From design to business, by way of product life cycle. The EAPPM initiative

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1. Introduction

Product and process information is a key element for manufacturing operations, from design to business by way of product life cycle.

The share of common data, and the requirement to find faster and reliable ways for data flow within industrial environments and manufacturer-customer relationships has during the last decade raised a set of proposals seeking methodologies and architectures towards a potential solution. Most of them were developed within the R&D community with the support of industrial companies, as it is the case of some European projects running under the JOULE, ESPRIT and Brite/Euram programmes. In building construction and related areas these are e.g. COMBINE, ATLAS, COMBI, ToCEE, VEGA, funStep, FSIG, CIMTOFI, ELSEWISE, CIMSTEEL [1 – 10] etc.

In order to assist data integration, the ISO TC184/SC4 standards, where the ISO 10303 (STEP) is included, have been performing an important role regarding product and to some extend also process data modelling, delivering a set of Application Protocols covering some of the main industries in the world.

Five years ago the European Association on Product and Process Modelling (EAPPM) was set up, whose main aim is to help organizations in the PDT field. Having the building and construction industry as a starting point, it gives special attention to the industrial horizontal approaches based on a consolidation of know-how, results and "cases of success" coming from projects in the scope of Integration in Manufacturing. The EAPPM intends to be a pragmatic link between R&D and industry, supported by industrial associations, user groups and networks of excellence.

The EAPPM [W 1] is taking the experience and results coming from some of vertically very successful experiences (e.g. VEGA and ToCEE from building and construction, or funStep for furniture industry and FSIG projects, mentioning only the most recent ones), enabling the re-use and re-adaptation in the same or other industrial sectors, consolidating and confronting the results in terms of methodologies, architectures and toolkits available to support the project's work, towards a generalized proposal in the field, covering large enterprises as well as very small SMEs.

Integration and mix of different standards created and developed for different purposes should also be encouraged and clarified by EAPPM close to the interested parties, explaining the understanding of the scope of each standard and the suitability of them for the purpose of integrating engineering and business processes (e.g. UN/EDIFACT and STEP; how can they interact).

The strategy for the near future and the actions already taken and to be taken in short/mid term will be presented within the paper, showing the natural continuation of the presented work and results within the EAPPM initiative.

2. Needs for product and process modelling in industry

In general there are representations to model products and processes for the different industrial sectors. These models come from software applications covering the different aspects related with appendant production and business aspects. In that way and as a first glance, the immediate conclusion should be that no more work is required to be done on this field. But reality teaches that exactly the contrary happens. Very often these models are proprietary of the software houses owning the applications, meaning that there is hardly any interoperability among them, when running within a company to support their day-by-day activities, from production to business, they are working isolated without automatic possibility for data exchange or sharing.

Even when some standards, or de facto standards, are adopted by these applications, valuable semantics gets lost when interoperability of data is required, once those models usually were developed intending to cover a wide spectrum of domains, and specifics were not considered. A typical example for this context is tentative to utilize standards for geometric representation (e.g. DXF) for product and even process descriptions. A potential solution is the development and posterior adoption of standard Application Protocols, where software applications must take them in, allowing the automate exchange and sharing of information among applications without lost of semantics.

Several initiatives exist with this purpose, as those running under ISO TC184/SC4, like STEP [13] or Plib [11], or under the International Alliance for Interoperability, IAI [15].

3. Evolution from Data Exchange to Concurrent Engineering

In 1994, when the EAPPM was founded product modelling was focused on the exchange of product data between design systems (CAD) and from design systems to manufacturing machines (NC). First successful test implementations of STEP was shown for the automotive area, e.g. at the STEP meeting at Berlin in September 1993. One of the important lessons learned there was that product modelling will have benefits also beyond product data exchange, namely it will penetrate and considerably improve the data models of the various software tools applied in design, construction and maintenance/facility management. However, supported by a comparable revolution concerning data modelling in business engineering, nowadays process is understood to be a technical as well as a business process. Recently, let's say for the past three years electronic commerce and the electronic market place have added an additional aspect to the understanding and modelling of processes. The engineering society migrated from discipline-specific product modelling to a global concurrent engineering society, moving borders of distance, disciplines and cultures [12].

