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Application of Big data to configuration management in a PLM context

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A B S T R A C T

The emergence of information and communication technologies (ICT) in the early 1990s, particularly the Internet, made it easy to produce data and distribute it to the rest of the world. Today's business information systems contain data that is more massive, complex and heterogeneous. The increase in complexity, globalization and collaborative work mean that an industrial project (product design) requires the participation and collaboration of actors who come from several fields and workplaces. Information retrieval is an essential function for any information system. However, the latter is never easy as it always represents a major bottleneck for all organizations. In the environment of complex, heterogeneous and multi-use data, providing all users with easy and simple access to data becomes more difficult due to lack of technical skills or different user perspectives. PLM (Product Lifecycle Management) being a business strategy that aims to create, manage and share all the definition, manufacturing, maintenance and recycling information of an industrial product, throughout its life cycle. life, from preliminary studies to end of life and Big data, the collection of large data sets that are complex and difficult to analyze by traditional data processing methods. In this context, this article proposes to establish the main obstacles to the deployment of Big data in PLM systems (the collection of data from the PLM system, the storage and transfer of data in the PLM, the processing of data based on industrialization knowledge and experience, data security and visualization, etc.). The objective is to apply methodologies related to Big data to the management of product configurations (management of product diversity in connection with the development of mass customization (mass customization)).

I. Introduction

The intensification of competition coupled with the accelerated evolution of technologies lead to an unprecedented complexification of the process of design, development and launch of an industrial product. As a result, the product and its development are no longer the work of a single team or a single company, but very often the result of collaborative work by multidisciplinary teams coordinated around the objectives of achieving the product [1].

In order to ensure the quality of the data, to avoid redundancies and dysfunctions of data flows, all actors must work on a common shared repository. In this multi-use data environment, each user brings their own perspective when adding new data and technical information. The data can either have different denominations, or not have verifiable sources. Consequently, these data are difficult to interpret and accessible to other actors. They remain untapped or untapped to the maximum in order to be able to share and/or reuse them.

Data access (or data search), by definition is the process of extracting information from a database using queries, to answer a specific question. Information extraction is an essential function for any information system. However, the latter is never easy as it always represents a major bottleneck for all organizations.

This article is interested in managing technical information across the entire product lifecycle and across the extended enterprise. Its scope is several areas associated with information systems engineering and software engineering, supporting PLM (Product Lifecycle Management) in the company. PLM is a business strategy that aims to create, manage and share all of the definition, manufacturing, maintenance and recycling information for an industrial product, throughout its life cycle, from studies foreplay until its end. PLM seemed to meet the need to control the growing volume of data in increasingly complex environments. In PLM applications, data is organized in configurations. Configuration management is used to control the complexity of products and the diversity of knowledge resulting from the diversity of companies.

Furthermore, the concept of Big Data, defined as a new type of highly competitive economic asset, is the collection of large sets of data that are complex and difficult to analyze by traditional data processing methods.We will be able to manage, from the lowest configuration level, multiple representations of the product associated with multi-view configurations: business, product and customer [2]. This consists in applying methodologies linked to Big data to the management of product configurations (management of product diversity in connection with the development of mass customization). To enable the on-the-fly construction of structures produced from a large collection of components/parts that would be stocked in bulk.

Despite the know-how of these companies, determining the functional boundaries of production-related software packages is far from efficient. We propose a methodological approach to integrating the PLM system taking into account MES (Manufacturing Execution System). The PLM is specially dedicated to the life cycle management of the product and tends to constitute the base of the information system of the companies while the MES is the system controlling the execution of the production. On this, we will focus on the integration of product data generated during the design and industrialization of the product directly in the production workshop and vice versa while managing the role of the ERP (Enterprise Resource Planning) system in production management.

In conclusion, this article presents the scientific and industrial perspectives in terms of exploiting instantaneous data from PLM using new Big data techniques and finally anticipating smart marketing.

