INTERNATIONAL DESIGN CONFERENCE - DESIGN 2006
Dubrovnik - Croatia, May 15 - 18, 2006.

DESIGN 2006

TRACEABILITY OF SIMULATION DATA IN A PLM ENVIRONMENT: PROPOSITION OF A STEP-BASED SYSTEM THAT SUPPORT PARAMETER INTEGRATION

G. Ducellier, S. Charles, B. Eynard and E. Caillaud

Keywords: simulation data management, computer aided design, knowledge based engineering

1. Introduction

Simulation Data Management (SDM) enables the organization, storage and reuse of simulation tasks during Product Development. It offers methods and tools for improving traceability in Product Development, especially in the aeronautic (Braudel, H. et al., 2001, Eynard, B. et al., 2002) and automotive fields (Chapman, C., 1997, Franck, D., 1999).

Researches conducted in the domain of Knowledge Management offer methods and tools to enhance the performance of design processes by capitalizing errors and successes for next product generations.

This paper presents an approach of SDM integrating results from Knowledge Management Reasearch, in a Product Lifecyle Management (PLM) context (Saaksvuori, A., Immoen, A., 2004). The SDM developed (EGDS) focuses rather on the product data itself than on the geometry and FEA data resulting from the CAD and simulation systems. EGDS enhances the creation, storage and reuse of simulation meta-data through an user-friendly environment. EGDS also implements STEP AP203, AP209, PDM Schema Standards and the SDM Schema we developed to meet the needs of SDM meta-data neutral exchanges. However, managing data during product development is not sufficient: most of the valuable informations that has to be stored or could be reused, that we call knowledge, are difficult to identify. In this paper, we developed methods and tools that could enhance the quality of the exchanges occurring during product development by identifying key elements (parameters) on which we concentrates.

The system developed presents three functions:

- a parameter manager, enabling the links between multiple geometrical views of the product (multi view points);
- a rule manager, impacting the changements occurring during the design process in the simulation activities (impact model);
- a workflow engine, organising simulation activities based on the capitalisation of prior simulation activities.

This paper discuses the integration of parameter management in EGDS based on the three functions described above. EGDS functionalities and SDM Schema have been detailed in others papers (Charles, S. & Eynard B., 2005a & 2005b). The parameter manager is presented and first experimentations are set in order to provide first results concerning the use of knowledge management approach during simulation tasks in a collaborative product development project.

2. Simulation Data Management

Numerical simulation methods provide solutions for improving the quality and the performance of the products. Industry gradually adopted different simulation approach that moved towards simulataneous analysis with multiple parameters, such as stochastic simulations (statistical), multi-physics and multi-scenarios analyses. The first impact of these new approaches is the increase of simulation alternatives. The second impact is the growth of the complexity of the models considered. Both generate exponential volume of data that becomes more and more difficult to handle during Product Development Phases. These factors reinforce the need for defining a consistent simulation data management environment in order to improve the communication, the synchronization and the tracabeality of the data generated during simulation activities occurring during design or validation tasks.

The issues of such an environement are:

- to garanteed homogeneity of the data, to ensure compatibility;
- to provide a simple and transparent access to the data;
- to provide an effective management of the data.

The Simulation Data Management (SDM) Approach emerges from these issues. Researches on SDM deal with the development of methods and tools to efficiently manage the simulation data by integrating the finite element analysis and the design activities in a concurrent engineering context.

Researches conducted in the domain of SDM are mainly support by industrial sector dealing with high level of complexity. Simulation issues are often focused on software development. For example, automotive industry has set up a large number of research projects regarding SDM research in the past decade. CAE-Bench (Hägele, J., et al., 2000) presented a web-based system managing processus of simulation. Other researches can be mentioned such as MSC Software researches (Schlenkrich, M. et al., 2004) and Renault (Baizet, Y., et al. 2003, Thomas B. & Crepel J.M., 2004).

In this paper, a SDM environment (Environnement de Gestion de Données de Simulation – EGDS in French, Charles, S. & Eynard, B., 2005a) is used and enhanced. This contribution enhances the shared objectives of SDM researches by taking into account :

- the simulation project lifecycle and workflows;
- the iterative specification of simulation processes;
- the management of simulation alternatives in STEP compliant approach.