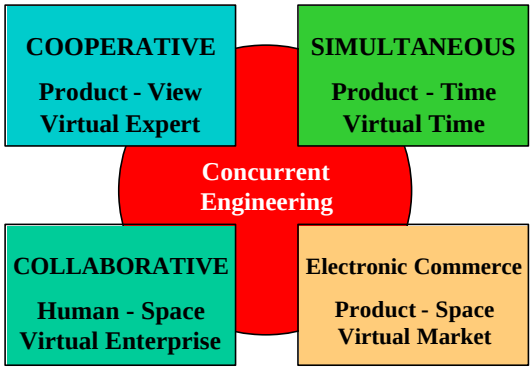

Figure 1: Components of Concurrent Engineering taken from [12]

Thus, concurrent engineering, a well-known method of working for a long time, has got a new push and far higher importance than ever before through the methods and abilities brought in by information technology. Concurrent engineering (fig. 1) can best be defined by the sum of four different, but complementary kinds of working: co-operative working, collaborative working, simultaneous working and working by incorporating electronic commerce.

4. A View on the Building and Construction Domain

Product modelling in the building construction industry for the purpose of design tool integration, i.e. design product data exchange tracks back to the early nineties. COMBINE [1] for instance implemented one of the first test beds and proved by demonstration that product models for the building construction industry are useful and valid. However, they found that building product models are going to get very huge and complex. This is not surprising, because as commonly known in the design of buildings many different architectural and engineering experts are involved, each of them representing another expert knowledge domain. This will definitely have its reflection in the product model. If we follow the good practice in ISO 10303 STEP and assume that a product model is fully pre-harmonized, the view problem on one side and the maintenance problem on the other side are the two main crucial problems. STEP is just strongly confronted with the later problem.

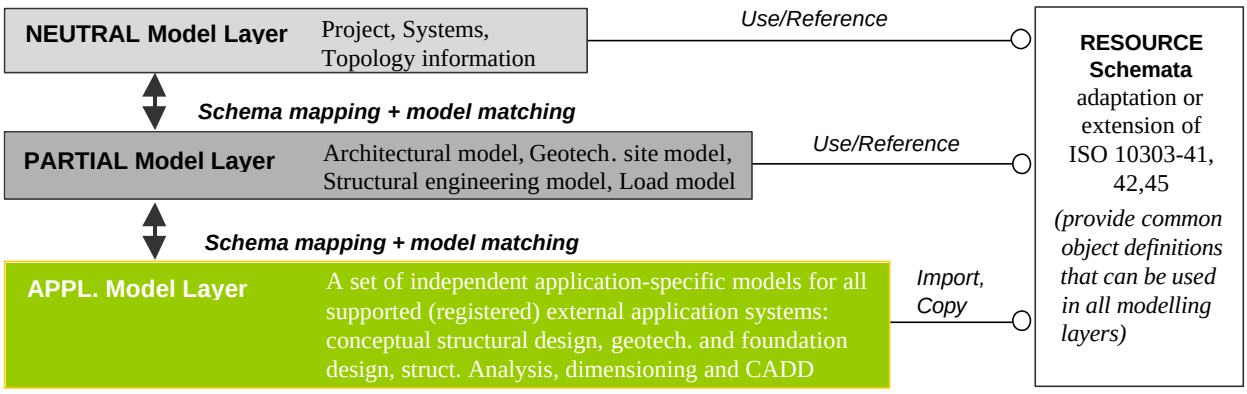

Figure 2: Hierarchical kernel pre-harmonized product model taken from [3]

As an alternative in [16] a structured approach is suggested, in which pre-harmonization is reduced to a small kernel of objects, called primitive objects. This approach was fully developed, implemented and tested in the COMBI project [14] in 1995. There, the product model is structured into three layers and a parallel resource repository, see fig. 2. The latter is an analogy to the basic resources of the ISO 10303 STEP (parts 40ties), whereas the hierarchical layers are introduced to allow highest flexibility and independence between the partial product models. Contrarily, the hierarchy chosen in ISO 10303 STEP is merely for avoiding redundancy. Interoperability in the COMBI model is done by dynamic mapping and matching, whereas in STEP there is static (pre-)mapping, i.e. interoperability is merely pre-harmonization. Static mapping and full pre-harmonization contra dynamic mapping and kernel pre-harmonization are the evens and odds of both approaches.