A. Problematic

ERP systems have aroused undeniable enthusiasm since the mid-1990s. They are intended to capture information, at the manufacturing stage, which consists of procedures (testing and manufacturing) [3], nomenclatures (Bill of Material - BOM), timelines as well as all the logistics of the manufacturing process [4]. However, the PLM concept appeared at the end of the 1990s. The successive deployment of integrated software packages in a company leads to an overlap in the functionalities of each software package and causes problems of storage and data redundancy. Taking the case of nomenclature management, companies manage definition nomenclatures or EBOM (Electronic Bill of Material) and manufacturing nomenclatures or MBOM (Manufacturing Bill Of Material). In addition, another problem arises when there are several systems managing the same data, which is the storage of this data. In this context, a survey was established in 2008 to demonstrate the multitude of business practices in terms of storage of production data. This survey was established by the Aberdeen Group entitled "Integrating the PLM Ecosystem" [5].

However, today these companies struggle to get product design and industrialization data directly to the production floor using only ERP software. The ERP system as the only system of the company, is unable to store and transmit all the data taking into account the industrial sector. This inability is due to the data structures of this system not adapted to support very detailed product data.

II. Method

A. Interaction Between Cycles Of Life

In the context of industrial enterprises, we distinguish two different concepts of the product: the object product and the instance product. We consider the object product as a virtual or digital product [6] [7]. The product instance is a physical product delivered to the user [8]. During our research, we identified a life cycle specific to each of the two concepts as well as the life cycle of the manufacturing system and that of the customer order. The point of intersection of these four life cycles represents the production stage of the product.

1) Instance Product life cycle

We have identified three stages that make up the life cycle of the instance product (Figure 1): the production stage or birth of the product, use/maintenance and the abandonment/recycling stage. For products produced in multiple copies, the life cycles of the different instances are shifted in time since at a time t when instance y is in production, instance x is in use. Usually, the time of use of any product varies depending on consumer behavior and conditions of use. We take into account that instance products are never strictly identical.

2) Life cycle of the object product

The life cycle of the object is made up of four main stages (Figure 2): design, industrialization, placing on the market and withdrawal from the market (transfer or abandonment) [8]. The object product design stage is carried out by the product designers using the PLM system and other tools such as CAD (Computer-aided design). At the end of this stage, the product nomenclature, the CAD model as well as that all product configurations are generated. The second stage of the object life cycle is industrialization. During this stage industrial engineers establish the product manufacturing range, instruction sheets as well as machine programs and the third stage is the marketing of the product. The duration of this stage corresponds to the period when the product is offered in the catalog and therefore available for purchase by the customer. Finally, the withdrawal stage of the market (change or abandonment of the object). During this stage, we decide to abandon production or to make it evolve in order to better meet market requirements.

In the case of single products (nuclear power plant, etc.), we find that the life cycle of the object merges with the life cycle of the instance to form the same life cycle made up of five stages: the design, industrialization, production, use/maintenance and the abandonment/recycling stage.

3) Life cycle of the manufacturing system

A production system is a product manufactured in a single copy, therefore, its life cycle has four stages: design, manufacture, use/maintenance and finally mutation/abandonment. During the industrialization of the product, the manufacturing process takes into account the architecture of the manufacturing system as well as the various manufacturing resources which leads us to note that the design of the manufacturing system begins just after the end of the design of the product object and in the course of its industrialization.

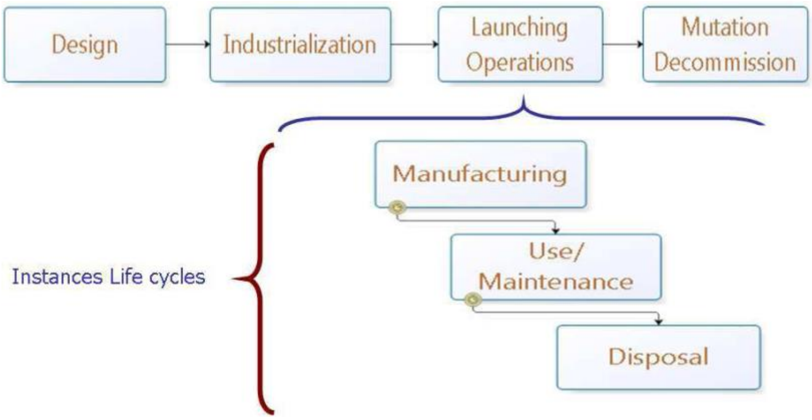

Figure 1: Life cycles of an object and n instances.

