Interoperability and Standards: The Way for Innovative Design in Networked Working Environments

C. Agostinho[1], B. Almeida[1], M.J. Nuñez-Ariño[2], R. Jardim-Gonçalves[3]
[1]UNINOVA-GRIS, Group for the Research in Interoperability of Systems, Campus da Caparica, 2829-516 Caparica, Portugal
[2]AIDIMA – Instituto tecnológico del mueble, madera, embalaje y afines, Valencia, Spain
[3]DEE, FCT-UNL – Universidade Nova de Lisboa, Caparica, Lisbon, Portugal
[1]ca@uninova.pt, bma@uninova.pt, [2]mjnunez@aidima.es, [3]rlg@fct.unl.pt

Abstract
In today's networked economy, strategic business partnerships and outsourcing has become the dominant paradigm where companies focus on core competencies and skills, as creative design, manufacturing, or selling. However, achieving seamless interoperability is an ongoing challenge these networks are facing, due to their distributed and heterogeneous nature. Part of the solution relies on adoption of standards for design and product data representation, but for sectors predominantly characterized by SMEs, such as the furniture sector, implementations need to be tailored to reduce costs. This paper recommends a set of best practices for the fast adoption of the ISO funStep standard modules and presents a framework that enables the usage of visualization data as a way to reduce costs in manufacturing and electronic catalogue design.

Keywords:
Interoperability, Modular Architectures, Morphisms, Standards, Visualization

1 INTRODUCTION

The globalised nature of the world economy is evidencing a tremendous increase in trade and investments. Nevertheless, in such an open market, the challenges to organizations, especially the smaller ones, are real and they must protect themselves to ensure that competitiveness doesn't decline. Customers demand more information every day and it must be complete, updated, understandable and without errors [1].

Electronic business as the way for communication will only be effectively achieved by industrial organizations when product data, business and technology become fully aligned and interoperable between them. To accomplish this goal, standards implementation is a must. Their usage is accelerating technological and organisational change, thus improving innovation performance [2].

Designers and manufacturers using standards will get a considerable advantage over those that don't. Sending and receiving e-commerce documents in standardised format may get easier access to new markets and facilitate the management of product data through product life cycle (PLC) phases, distributing information from the designers to manufacturers, retailers and e-marketplaces. These advantages give the possibility to reduce administration costs when handling quotations, orders, etc., as well as the opportunity to have electronic catalogues, product customization, user-centric design and e-commerce.

However, in the SME-based industries, as furniture, Information and Communication Technology (ICT) systems, namely the ones with greater concerns with interoperability, are still often viewed with some scepticism. Organisations seemingly spend large amounts of time and effort trying to implement standard recommendations, and training the employees [3].

Therefore, this paper, supported by the European research project INNOVAFUN (standards.eu-innova.org/Pages/Innovafun/Default.aspx), proposes a methodology based on use-cases that serve as guidelines for the adoption of STEP standards [4], covering the needs expressed and promoting innovative and error-free design. In addition, to help SMEs reducing costs related to the manipulation of geometrical information in the design, manufacturing and commercial stages, the authors propose a framework based on open-standards for the usage of visualization data. The challenge is to extract basic geometry information from complex CAD drawings and enable it to non-expert users [5].

2 ISO 10303-AP236, THE FUNSTEP STANDARD

To cope with interoperability problems in the furniture industry supply chain, the funStep group (www.funstep.org) engaged in standardization activities within the STEP group of standards and created the funStep standard, officially known ISO 10303-236 [6]. This standard, also known as Application Protocol 236 (AP236), is the part of STEP that defines a formalized structure for catalogue and product data under industrial domains of the furniture sector.

AP236 is focused on product definition of kitchen and domestic furniture, extensible to cover the whole furniture domain (e.g., bathroom, office, etc.). It is a foundation for data exchange in the furniture industry so that all the software involved in the design, manufacturing and sale of a product, understands the same vocabulary [6].

2.1 Modular Architecture

The AP236 is designed in order to optimize reutilization of existent standard models, and modularization was the answer. Therefore, similar and common requirements were identified from existent STEP APs, and subsets of these models were selected to be integrated as part of AP236 (see Figure 1) [7][8]. This characteristic enables a faster standard development process and a guarantee of cross-sectorial interoperability since some of the modules are the same. Product and interior designers, as other stakeholders, may now be part of multiple supply chains without greater concerns with interoperability issues.

However, in addition to reutilization, modularization in AP236 also enables to define implementation classes and options according to the stakeholder profiles. For example, in the furniture case, retailers, manufacturers, suppliers, e-marketplaces and interior designer/architects are the principle stakeholders, whose characteristics and relationships lead to different implementation requirements [9].