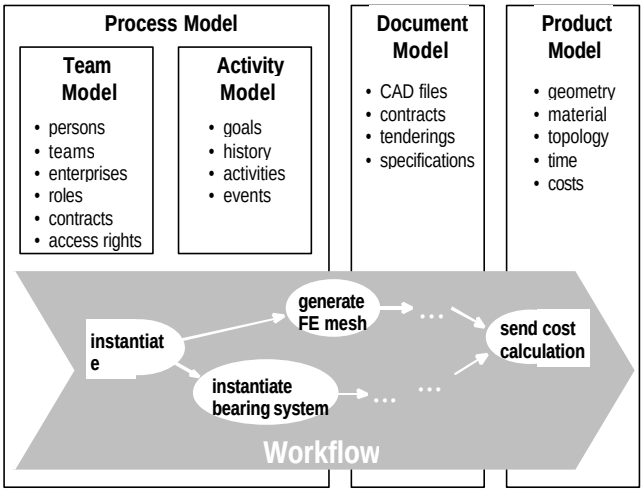

Figure 3: Work flow centred integration of the technical engineering world

Due to the impact of business engineering a strong duality between product model and document representation was recognized. In practice, the latter was given higher priority, because document handling is a serious daily problem due to the bulk of CAD 2 files arising from the still unsatisfactorily solved version management. In the last years, industry has put the main efforts on development of electronic document management system and from that point of view product model technology is going to be adopted by practice via the software vendors and the leading users. Documents are considered views on the product model and it was expected that the importance and usage of documents are more and more decreasing due to the growing importance and the inherent benefits of the product model.

Meanwhile, recognizing that documents in fact have an inherent meaning concerning provability, verification, proof of evidence and legal validity, which was strongly pushed by the business-engineering point of view, a simple duality between product and document representation, where each one can replace the other one is going to be considered insufficient. Both are carriers of different information contexts and therefore both are needed in parallel. From the combined technical and business engineering point of view a new level of demand is going to be established, where product model data and document model data are only to be seen as components of the whole data world, where each component definitely has its own inherent objective.

Workflow as the integration of activity and document make up only one other aspect which has been introduced in the engineering-design and technical-manufacturing world but which is one of the main favourable subjects, at the time being (fig. 3).

In this context of a work flow modelled world it was recognized that information has to be regarded as a good that deserves the same attention like products has always got for a long time. A logistics system is necessary to collect, manage, distribute and archive information just in time and to the amount demanded. This means that the triple model – product, document, process – underlying the work flow centred approach is to be extended by an information logistics model [4]. The product model is now embedded as one component into a broader object-oriented world leading to the five-layer data model approach [18], which is adopted, developed and implemented by the ToCEE project [4] (fig.4).

To some extend such an engineering data model is also chosen by the IAI [17]. The Industry Foundation Classes, IFC, V2.0 is by definition of the IAI a three-layer model. According to the definition of the five-layer engineering data model it shows four layers, however, where the Kernel and the Neutral Model Layer are merged to one layer, which is called the Core Model Layer. The Meta Model Layer is missing, i.e. it is implicitly modelled in some sense.

Another impact comes from the client-server technology, where servers can be distributed units as a whole or as parts as long as a logical integration is provided [20]. According approaches are developed and implemented by the projects ToCEE [4] and VEGA [5].