4) Customer order life cycle

Nowadays, companies are looking forward to minimizing inventory and produce by approaching the concept of "just in time". With this in mind, they no longer produce on stock but on the basis of firm and forecast orders. Taking into account the lifecycle of orders is essential. The sales order has four main stages: verification, waiting, preparation and delivery.

A. Intersection between life cycles

After analyzing the different life cycles, we see that the production stage represents a meeting point of these four life cycles. This step involves instantiating the object product using the manufacturing system to fulfill a sales order. Figure 2 illustrates this correspondence at the time of production of the product.

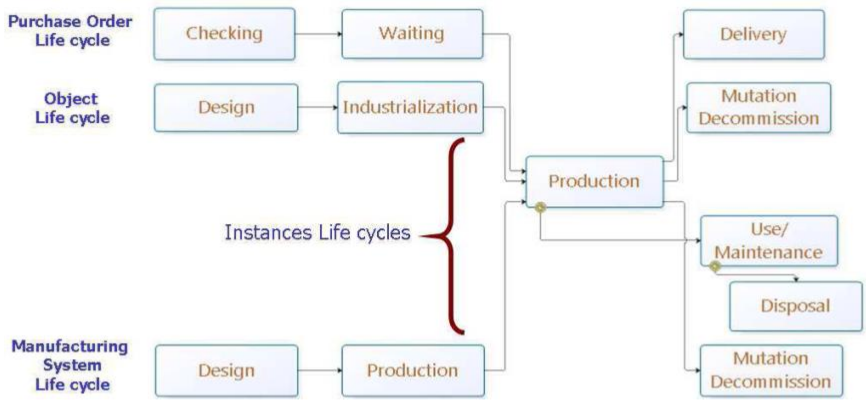

Figure 2: Intersection of the four life cycles.

In order to group together the activities carried out during each stage of these four life cycles, we followed an analysis process for each activity in order to subsequently specify which software manages which activity. This analysis led us to classify these activities into four categories:

a) Certain activity generating only data;
b) Certain activity generating data and physical effects;
c) Uncertain activity generating only data;
d) Uncertain activity generating data and physical effects.

These categories have been identified following the crossing of two points of view:

a) The type of activity (certain or uncertain);
b) The result of the activity (physical effect and/or data).

Table 1 represents the classification of activities according to these two points of view.

Table 1: Classification of activities.

Activity Type / Output Type	Certain	Uncertain
Data	**Pu**: Reception, Preparation, Delivery, Invoice	**PO**: Design, Industrialization, Mutation **MS**: design, mutation
Physical effect	**PI**: Manufacturing, maintenance, disposal **MS**: Use/Maintenance	**PI**: Use **MS**: manufacturing, disposal

PO: Product Object Life Cycle **MS**: Manufacturing System Life Cycle
PI: Product Instance Life Cycle **Pu**: Purchase Order Life Cycle

We have defined a certain activity as an activity whose duration and result are known a priori in the absence of hazards (machine breakdowns, absence of personnel, etc.). For example, the manufacturing activity of the instance product is a certain activity since the production duration is known beforehand. Conversely for an uncertain activity, the result and/or the duration are not known a priori such as the activity of use of the product. This activity is uncertain since its duration is unknown and depends on user behavior and conditions of use. According to the second point of view of our classification, we distinguish two cases: the case of activities whose result is data and the case of activities which generate both physical products and data. In this case, this data represents the data of the course of the activity.

B. Interaction between activities The interaction between the different activities of different life cycles is

essential at this stage of our research. In this context, we have defined several cases of data exchange between several activities directly linked to the production of the product.

a) Verification (Customer order)/Design (Object): generally, following the verification of the company's capacity to meet customer requirements, customer needs as well as all the data of their order are communicated to the design office in order to design the ordered product.

b) Industrialization (Object)/Production (Instance): this link is essential in order to send all industrialization data (ranges, job descriptions, etc.) to the manufacturing workshop to start production.
c) Industrialization (Object)/Design (Manufacturing system): the accomplishment of these two activities is simultaneous. Industrialization data is important for the design of the manufacturing system and vice versa.
d) (Instance)/Industrialization (Object): after the product has been produced, several production data (breakdowns, wear, etc.) are communicated at the product industrialization stage in order to benefit from this information to improve performance. Future production ranges, job descriptions, etc.
e) Use (Instance)/Mutation (Object): data related to the use and maintenance of the product play a very important role in order to improve and develop the existing product in order to better respond to market requirements.
f) Production (Instance)/Delivery (customer order): in this case the physical product switches from production activity to delivery.
g) Preparation (order)/use (manufacturing system): the preparation of the customer order obviously interacts with the stage of use of the manufacturing system. Use this link to send the manufacturing system usage plan. It also helps give better visibility of the status of this system throughout production.
h) Coverage of activities by PLM, ERP and MES