3. Knowledge Management enhanced product development

Nowadays, knowledge management issues in engineering science become strategic (Grant, R., 1996). The first applications started with Artificial Intelligence and Expert Systems (Brown, D.C & Chandrasekaran, B., 1985). Researches concerning the integration of knowledge in traditional CAD Systems have been conducted (Susca, L. et al., 2000). Industry started research projects in this promising domain especially in the automotive and aeronautical sectors (Chapman, C., 1997, Franck, D., 1999). Nowadays, researches are conducted in the domains of capitalization and reuse of design knowledge (Zhang, J.S. et al. 2005). (Seshasai, S. et al., 2004) adopt an approach of knowledge management that involves raw information acquisitions based on the keystroke entered by the user. In this approach, the knowledge manipulated is mainly based on the user rather than on the data managed during the product development activities. The objective of the approach is to provide an information acquisition that can be distilled in order to produce valuable knowledge for later use, without imposing additional tasks on human users involved in the product development process.

If different options are set regarding the definition of "knowledge" in the domain of product development, researchers and industry shared the same opinions concerning the difficulties for enabling knowledge management for product development issues: difficulties for identifying the knowlegde to be capitalized, for managing and maintening knowledge based systems and for acceptance of the system by the users.

In this paper, we concentrate our research on a data management approach of knowledge management rather than on a human approach. In this context, we adopt the block divisions identified by (Probst, G. et al., 1999) and the definition of knowledge that comes from these researches: knoweldge is '*…*

the entirely of skills and abilities used by individuals for a problem solving. Knowledge relies on data and information and is always bound to persons.' This approach enable the identification of key elements, block divisions, for knowledge management. From the six original block divisions, (Anderl, R. et al., 2005) propose to add two new blocks defining a control cycle. The eight blocks optained are:

- Knowledge Identification (overview of existing knowledge inside and outside of the company);
- Knowledge Acquisition (company's decision to obtain knowledge from inside and outside, such as partners, suppliers);
- Knowledge Development (complement of knowledge acquisition, it symbolizes the action of knowledge creation);
- Knowledge Dissemination (enables the dissemination of knowledge);
- Knowledge Utilization (the main purpose of the process);
- Knowledge Retention (consists in the separation of valuable knowledge from the obsolete one);
- Knowledge Goals (determines basic goals in the company);
- Knowledge Assessment (consists in evaluating the achievement of the basic goals and taking decisions to improve the solution adopted).

These aspects of knowledge management presents opportunities for managing the product development process.

The research presented in the paper is mainly based on IT-oriented factors that enable the management of valuable knowledge for simulation activities, especially in the domains of Knowledge Development and Knowledge Utilization.

4. EGDS – a system dedicated to Simulation Data Management

In a context of Collaborative Product Development, Simulation Data Management (SDM) is a key issue to ensure data homogeneity and compatibility with CAD and PDM, trough the product development process. Our researches concentrated on the use of EGDS, developed in Troyes University of Technology (Charles, S. & Eynard, B., 2005). EGDS is an environment defined for managing all the data required by analysis activities within the product development process. Figure 4 presents the integration of EGDS in a collaborative product development context. EGDS is presented as a simulation expert application enabling the data storage and exchange during simulation phases.

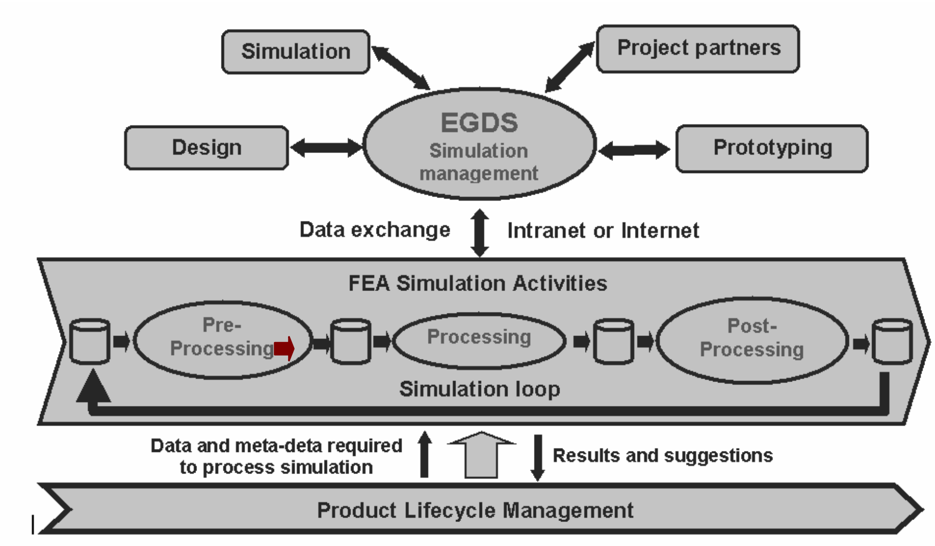

Figure 4. EGDS in a PLM Organisation

EGDS has to fullfill the two major requirements described bellow:

- A full integration between design and analysis activities, in terms of product entities exchanges based on PDM Enablers and developed methodologies. The researches regarding these aspects are described in section 4.1.
- A computer aided interface for managing data created during analysis phases. An effort of standardization has been accomplished for enabling data exchange with existing FEA Applications through the integration of SDM functionalities in PDM Schema. The researches regarding these aspects are described in section 4.2.