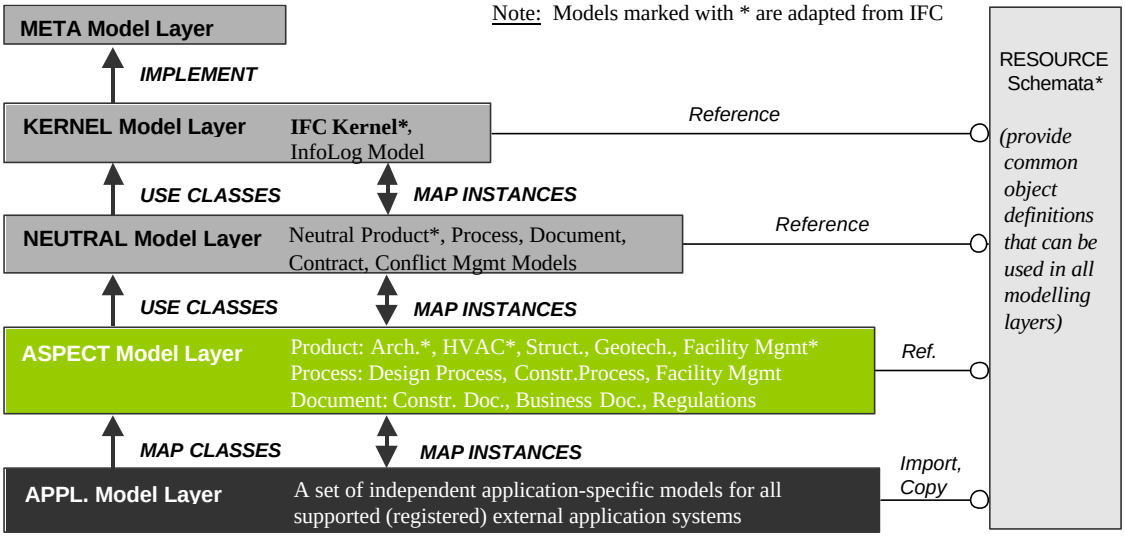

Figure 4: Five-layer engineering data model (taken from [23]

5. A View on the Furniture Domain

A wide offer of specialised CAD systems for furniture representation and interiors design projecting (CAD2 systems) is available in the market, but the capabilities for exchanging information among them are quite reduced, because there is no "universal standard" for CAD2 information interchange (i.e., each company, or association, often claims its data model as a "standard de facto"). The result is that true EDI -based solution for furniture industry is not usual. Furniture manufacturers, decoration studios and retailers are finally acknowledging the need for exchanging graphic and non-graphic product information, independently of the Computer Aided Design system used, because they understood the complete potential on the increasing of flexibility, client satisfaction and consequent business profits involved.

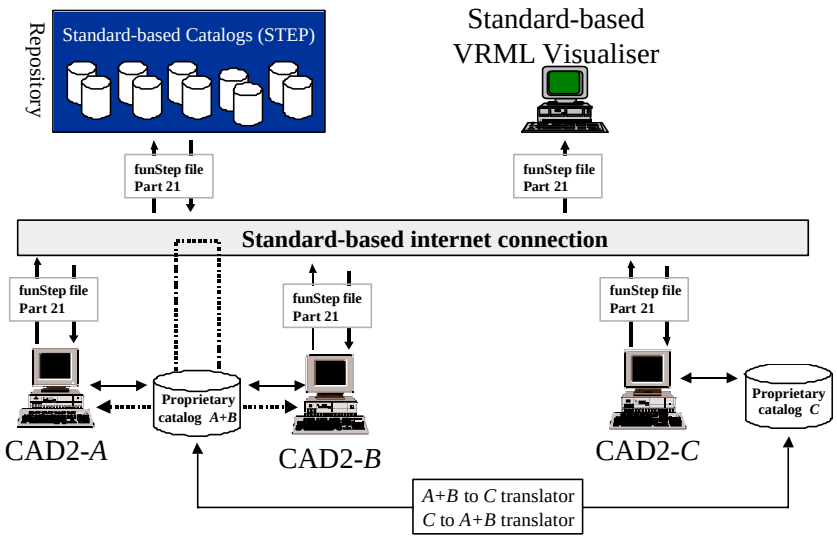

Figure 5: Standard-based integrated environment to assist electronically furniture commerce

The main problem is that all the entities involved in the process are postponing the decision of changing because they want to be sure that their investment (equipment, training and libraries introduction) will be secure. A huge step towards system credibility would be its stability which can only be achieved if a standard modelling for product and interior design projects data exchange is finally defined. To achieve an integrated environment, suitable to assist electronically the commercial services for the furniture industry, funStep proposes the environment depict in Figure 5.

This environment assumes the exchange and share of product data among different CAD2 systems, where does not exist a complete compatibility between the different data formats accepted by them. Then, several situations can take place to make possible the integration of product data.