After grouping the different activities of the different life cycles into four main categories, we followed a verification step that allowed us to identify the coverage of these activities by PLM, ERP and MES software packages. We have defined the limits of these solutions available on the market. In order to fully understand the coverage of activities by the three software packages, we produced a figure (Figure 3) illustrating the current coverage of activities of each of these three systems.

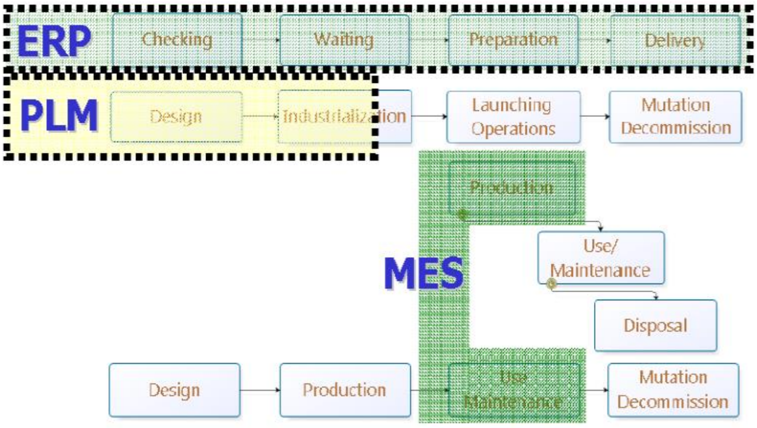

Figure 3: Functional boundaries of PLM, ERP and MES.

The PLM system currently aims to support all of the product's processes and data at all stages of the lifecycle. However, part of the industrialization stage, the whole go-to-market stage and the market withdrawal stage are no longer handled by PLM systems. However, there is a solution offered by PTC in the case of a complete management of the industrialization stage by the PLM system. This solution is called MPM Link capable of generating all the industrialization data of the product. This solution is offered as an add-on to PTC Wind Chill's PLM solution [9].

We see that there is a significant gap between the number of activities present in the four categories and the number of activities covered by PLM, ERP and MES [12]. Looking closely at this current coverage, we find that there are several activities not covered and left today to be managed manually or after several specific developments which will decrease the flexibility of the company's information system.
In order to bridge this gap, an adequate solution is needed. This solution will provide coverage for all activities classified in the four categories. Consequently, this new solution will make it possible to promote exchanges and define the functional perimeter. In order to define the existing exchanges between the different PLM and ERP systems, we have proposed a model allowing the exchange of product data. This architecture is presented in Figure 4.

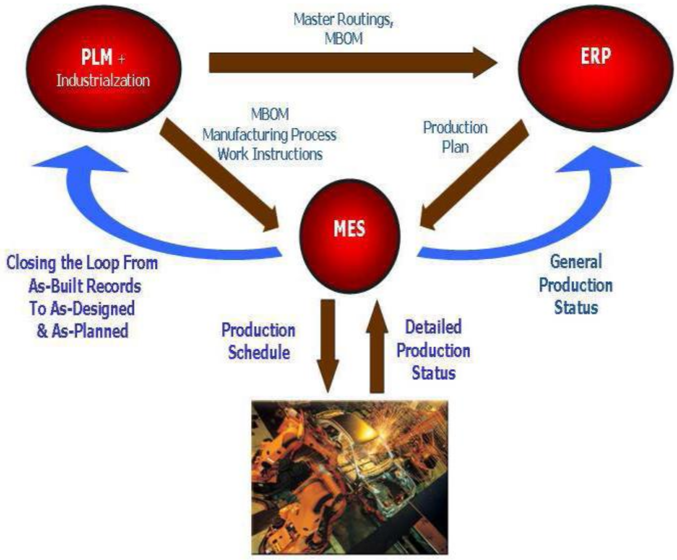

Figure 4: PLM, ERP and MES data exchange architecture [10].