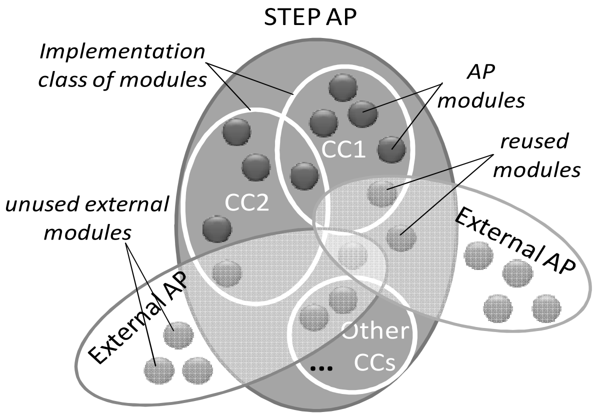

Figure 1 - Modular STEP AP.

Therefore, AP236 groups the standardized modules from the STEP community in six different implementation sets (designated by conformance classes – CCs in Figure 1). With them, anyone could implement funStep at different levels of compliance namely[1]:

1) Simplified catalogue representation (CC1);
2) Catalogue data and product geometry representation (CC2);
3) Parameterized catalogue (CC3);
4) Interior decoration project (CC4);
5) Parameterized catalogue data and product geometry representation (CC5);
6) Full AP236 that encompasses the others (CC6).

3 BEST PRACTICE METHODOLOGY FOR THE ADOPTION AND IMPLEMENTATION OF FUNSTEP

Traditional manufacturing sectors are interested in changing and evolving. They are motivated to innovate and explore new markets by means of global integration, creative and sustainable design, homogenization of business methods and services, and also to explore opportunities through widen collaboration better customer service and support [10].

To support this, the funStep standard was officially published by ISO in December 2006, and even before that, organizations have been demonstrating interest on using popular technologies such as XML to implement it [11][12][13].

Despite of the value of the openness of the solution as it prevents future dependence of proprietary technology or services thus assuring reusability of investments, companies have the perception of risk on following these new technologies. Knowledge costs are also considered a threat as extra personnel training should be required.

[1] The enumerated names are simplified and do not correspond to the official AP236 CC names. Please refer to [1] for the formal designations.

Due to their reduced size and lack of resources, and given the complexity of STEP technologies, SMEs have been facing some difficulties understanding and implementing the standard [9].

Therefore, the funStep group, to which the authors are part of, has defined a set of innovative services and implementation guidelines for the funStep standard adoption, in order to help organizations to overcome these barriers.

3.1 funStep services

The funStep services are available to the end user in the form of: a) Software Services; b) Training Services; c) Validation Services and d) Consultancy Services, to support the funStep standard-based solutions [14]. The services have the objective of assisting on the funStep standard comprehension, implementation process, and also on development and design of new business practices on SMEs. They offer new opportunities for innovation and content management, while also achieving lower costs and more rapid deployment.

Software services

They are the key to complement legacy systems, or support new software design and development in different companies. With businesses needing closer cooperation between suppliers and customers, companies need the capability to link up their systems quickly with other companies.

Training services

They are meant to accelerate the transfer of knowledge, skills, and competencies to the stakeholders according to their requirements and profiles. The training is structured in the form of modularized tutorials [15], and is delivered in different ways, such as: traditional Classroom, Virtual Classroom and by E-Learning.

Validation services

The validation of implementations plays an important role, guarantying that the stakeholders are using correctly the funStep standard, and are interoperable.

Consultancy services

Whenever the case justifies, the funStep community may designate experts to provide external in-house services.

Partially Compliant		Catalogue	Geometry	Expressions	Interior decoration
Level 1	CC1	√			
	CC2	√	√		
	CC3	√		√	
	CC4	√	√		√
	CC5	√	√	√	

Table 1 - Level 1 of funStep compliance.

3.2 funStep compliance and ICT adoption

The ideal scenario in the communication between two different furniture stakeholders is that both of them are fully compliant with the funStep standard for product data. However, if that is not possible, the stakeholder receiving the information should have the same or higher level of compliance than the sender. Considering the number of CCs implemented: it is possible to define three different levels of funStep compliance [9]:

- Level 0: the stakeholder has no funStep standard adopted and interoperability is never guaranteed;
- Level 1, for the stakeholders that have adopted some CC modules of AP236. Inside this level, there can still be different sub-levels according to the parts of AP236 implemented (see Table 1). Here,

interoperability is only assured if the sublevels implemented are the same or if the receiver level encloses the sender's;

- Level 2, for the stakeholders that have adopted full AP236, i.e. CC6;

3.3 Use-case (UC) suite by level of compliance

At present most of the furniture organizations have not yet adopted any funStep standard and will be on level 0 of compliance. Indeed, many have still different ICT usage situations. Below, it is presented an analysis of the more common situations [9]:

- Situation 1 - "Does not have an ICT Infrastructure". This is the case where no ICT equipment is used in the organization and all information is stored in paper format. Fortunately, this case is currently being reduced, and is concentrated in the micro-enterprises with less than 10 employees. In those many design specifications are still being sent by fax to manufacturers;
- Situation 2 - "Has an ICT Infrastructure, but is not focused for information exchange". This is the case common to the majority of SME environments and is the case where companies have computers, internet connection but have no specialized system to enable creative design, e-commerce or any kind of information management (e.g. ERP). Companies in this situation normally store their information in MS Excel®, MS Word® documents, or in very specific software formats.
- Situation 3 - "Has an ICT Infrastructure for information exchange and management". This case reflects the situation of companies that have already invested money in a system to enable e- business and PLC management. In this situation companies might already be adopting funStep (fully or partially), or may use proprietary formats not understandable by all, thus obstructing seamless interoperability.

Considering this, the levels of funStep compliance and the typical stakeholders' profiles in SME environments, the authors propose a set of UCs which will show the actions stakeholders should carry for a fast implementation of STEP standards, namely funStep.

Depending on the ICT starting situation, Table 2 guides the implementors on the order of UCs they should follow, to adopt certain parts of funStep and raise the level of compliance. Therefore, the guidelines eliminate part of the complexity of implementing a STEP standard, i.e. where to start [9].

3.4 A use-case and its recommended action plan

Nowadays most SMEs, independently of their profile, will be on situation 2 or 3 without any funStep CC modules implemented. To better illustrate how the UC suite works, its best to follow an example: Taking for instance a furniture retailer that decides to implement the funStep standard. Due to its business scope, the retailer already uses an ICT system that enables to electronically receive furniture catalogues from different manufacturers. However, due to the heterogeneity of the information received, it has trouble enlarging its business network.

Clearly the retailer is suffering from an interoperability problem, and might gain from funStep. By the description above, the retailer is on situation 3 and on level 0 of funStep compliance.

Following Table 2, it should start by finding and detailing the exact requirements that the current system does not answer (UC-07). At this stage, the actions in the use-case, should be partially accomplished otherwise the retailer would never have felt the need to change and innovate. Next, the second step relies on the profound analysis of the standard capabilities to see if and how it will solve the problem (UC-08). The procedure continues with UC-09, UC-10, UC-11, UC-12, until it reaches UC-05 where it is foreseen that the organization will check if its implementation has been successful and obtains a compliance level certificate.

Due to space restrictions only the last UC of the recommended implementation process is detailed in the paper (refer to [9] for others).

Use-Case 05 – "Test the level of funStep compliance"

The UC 05, illustrated in Figure 2, represents a scenario describing how a company tests the level of funStep compliance of its own software system.

This test will help the company to know if its system is in conformance, both syntactically and semantically, with the funStep standard and if it is interoperable with other systems already using AP236 [16].

ICT adoption	funStep Compliance	Priority Steps (#, name)		Use-case
Situation 1	Level 0	1	Uptake basic ICT	UC-01
		2	Build data system based on funStep	UC-02
		3	Implement system interfaces	UC-03
		4	Populate data system	UC-04
		5	Test the level of funStep compliance	UC-05
Situation 2	Level 0	1	Build data system based on funStep	UC-02
		2	Implement system interfaces	UC-03
		3	Migrate internal data to funStep system	UC-06
		4	Test the level of funStep compliance	UC-05
Situation 3	Levels 0, and 1	1	Find requirements that the current system does not answer	UC-07
		2	Analyse how funStep could answer the requirements	UC-08
		3	Discover mapping from internal system to funStep *(if starts from level 0)*	UC-09
		4	Implement functionalities/ services to transform internal data in funStep data and vice-versa *(if starts from level 0)*	UC-10
		5	Implement new parts of funStep	UC-11
		6	Implement system interfaces for the new parts	UC-12
		7	Test the level of funStep compliance	UC-05

Table 2 - Use-Case suite for the adoption of the funStep standards.

