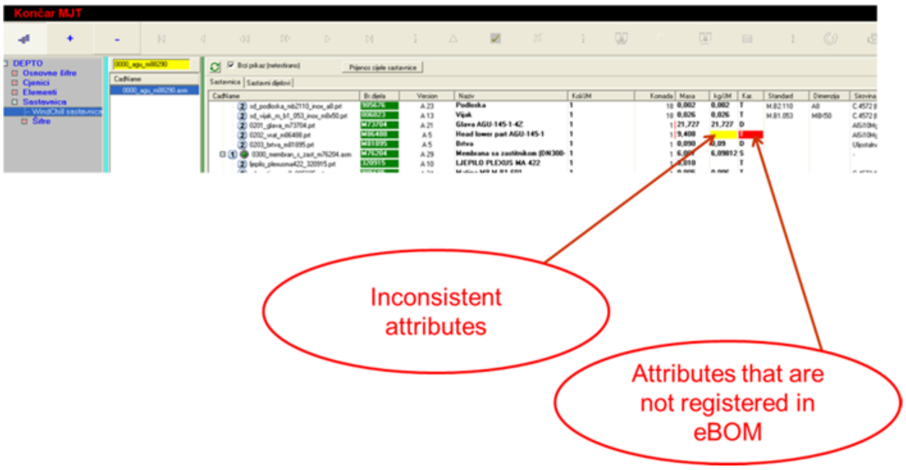

Figure 3. Visualization the completeness of additional attributes

3.2.3 Checking the version of an assembly

After checking the basic and additional attributes in the ERP and PLM, it is necessary to verify the version of assemblies in the PLM is the same with those that were previously recorded in the ERP.

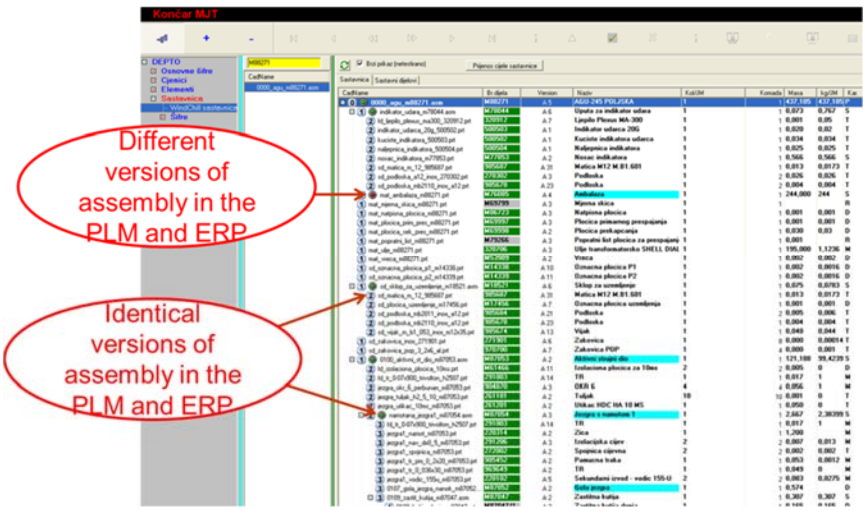

Figure 4. Visualisation of the assembly version

If an assembly version is recorded in the ERP and new product consists of new assembly version, the new assembly version should be exchanged to the ERP. Exchange assembly includes exchange and new relationships between superiors and subordinates components of the assembly. This fact requires that the ERP side contains information about the versions of assemblies used in the PLM. To display the same or different versions of assembly in the PLM and ERP, the visual signs are used in green and red color. The green color indicates that PLM and ERP used the same (latest) version of the assembly, while red indicates the presence of different versions of the used assembly.

3.2.4 Data exchange

After the basic and additional attributes, and version assemblies verified and matched in both systems, the data can be exchanged, which represents a last step in integration between the two systems at the process level.

4. Conclusion

For the vast majority of manufactures, the question should not he ERP or PLM but how to most effectively implement and integrate these two solutions. This paper presents one way of integration between PLM and ERP systems. It shows the integration as a process of exchanging data between two systems. The process of exchange data comprises four steps in which the designer, using visual inspections, quickly and easily detects data that are different in the systems. Once the data are consistent in both systems, the data exchange is performed.

The presented method does not perform automatic data integration, but in addition to the integration, is used as a support to a designer for verification of entered data, which gives additional value to this method of integration.

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