This architecture implements the concept of closed loop PLM [11]. Today, it is far from being achieved, causing several problems with the exchange and visibility of product data.

III. PLM Integration

The complete analysis of the different life cycles during the previous section allowed us to determine the data exchanged between the different activities of the four life cycles. By focusing on the production stage, we have distinguished three types of data necessary for the production stage [10]:

a) Sales order data: number of copies, desired delivery date, product configuration, product characteristics.
b) Product data: CAD model, production range, instruction sheets, job description, PLC programs and control sheets.
c) Manufacturing system data: number of machines available, number of operators available and depots available.

These three types of data must communicate in the system. In this article, it is proposed that the data of the manufacturing system be stored in the PLM. The object product information is predictive information while the instance product information is effective. Consequently, the comparison of this different information leads to the triggering of several modification processes managed mainly by the PLM.

IV. Case Study

The product used in our case study is the one configurable on demand. It consists of assembling several different parts in sizes, heights and shapes on a pallet, so that the customer will be able to modify these characteristics of the product. The manufacturing system used is controlled by a Global Screen Intra (GSI) system. The products that can be manufactured on this system serves to illustrate two processes of interactions between PLM, production management and production.

A. The product produced

In our case study, the product consists of a support and several inserts in different colors. The support has 1 to 5 axes. The dimensions of the inserts may vary (height, outside diameter and inside diameter depending on the diameters of the pins).

B. The manufacturing system

The system is made up of 6 stations: the robotic station for engraving the product reference on the support with camera control, the station for launching empty pallets and receiving compliant finished products, the receiving station for non-compliant products, the assembly station equipped with an Adept scara robot, the manual assembly station used in the event of failure of station 4 or 6 and the assembly station equipped with a 6-axis Staubli robot.

In this configuration of the production system, the objective of which is to illustrate a problem, is very close to the system actually installed. Indeed, only station 1 is not equipped with an engraving robot and a control camera. The central loop is used to supply all the stations with pallets. The pallets which circulate on this loop enter the stations according to the data entered on their electronic label.

C. An integrating system

An integrating system is a PLM tool that centralizes information from different businesses. This unique system is generally complex to implement but limits the number of connections required. Data management is also considerably facilitated by the uniqueness of the information generated. In this architecture, the central server hosts the data safe (Vault) and manages the access rights generally from the definition of the Role/Person pair: to each individual, one or more roles are associated according to these responsibilities.
A person can thus be a project manager for a project A and a quality manager for a project B. Depending on their role, they will only have access to certain data in each of the projects. Figure 5 schematically represents an architecture based on an integrating system.

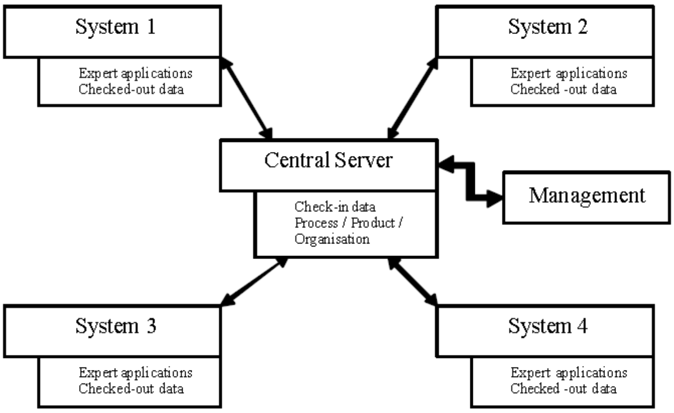

Figure 5: architecture based on an integrating system.

D. Web services

We chose, in our case study, the structuring of our data in XML files which will be used to transport the data via the technologies using the Internet to help the companies and more particularly of the extended companies to take advantage of the opportunities produced by the Web services. The notion of "Web service" essentially designates an application (a program) made available on the Internet by a service provider, and accessible by customers through standard Internet protocols [15] [16]. Web services are based on standard mechanisms and protocols and are therefore independent of programming languages (Java, J #, C ++, Perl, C #, etc.), of the object model (COM, EJB, etc.) as well as of implementation platforms (J2EE, .NET, etc.) [17] [18].