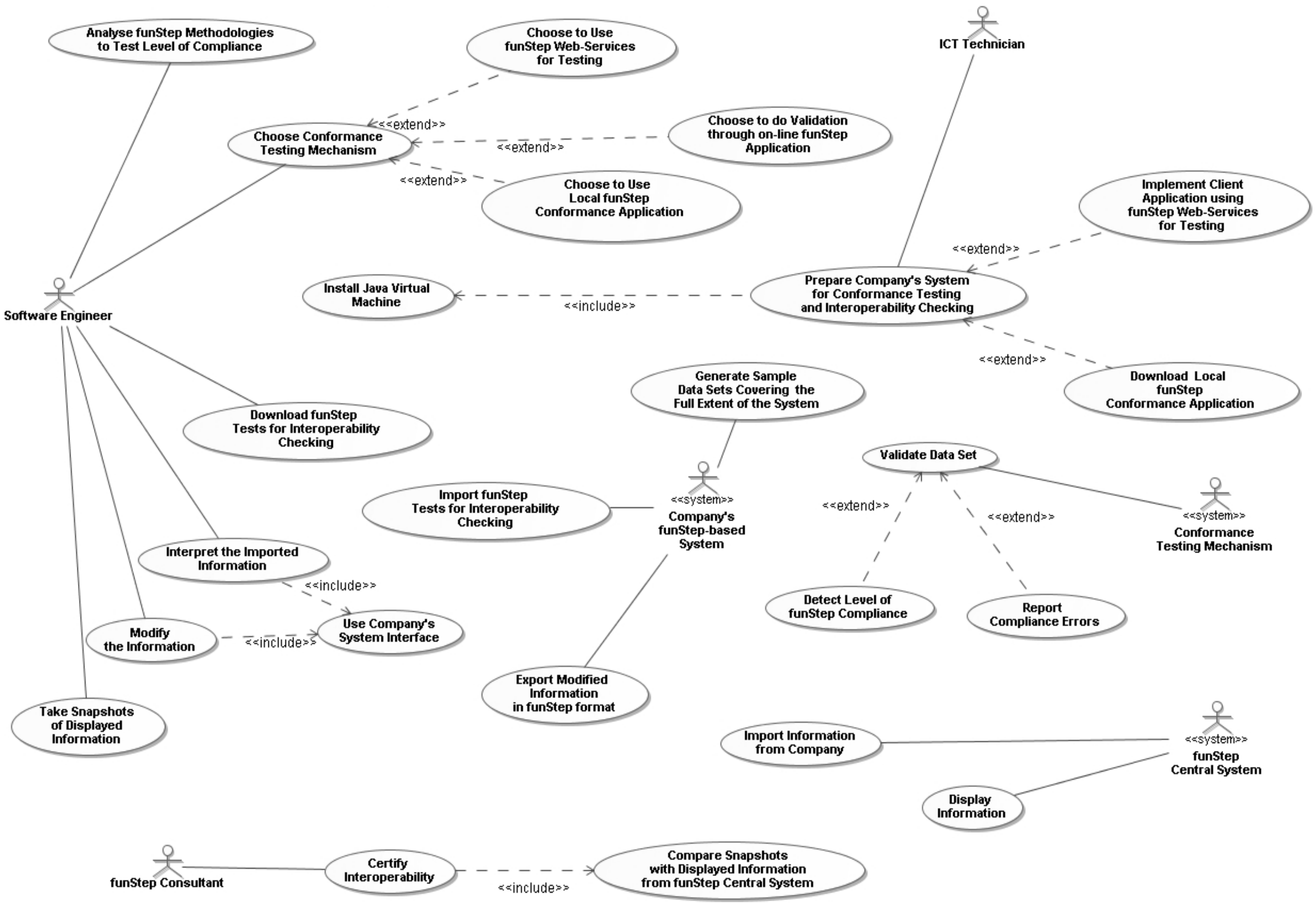

Figure 2 - Use-Case 05 “Test the level of funStep compliance” [9].

This UC is rather complex in terms of the diversity of actors involved. Six actors have actions assigned. However the “Software Engineer” and the “funStep Consultant” have preponderance regarding the others: the former, because he/she is in charge of leading the testing process on the company side, and the latter because he/she is the one responsible for making the final certification on the funStep side.

Using the sequence of actions represented in the use-case the organization that wants to test the level of compliance of their software, knows exactly the sequence of actions to carry, which are:

1) The “Software Engineer” starts analysing the available funStep methodologies in order to test company’s level of compliance;
2) Then, he chooses the conformance testing (CT) mechanism [16]. It can weather be remote through the funStep web-services, the online testing application[2], or local;
3) After that, the “ICT Technician” is in charge of preparing the Company’s System for the CT and interoperability checking (IC) procedures [16];
4) The next step, consists on the generation of a sample data set covering the full extent of data that the system can handle;
5) With that, the “CT Mechanism” can execute the validation of the data set, detecting the level of compliance and reporting the errors found in the implementation of the “Company’s funStep-based System” if that is the case;
6) After these tests, the “Software Engineer” continues with the IC procedures, downloading the pre-prepared funStep battery of tests and feeding them to the “Company’s funStep-based System”;
7) He visualizes the imported information and modifies it using the system interfaces;
8) Before storing and exporting the modified information in funStep format, the “Software Engineer” takes snapshots of the displayed information. This procedure provides a printable document to make proof of the information inserted in the “Company’s System”;
9) Finally, the “funStep Central System” imports the information from the company and then displays it to a “funStep Consultant” that will compare the snapshots with the displayed information. If everything matches, he/she will certify the software system as funStep compliant.