EGDS is an environment guaranting the structuring of data exchanges between design and analysis using a PDM approach.

The communication with CAD and FEA systems is based on the integration of STEP PDM Schema and OMG PDM Enabler standards. These standards aim to the interoperability with PDM Software (Starzyk, D., 1999). The paragraph 4.1 presents the PDM Enablers functionalities. STEP functionalities are presented and developed in paragraph 4.2.

4.1 Communication with other applications through the use of PDM Enablers

The PDM Enablers are a standards-based Application Programming Interface (API), specified in IDL, that makes PDM services available in a CORBA environment to other systems that require them (such as CAD and even other PDM systems). The PDM Enablers provide direct interfaces to support document management, product structure management, change management, configuration management (product options), and manufacturing implementation specifications, and include support for views, effectivity, and baselines.

4.2 SDM schema for data exchanges during analysis phases

EGDS integrates STEP functionalities such as AP203, to ensure interoperability with CAD System, AP209, to exchange simulation data with FEA applications and finally PDM Schema to ensure data exchange with existing PDM systems.

However, the management of the data resulting from the simulation phases is operated by EGDS itself. Therefore, in order to fulfil the requirements of simulation activities, we developed a STEP schema dedicated to SDM exchanges. This SDM Schema (Charles, S. & Eynard, B., 2005b) is used to ensure the standardization of data exchanges induced by SDM software communication.

4.3 Synthesis on EGDS

EGDS concentrates on the creation, storage and reuse of simulation data through the implementation of STEP Standards. It allows a user-friendly management of simulation projects, lifecycles, workflows, loops and alternatives in a efficient way. EGDS also offers functionalities for interoperability with existing CAD Systems and PDM through the use of STEP Standards such as PDM Schema. SDM Schema has been developed to offer a native interoperability with FEA Applications.

The next step of the researches conducted on this project is therefore to identify and develop methods and tools that could enhance the quality of the exchanges occurring during product development. This quality integrates:

- the pertinence of the data exchanged;
- the facility for retrieving informations easily in the data exchanged.

In order to satisfy these two criteria, we propose to enrich EGDS with an integrated parameter manager described in section 5.

5. Proposal for supervising EGDS data transfer: Parameter Manager

Section 4 of the paper presents EGDS as an application for managing and exchanging simulation data. The global structure of the system is presented the STEP SDM Schema is proposed for enabling neutral data transfer between simulation phases. These developments enable the structure of simulation data in order to satisfy the requirements listed bellow:

- homogeneity of the data and compatibility between platforms
- simple and transparent access to the data
- effective management of the data

However, the current existing EGDS ensures mainly the first requirement: most of the researches conducted in this project are based on the structuration of data for satisfying the homogeneity of the data.

In this context, further developments are presented in section 5 to enrich EGDS by providing an access to data that influence the global collaborative product development process resulting from the simulation phases.

5.1 Simulation Process organisation: the simulation loop meta-data model

The management of data in EGDS is highly linked to the specific phases dealing with simulation: the process of simulation implies the possibility of iterations.

The meta-data model resulting from this context enables the creation of projects that are highly based on loops and historics of simulations. A simulation loop meta-data is made up of one original CAD model, additional models (like mannequins used in crash tests) and alternatives of idealized CAD models, FEA complete models, meshing, boundary conditions, load cases, materials, simulation parameters. This integration of simulation components alternatives is very important to test different configurations of simulation models. The loops organization and this simulation alternatives integration are the main innovations proposed by the SDME system.

The loops can be defined according to these five explicit relations:

- sequence (to create a chronological order between simulation loops);
- origin reference (to identify the source of the current loop);
- alternative (to propose an other iterative solution to solve a problem);
- parallel (to specify that two ore more loops are processed in parallel).

The loops are linked one to another with links. Therefore, the specific object common to two, or more simulation loops is the link between them. In this context, a simple way for interacting with loops by introducing informations such as parameters describying the context of the simulation is to incorpore these informations directly within the links. The parameter manager is composed of two functions:

- enabling the access and the modification of the simulation data;
- impacting these modifications within the PLM, if needed.

Figure 5 presents the global interaction between PLM and EGDS across the parameter manager.