One is that where the CAD2 systems are able to import and export the product data using a proprietary format. This integration is simple and direct, does not requiring any other additional effort to allow data share and exchange. Even when the CAD2 systems are in places physically separated, using a mean like internet, the data exchange can be done automatically using the available internet services/tools. This is the example depicted in Figure 5 integrating CAD2-A with CAD2-B. Another situation is when a CAD2 system is not able to read the proprietary data format of another one. In this situation, to make possible the data integration, a translator between the two proprietary data representations should be developed and linked with the CAD2 systems. This is the case depicted in the same figure showing the data integration between CAD2-A+B and CAD2-C. When thinking to have an environment composed by several CAD2 systems, where each one has its own data format representation, the number of different translators required to develop explodes exponentially.

To get a harmonised integrated data system, the role of standards is then fundamental, assuring to have a normalised way to represent and exchange the data among the different applications connected with the global system. This implies that, in the limit, instead of developing different translators between each pair of CAD2 systems (n*(n-1) translators, where n is the number of CAD2 systems), it is only required to develop one interface between the proprietary data format and the standard one (i.e., n translators). Setting the standardised environment up for the product data representation, means that afterwards each participant in the global system can provide standardised repositories of products (e.g., Electronic Product Catalogues), where anyone adopting the standard can access immediately.

In the particular case of furniture sector, the possibility to have these normalised electronic catalogues it is of extreme importance to assist electronically furniture commerce, once most of its customers are individuals or very small companies, like small shops or interior designers. Therefore, using this approach it is possible to make available at a very little price a visualisation tool appropriate to handle the standard format (e.g., to observe the different pieces of furniture). This tool can be uploaded via internet using a WEB browser, and then used to support the furniture commercialisation.

In order to validate the funStep's architecture, a test bed environment was created (Figure 6). The test bed is constituted by two CAD2 systems, (*TCP Open* from TCP and ARCDeco from ACA), integrated using the development environment and the defined funStep model. This environment will enable a Query and Browser System (QBS) responsible for supporting the mechanisms of synchronization and communication between the manufacturers, customers and CAD2's systems suppliers.

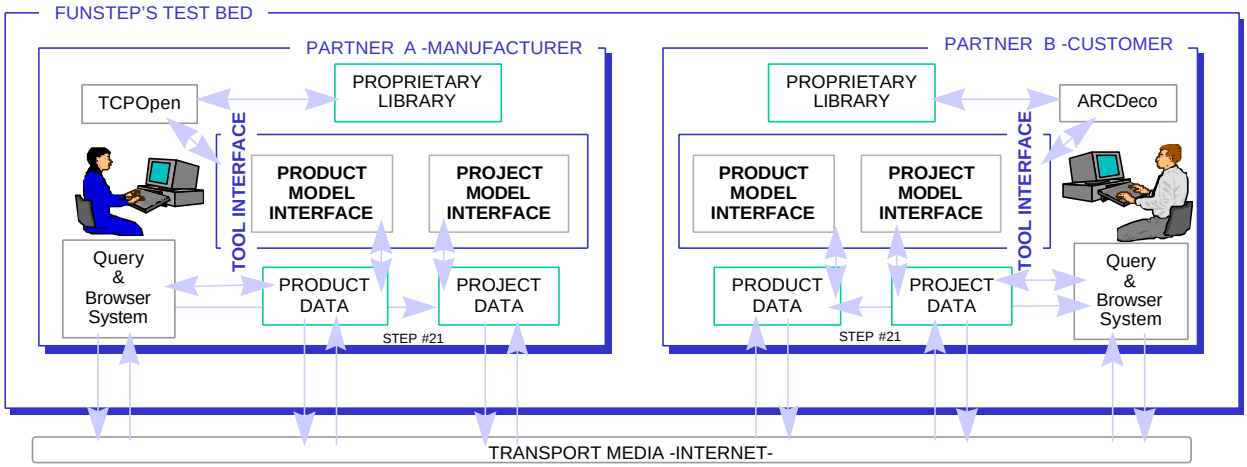

Figure 6. Integration of data using funStep's platform

An example of QBS' usage is the following: suppose that a CAD2 system supplier has a new product library; through QBS it can inform, to whom it may interest, its existence. A customer can then ask for reading permission in order to download it and automatically update is local system.