4 HANDLING VISUALISATION DATA

With the path towards product data standards adoption cleared, communications, interoperability, and innovation should come easily. Nevertheless, software vendors are still pushing their proprietary solutions and delaying information openness. The exchange of geometry and computer-aided design (CAD) data is one of the most prominent barriers still remaining. End users experience many difficulties trying to read geometry files from other systems and most of the times have to pay for expensive solutions that deal with it. CAD vendors generally claim to be interoperable through the usage of translators, yet their formats remain closed and are only partially exchangeable with different systems [17].

This problem is many times transported to users that don’t really need the full complexity of a rich CAD drawing. Users might just need a “light” view on the

[2] http://gris-public.uninova.pt:8080/funStepServices/

geometry, and visualization data would be sufficient enabling to adapt the information to their needs, e.g. show geographical information on a map instead of on complex tables [18].

Visualization could also be useful to complement the funStep standard efficiency. As described before (see Table 1), one of its parts, i.e. the CC2 is meant for geometry representation. However, maybe not all industrial stakeholders that need to deal with geometry need the full complexity of AP236 geometry modules. Therefore, one of the actual challenges on this area is a creation of a framework that regardless of the format of the geometry exchanged can show the information accordingly with the goals of the worker. Thus capable of simplifying the complex geometry based product data in a way accessible to all. Activities like virtual simulation would be accessible to all, thus enabling optimization and sustainability.

4.1 Model-driven in visualization framework design

The Object Management Group (OMG) has been proposing the Model-Driven Architecture (MDA) as a reference to achieve wide interoperability of enterprise models and software applications. Model-driven Development (MDD) consists on the software development starting from a high level of abstraction, which enables the interaction of the final user in the development phase, i.e. customization. With this, the software can be more efficient meeting their goals and requirements. The MDA provides specifications for an open architecture appropriate for the integration of systems at different levels of abstraction and through the entire information systems' life cycle [19][20][21].

For these reasons and due to the automation process on the software generation, the framework architecture was designed following the model driven paradigm (see Figure 3). The MDD leads to a need that everything is described as a model, i.e. the diverse formats (inputs and outputs) need to be expressed as models, thus enabling the integration of different applications by explicitly relating and transforming their models.

The model relationships are based on the concept of Model Morphisms, which addresses the problem of mapping and transformation of models [22]. In this context, there are two classes of morphisms: 1) non-altering, where given two models, source and target model, a mapping is created relating each element of the source with a correspondent element in the target, and leaving the two models intact; 2) model altering, where the source model is transformed using some kind of function that applies a set of mapping rules to the input model, modifying it into the targeted output.

The above concepts have been applied in the architecture design. Looking at Figure 3, there are two major divisions that are relevant. First, the four level approach defined by the MDA, seen vertically from the meta-meta model (level M3) to the data (level M0), and second, the three parts that compose the morphisms architecture (seen horizontally).

The "Common Base" is the pillar of the architecture. Its goal is to provide a meta-structure capable of describing the largest number of geometric artefacts. The author's purpose was not to invent a new geometry representation format. Therefore, on [5], the authors elaborated a study that selected X3D, an ISO standard for the representation of 3D scenes, as the core format for the Common Base meta-model [23].

With the "Common Base" specified, non-altering morphisms can be used to discover relationships among the "Specific Formats". These two parts of the architecture enable importing and exporting data from and to a neutral format. The process may result in information loss at the M0 level if the models have different degrees of expressiveness.

The last part of the conceptual framework is related to the views. It defines the data structures that the views use to show the information graphically to the users. For instance, in a table, the model defines what information goes to which column. This part is related to the Common Base using model altering morphisms where the geometrical information is simplified for visualization.

5 A SCENARIO FROM THE FURNITURE INDUSTRY

Throughout the different product life cycle stages, there are many people working together and handling with product and geometry information. Some are working in the product design, while others are more concerned with manufacturing and others with the marketing and selling of that product.