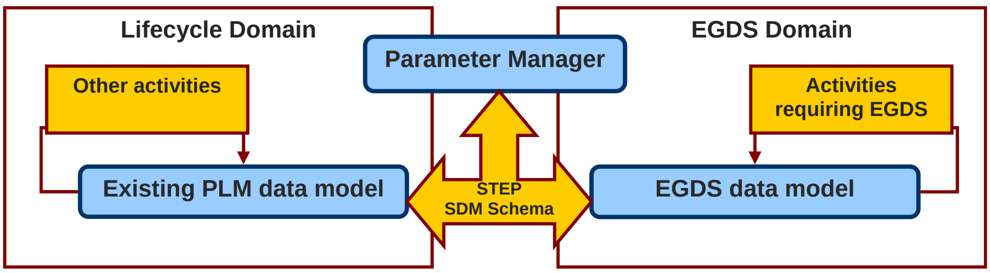

Figure 5. The global interaction between PLM and EGDS across the parameter manager

5.2 Accessing the Simulation Data: parameter manager

The very first requirement that should be fulfilled by the parameter manager is the possibility to access and to modify the links between simulation loops. In this context, we developed an interface mapped on the data structure of EGDS and compatible with the STEP SDM Schema. A user interface presents the different characteristics of the link, such as its type (sequence, alternative…) and its status.

5.3 Impacting the changes occurring in EGDS into the PLM Data Base

In order to impact the modifications occurring in EGDS into the PLM Data Base, the parameter manager is mapped to the PLM. This mapping is provided by the PDM Schema if the PLM Application supports the STEP Standards. In the other case, the mapping is dedicated to the PLM and developed according to the technology available (Visual Basic Scripts, Shell Scipts, XML, etc.).

5.4 Synthesis on the development of the parameter manager

The parameter manager tends to offer methods and tools for capitalizing the simulation loops computed in the SDM System. It is based on the STEP SDM Schema in order to provide a native compatibility with EGDS and adopts technologies for communicating with PDM and CAD Applications.

The parameter manager provides different functions for:

- enriching the links by specifying key attributes in order to
  - reuse simulation loops;
  - capitalize results;
  - retrieve informations.
- linking simulation loops to the PLM Systems in order to
  - provide information to other actors of the product development process;
  - incorpore information provided by actors of the product development process.

The parameter manager is the first step of the researches done for linking the SDM developed to the already existing PLM Approach.

6. Conclusion

Research community proposes a large numbers of development in the field of Product Data Management. However, few researches deal with the field of Simulation Data Management. This domain includes particular factors relative to the simulation expert phases, such as:

- multi model definitions depending on the type of simulations computed;
- organisation of the data using loop definitions rather than product definitions;
- large amount of data that cannot be all stored.

Adding to these specificities of simulation phases, some of the usual requirements of PDM Systems are needed:

- homogeneity of the data and compatibility between platforms;
- simple and transparent access to the data;
- effective management of the data.

In this context, this paper proposes a Simulation Data Management System integrating STEP Protocols such as AP203, AP209 and PDM Schema for enabling transfer with existing PDM Systems. An SDM Schema is proposed in order to provide a global data model to the SDM developed and is described using UML language.

Adding to this development, researches are conducted to enhance the quality of the data exchange, in term of relievance. Three major steps are described:

- a parameter manager, enabling the links between multiple geometrical views of the product (multi view points)
- a rule manager, impacting the changements occurring during the design process in the simulation activities (impact model)
- a workflow engine, organising simulation activities based on the capitalisation of prior simulation activities.

The first step, consisting in the development of a parameter manager based on SDM Schema is presented.

Finally, further developments are presented and accessment using Business studies are foreseen.

7. Future works

The researches described in this paper present the functionalities of a SDM System that organise, store and make reusable simulation data. This system is actually under development at Troyes University of Technology and a prototype of the application should be available by the end of 2006.

However, the system presentes lacks in terms of links with other expert tasks resulting from the PLM organisation such as links with product definition, CAD phases, manufacturing phases, etc.

Adding to that, the storage of information is definied to be performant during the simulation activities that occure in a Product Development Project. However, there is not methods and tools for assisting the simulation experts for capitalising their results for further projects.

In this context, the perspectives of development are multiple. The very first consists in developing the parameter manager presented in this paper for managing the changements occurring during the development of the product. From now, This perspective conducts us to the use of rule based methodologies.

The second perspective of development consists in managing the global process of simulation activities in a PLM Context. Researches in the domains of process organisations are conducted, leading to the development of workflows as defined by WfMC (Join et al. 02).

Finally, the development of the system has to be access through the implementation of pertinent use cases. Our last perspectives is then to use the SDM developed in a industrial context using simulation activities during their product development process.

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Mr. Guillaume Ducellier
UTT
12 rue Marie Curie BP 2060, Troyes, France
Email: guillaume.ducellier@utt.fr