It is expected that the application of funStep architecture will produce profound impacts in furniture and customers, and in CAD2 systems suppliers as well. In furniture manufacturers and customers the main impact is on the existence of compatible systems on the market, investment assurance, customer service improvement, customers' error rate reduction and manufacturers' faster response, reduction of non-productive workload, and empowerment of Electronic Commerce. In CAD2 System suppliers the impact is on the actual market size that will become larger, increased customer's reliance on CAD products, development resources will be applied to development and not to third parties' libraries translation, and new way to improve the systems in terms of data exchange modules via telecommunications.

Now, and with the support of the European Commission, an international funStep Interest Group is being co-ordinated, and it is obtaining a good industrial response both from software providers and end users. Now more than 100 organisations from 15 countries around world already joined this initiative, where more than 75% are industrial companies.

6. The EAPPM – Aims and Structure

Five years ago the European Association on Product and Process Modelling (EAPPM) was set-up, where its main aim is to help organizations in the PDT field. It is a non-profit organization. Having the Building and Construction industry as a starting point, it deserves special attention on the industrial horizontal approaches based on a consolidation of know-how, results and "cases of success" coming from projects in the scope of Integration in Manufacturing. The EAPPM intends to be a pragmatic link between R&D and industry, supported by industrial associations, users groups and networks of excellence.

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Integration and mix of different standards created and developed for the same purpose, such as STEP-BC (ISO 10303 parts for building construction) and the IFC from the IAI, both concerning product modelling, and for different purposes, such as UN/EDIFACT, XML and the above mentioned should also be encouraged and clarified by EAPPM close to the interested parties, explaining the understanding of the scope of each standard and the suitability of them for their individual needs.

Membership to the EAPPM is free. However it is expected that inscribed members are actively contributing to the promotion of product and process modelling in the building construction industry and related areas by exchanging their experiences, lessons learned and providing results of success and good practice. The aim is to bring together consumers and suppliers for Product and Process Modelling Technology. The association is a non-profit organization. Therefore extended consultant work is not in its scope. This should be done on an individual agreement among the members.

The association is headed by a chairperson and a vice-chairperson. They are supported by a steering committee. Each EU member state and some associate states are represented by a person in the steering committee. A web server is maintained by the chairperson's institution. This web server acts as the information exchange platform. An electronic newsletter is published and distributed via the exploder to all inscribed members. A discussion forum and an electronic pin-board for search and offers is in preparation. A regular assembly is held every two years together with the European Conference on Product and Process Modelling, which is supported by the associated and organized by the vice-chairperson.

7. Future work and trends

In the approaching information society, different disciplines and technologies will get more and more close together. Therefore product and process modelling has to be looked at in a broader context of several disciplines, such as technical engineering, business engineering, manufacturing and supply chain management. Also the web as a big market place has to be taken into consideration. Global concurrent engineering as described in fig. 1 is the future trend. All four components has been developing continuously and first successful attempts have been undertaken to integrate each other. A personal market survey of the German building and construction market [20] by the second author and an extrapolation based on ongoing R&D projects, standardization work, public and private projects and strategic research projects of leading software companies have led to forecasting an exponential growing trend for next 10 years, in EDMS, Product Model based CAD, engineering workflow and electronic commerce tools.

First, electronic document management systems, EDMS penetrated the building and construction sector, followed by the first trial applications of STEP-AP225 in Germany in 1998 and in Japan in 1999. However, industry decided to support more the IAI initiative but STEP and at the time being first prototypes with IFC product models are on the market by such leading software vendors in the building construction market like AUTODESK, USA, NEMETSCHEK, Germany, and GRAPHISOFT, Germany. A breakthrough for the practical use of IFC is to be expected with version 2.0, which will most probably be on the market in late 1999 or early 2000. In parallel to the success of EDMS in practice, engineering workflow systems penetrate the building construction market, from the business engineering and project management point of view as add-ons of EDMS. Merging this technology with product modelling is still on the research level. Electronic commerce is already penetrating the building construction market as trial application and test studies carried out by building element suppliers and big publishing houses, multi-media companies and tele-communication companies, which do see electronic catalogues as services for a broad mass market in the future information society. It is to be expected that in 2000/2001 tools and services are to be launched to the market, which are integrated in design and procurement tools and therefore will show enough benefits to the user that they will widely be accepted.