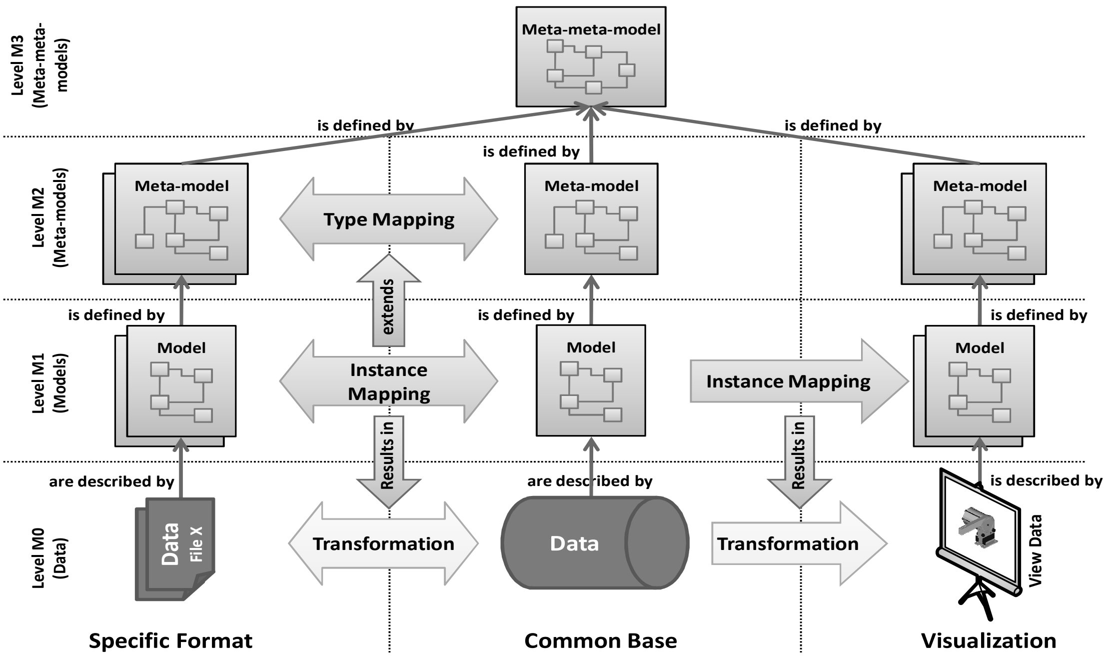

Figure 3 –MDD principles applied on the design of the visualization framework

However, for example, for marketing purposes, people are more interested in the visual characteristics for promoting that product and not the specificities. Also, marketing departments need to develop product catalogues where they need to specify all the variants of a single product. Most of the times, these activities are performed by people that are not expert users in CAD tools leading to mistakes and extra time creating and updating catalogues. For these situations, visualization software is more effective for the organization because it saves both time in training of personal, and money in CAD software licences and error recovery [5].

The example introduced in section 3.4, is actually a real example of a furniture organization implementing the funStep standard. It is taking advantage of visualization techniques to have affordable and sustainable design along its supply chain, i.e. from the product designer to the manufacturer.

The advantages of using a standard for data exchange are only noticed if its suppliers and/or costumers use it as well. For this reason and despite of being a retailer, it felt the need to use visualization software so that it can provide its suppliers, i.e. the furniture manufacturers, an easy tool to help in the process of semi-automatic catalogue creation following AP236 [24].

Figure 4 illustrates the process in more detail. In this particular scenario, the furniture designers remain producing and sending the CAD data to the manufacturers using the traditional rich formats. In turn, these use that data to proceed to the fabrication of the object and its catalogation. However, this last process typically involves other departments and personnel not specialized in CAD.

Therefore, and to assure a funStep data communication the retailer provides a tool that enables the manufacturer to establish an easy link between the product specifications, visualization, and configurability, thus accelerating the catalogue creation and communication. Manufacturers which have neither implemented funStep, nor use this tool will remain sending their catalogues in the traditional way where errors and misinterpretations may demand further iterations between the manufacturer and the retailer (right side of Figure 4).

This strategy enables the retailer to enlarge its business network seducing manufacturers with a way of exchanging information following an international standard, and at the same time enables furniture manufacturers to create electronic catalogues at low costs and widens the possibility of spreading them worldwide being sure that the receiver will understand the data structuring. Similar advantages pose to the designers.

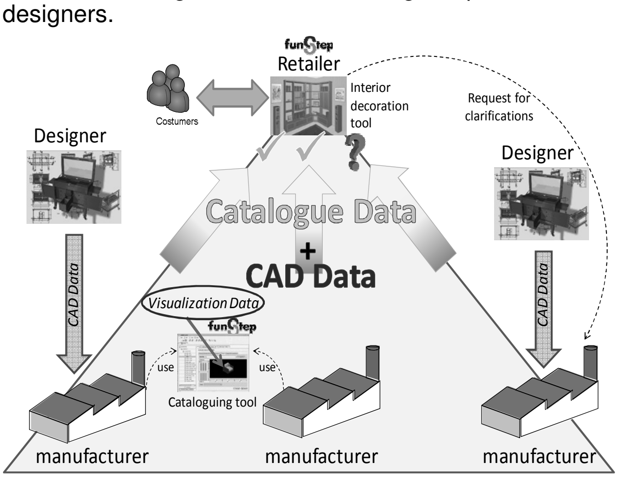

Figure 4 – funStep implementation scenario using visualization data.

At the time of the paper preparation, the retailer in question was already receiving catalogues in funStep format from 25 companies as part of a pilot project.