V. Conclusion

One of the main goals of our research is the integration of PLM. The direct exchange of data in the system will solve the problems posed in the research stages. Sending data related to the production of the PLM is important to do in order to avoid this passage of data in paper format which will inevitably generate a lot of entry and update errors [13]. This PLM integration is therefore a need expressed by several manufacturers. The proposed functional scope of PLM and ERP as well as the proposed data exchange will save time for marketing the product and will guarantee the return of production status to the office in order to have better visibility of this that takes place in the production workshop [14].
Our technical approach applied to our case study will require four important steps:

a) Building a design/industrialization project for our product using Windchill PLM and @udros.
b) The development of a platform for extracting and filtering data in the PLM.
c) Generation of XML files containing the data extracted from the PLM and filtered.
d) The creation of services for collecting, distributing and modifying information in the PLM.

Daftar Pustaka

[1] I. Bouhaddou, A. Benabdelha, "Model PLM (Product Lifecycle Management) based on multi-agent systems. "Xth International Conference: Integrated Design and Production. Tanger, Morocco, december 2015

[2] Geryville, M.H., A. Bouas, Y. Ouzrout et N. Sapidis, 2006. Collaborative Product and Process Model: Multiple Viewpoints Approach. 12th International Conference on Concurrent Enterprising Center for Concurrent Enterprise, Nottingham University Business Sch.

[3] http://www.isa-95.com

[4] Cimalore, C., (2007). PLM's changing role. Tooling & Production 73(4), 32

[5] David Houlihan (2008) 'Integrating the PLM Ecosystem', Benchmark Report, Aberdeen Group, http://www.aberdeen.com/summary/report/benchmark/4646-RA-integrating-plm-ecosystem.asp

[6] Sudarsan Rachuri, Eswaran Subrahmanian, Abdelaziz Bouras, Steven J. Fenves, Sebti Foufou, Ram D. Sriram (2008) 'Information sharing and exchange in the context of product lifecycle management: Role of standards', Computer-Aided Design 40 (2008) 789–800.

[7] Ali Muhammad, Salvador Esque, Liisa Aha, Jouni Mattila, Mikko Siuko, Matti Vilenius, Jorma Järvenpää, Mike Irving, Carlo Damiani, Luigi Semeraro (2009) 'Combined application of Product Lifecycle and Software Configuration Management systems for ITER remot

[8] Javier Pereda, Mauricio Hincapié, Arturo Molina, Product, Process and Manufacturing System Lifecycles Analysis for a Concurrent Development PLM08 international conference, 2008.

[9] PTC (2007) 'Manufacturing Process Management', Topic Sheet, 2074-MPM-TS-0107

[10] Anis BEN KHEDHER, Sébastien HENRY, Abelaziz BOURAS 'Industrialization and manufacturing steps within the Global Product Lifecycle context', APMS international conference, 2009

[11] Hong-Bae Jun, Dimitris Kiritsis, Paul Xirouchakis (2007) 'Research issues on closed-loop PLM', Computers in Industry 58 (2007) 855–868

[12] Michael Grieves (2007) 'Multiplying MES Value with PLM Integration', Whitepaper

[13] Anis BEN KHEDHER, Sébastien HENRY, Abelaziz BOURAS, 'An analysis of the interaction among design, industrialization and production', PLM10 international conference, 2010

[14] Intercim, Paul Meyer, Jud Plapp, Intercim white paper (2008) 'Extending PLM to the Shop Floor'.

[15] D. Fensel, C. Bussler, & A. Maedche (2002). Semantic Web Enabled Web Services. In International Semantic Web Conference, Sardinia, Italy, pages 1–2.

[16] Amer _ati_, Dag Bergsjö and Johan Malmqvist, Supporting Engineering Change Management by Integrating KBE and PLM in a Service Oriented Architecture, PLM08 international conference, 2008.

[17] Patrick Kellert et Farouk Toumani, Les web services sémantiques, revue i3 hors-série 2004 web sémantique, http://www.revue-i3.org/hors_serie/annee2004/index.php.

[18] Saïd Izza, Lucien Vincent, Patrick Burlat, Ontology-Based Approach for Application Integration, Doctoral Symposium, Pre-proceedings of the, First International Conference on Interoperability of Enterprise Software and Applications: INTEROP-ESA'2005, Genev