All four components of concurrent engineering in the information society (fig. 1), co-operative engineering, collaborative engineering, simultaneous engineering and electronic commerce (engineering) still need substantial research and development efforts, where the main focus has to be put on the integration aspects of the four components, from which the most profitable synergetics can be expected. Integration there is a very sophisticated, multi-layered interoperability problem due to the fact that besides technical interoperability, i.e. product model interoperability and platform interoperability, also notational interoperability, i.e. the ontology problem, and co-ordinational interoperability arise [22]. Global concurrent engineering is the challenging task for the engineering information society due to the fact that such working will no longer be restricted to big, well organized companies but

will be open to SMEs if the integration problem, i.e. co-ordinational and platform interoperability can sufficiently be solved and provided to the market as service systems combined with cheap clients according to the potential of SMEs for financial and human investments.

For the support of future work, thematic Associations and Networks should deserve special attention on consolidation of "cases of success" coming from previous projects, where most of them present and deliver results in a vertical perspective, i.e. industrial sector oriented. Focusing tasks are:

1- Taking the know-how and experience coming from some of vertical well succeeded experiences (e.g., from building and construction or furniture projects, allowing the re-use and re-adaptation in the same or other industrial sectors.

2- Consolidating and confronting the results in terms of methodologies, architectures and toolkits available to support the project's work, towards a generalise proposal in the PPM field, covering from large enterprises to VERY SMALL SMEs (an important target).

3- Also, it is very important to establish a strategy to consider the dissemination and realistic approaches close to the VERY SMALL SMEs, sensitizing, preparing and pull them to take advantage of PPM when adopting it. This is very important especially for those very small companies, potentially interested in virtual and collaborative work, which is the case of B&C and furniture.

For that, to stimulate the constitution of Groups of Interest (like funStep Interest Group - FSIG), mainly supported by end-users is very important, in order to put them in touch and following what they can get from project results, and get industrial contributions to improve the existent developments towards the industrial needs. The co-ordination of this group should be done by "experts" coming from organizations with strong experience doing R&D and consulting in the field together with representatives of the industrial sector involved (e.g., industrial associations), or sectors when thinking on a horizontal way (like the EAPPM objective). In this way a complete structure will be ready to cover the usual needs as in terms of development, tools and industrial requirements in the area.

4- The usage of standards is very important in this field. Usually the SMEs have not enough resources to deal with them and to adopt them. In the STEP area for instance, this standard is very well disseminated and put in practice for industries owned by big companies, like automotive, shipbuilding, aircraft. When talking about B&C or furniture, where lots of SMEs are involved, the figure is completed different, where we found a lot of R&D and consulting organisations involved them, but no SMEs. In this case, a solution can be for instance that adopted by funStep, setting-up Users Interest Groups, where representatives will establish the required link between the companies interests and requirements and the ISO works. To stimulate this initiatives, also in a horizontal way, to aggregate common interests from different industries, should be considered.

5- Integration and parallel application of different standards created and developed for different purposes should be encouraged, explaining the understanding of the scope of each one and the suitability of them for the purpose (e.g., UN/EDIFACT, STEP, IFC, XML).

6- To have a way to support long-term developments, which are strategically important. The usual three- years projects are not enough for a continuous work in terms of research & development plus putting the results into practice at the target companies, even if very well defined exploitation plans are presented. To be possible to reach the market a chain of projects are then potentially required to assure that the previous work and investments will not be lost. If some of those projects in the chain were not approved, it means that the work spent so far will be lost and will not reach the expected results).

7- Making the connection with countries abroad Europe more will be very important, especially when advanced development and implementation phases are reached, once it enables the share of experiences and know-how/expertise that some time was experimented and acquired by them, e.g., ASIA (Singapore, Hong-Kong and China), Japan, USA, CANADA, Latin-America (Mexico, Argentina, Brazil and Chile), Australia and New Zealand. A potential problem is to find the formal way in terms of funding to proceed.

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