5.1 Use-case matching and services applied

Based on the scenario description and on the retailer business description, it is possible to verify that it had an ICT infrastructure for information exchange but using proprietary non-standard solutions (third-party and home-made solution). This way it meets the ICT situation 3 and level 0 of funStep compliance [9].

Applying the use-case suite best practices from section 3.3 to the scenario implementation, the steps carried were the following [24]:

1) UC-07, the search for requirements that the retailer system was not accomplishing was performed by three directors from the ICT, furniture, and decoration sections of the company. The technical feasibility report reflected the need to use a standard for receiving furniture product data. The goal of the adopted solution was to use all the product data and CAD associated files of every configured product from their furniture providers in order to do interior decoration projects;
2) UC-08, the analysis of funStep to meet the requirements was performed by their software engineer in collaboration with the authors that explained how funStep worked and how it could respond to their needs;
3) UC-09, the mapping discovery was a consequence of that collaboration, i.e. both teams joined and formalized a mapping between the retailer internal structures and the funStep standard;
4) UC-10 followed, using a mediation database with import/export functionalities. It accepts all the information coming from the associated manufacturer's catalogue products (already in AP236 thanks to the cataloguing tool developed), but at the current piloting stage and for security reasons, it requires management approval before synchronization with internal structures;
5) Neither UC-10 nor EC-11 was implemented at this stage because the retailer is still evaluating the efficiency of funStep on the transactions they already were doing. Thus they are not yet enlarging their business scope;
6) The final activities were related to the testing of the implementation (UC-05); Thanks to this, several misinterpretations and implementation errors were resolved. The retailer is currently CC1 compliant but already with some part of CC2, CC3 and CC4 working on the interior decoration.

As is implicit, for the execution of these steps, the funStep services revealed an added value as well [24]:

- Software services such as the online testing application and CADEF[3], i.e. the funStep cataloguing tool mentioned in the scenario were used and adapted at their needs;
- Several training sessions regarding the standard explanation were carried;
- Validation services and methodologies have been applied as predicted in the UC-05;
- And also consultancy has been used on the analysis and definition of the mapping between the standard and the internal information model.

[3] Developed by AIDIMA (http://www.aidima.es)

5.2 Visualization framework: an instance

The model driven framework presented in this paper (Figure 3) has been instantiated and used to provide CADEF the capability of extracting visualization information from the original CAD and merging it back together with the product characteristics in order to build a funStep compliant electronic catalogue reusing the original product design.

CADEF uses the presented framework in such way that completes the product and parts information described in the catalogue with a CAD model in DWG™ format from Autodesk®. Once the CAD model is opened in the embedded viewer, all the product variability defined in the catalogue could be selected and delaminated according to the manufacturers needs [5][14].

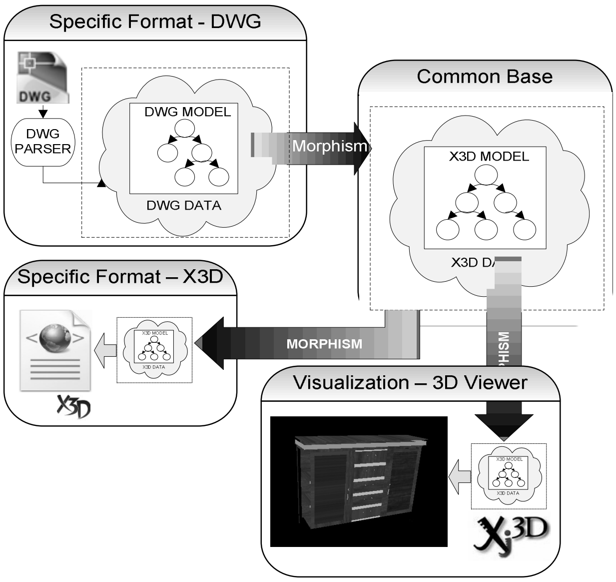

Figure 5 - DWG™ to X3D instantiation of the visualization framework.

Figure 5 depicts the morphisms that are present in the CADEF implementation of the framework. The authors' used the DWG™ specification published by the Open Design Alliance (ODA[4]) as starting point to define the "Specific Format" model, meta-model and parser. With them defined, links with the X3D model and meta-model ("Common Base") have been detailed and specified implicitly in the tool. Finally, since the 3D viewer embedded in CADEF also uses X3D, the morphism to the output ("Specific Format") was direct and it was only required to choose the visualization properties desired so that the visualization morphism could be described.

Hence, level M0 of the visualization framework represents the execution stage. When CADEF imports DWG™ data, it automatically imports it into an internal X3D structure which enables to generate an X3D file, or show the visualization data in the embedded Xj3D[5] viewer.

6 CONCLUSIONS AND FUTURE WORK

To solve interoperability problems in the furniture industry supply chain, which is comprised mostly by SMEs with heterogeneous needs, the funStep group has created an ISO standard which defines a formalized structure for catalogue and product data under industrial domains of the furniture sector.

Due to the modularization properties of STEP it is possible to establish direct cross-sectorial links with other ISO standards. Among them are the automotive, aircraft, ship-building, building & construction and other relevant sectors to the furniture segment, e.g. many furniture manufacturers and designers act as suppliers sub-contracted by other sectors, like automotive (refurbishment), ship-building (luxury Yates) or building & construction (wood-made houses).

However, the main benefit of adopting the ISO funStep standard is the increased efficiency that results from sharing data between different ICT systems seamlessly bringing additional benefits without the need for re-enter information. Thus, there is a reduction of human errors and end-to-end transaction time (lead-time).

Using standard compliant systems means that, component or products suppliers can provide full technical information about their products to the retailer, who in turn, can publish catalogues, operate e-commerce systems, manage stock control systems or supply data to interior designers in an interoperable manner, all without the need to enter any data more than once. Customer orders placed with retailers can be communicated back up the supply chain immediately, enabling components, materials and manufacturing resources to be allocated at the earliest opportunity.

Furthermore, it enables to combine catalogue data from several sources in a single retail management system by importing component specifications from multiple suppliers to a furniture design or manufacturing system.

However, due to the complexity associated with the implementation of standards, especially STEP standards, the SMEs require a push. Mechanisms to facilitate and accelerate the adoption task and simultaneously minimizing the costs are required. Therefore, this paper recommends a use-case based methodology to assist in the adoption of the funStep standard (AP236) by furniture related organizations and proposes a framework applying the principles of Model-driven Development to support dynamic integration geometry vital information in the form of visualization data to non-expert users.

Using the public DWG™ specification made available by the ODA, the authors implemented one instantiation of the framework, developing a DWG™ model, meta-model and parser, and defining the appropriate morphisms for intelligent integration with the X3D standard open format.

During the INNOVAFUN project, the presented framework has been validated in an industrial scenario from the furniture industry, where CADEF, a tool to build product catalogues has been successfully integrated with the framework. It enables access to visualization data for support in manufacturer catalogue creation and design.

Manufacturing and retailing systems are complex and dynamic. They need to be constantly adapting to new market and costumer requirements who more and more demand a faster and better quality service. Even standards need to be adjusted from time to time.

This behaviour is reflected in a constant fluctuation and evolution of business networks and system models, which makes interoperability difficult to maintain. The authors intend to address this non-linear problem in future research involving feedback, monitoring and prognosis mechanisms as part of the business networks. With these, they intend to include dynamism in the morphisms maintenance among systems, thus allowing automatic readjustments in the information flows without the need to reprogram the full systems.

---

[4] Open Design Alliance (http://www.opendesign.com/)

[5] open source Web3D toolkit (www.xj3d.org)

7 ACKNOWLEDGMENTS

The authors would like to thank all the organizations that supported the international projects that enabled the required budget for the development of the best practices and framework presented in this paper. Namely, the European Commission, the INNOVAFUN project partners that somehow contributed for the presentation of this work, CEN/ISSS and ISO TC184/SC4 for the effort in developing industrial standards and binding guidelines.

8 REFERENCES

[1] Global Competitiveness Council, 2006, Rising to the Challenge of Global Competition, State of Washington, USA.

[2] European Commission, DG for Enterprise and Industry, Europe INNOVA Annual Report 2006.

[3] funStep Interest group, 2004, SMART-fm marketing material for manufacturers, www.fsig.funstep.org, retrieved on 24 September 2008.

[4] Kemmerer SJ, 1999, STEP: The Grand Experience, NIST Special Publication 939.

[5] Almeida B, Agostinho C, Nuñez-Ariño MJ, and Jardim-Gonçalves R, 2008, Model Morphisms as an Enabler for Open Visualization of Product Data, 4th International Conference on Intelligent Systems (IS 2008), Varna, Bulgaria, September 6-8, 2008.

[6] ISO TC184/SC4, Industrial automation systems and integration -- Product data representation and exchange -- Part 236: Application protocol: Furniture catalog and interior design, Dec 2006.

[7] Jardim-Gonçalves R, Cabrita, RO, Steiger-Garção A, 2005, The emerging ISO10303 Modular Architecture: In search of an agile platform for adoption by SMEs, International Journal of IT Standards and Standardization Research (IJITSR), Vol. 3 (2). pp. 82-95, ISSN 1539-3062.

[8] Feeney A, 2002, The STEP Modular Architecture, Journal for Computing and Information Science in Engineering, Volume 2, Issue 2, 132.

[9] INNOVAFUN - EC INNOVA Project No.: 031139, 2007, Deliverable 1.2, Use cases and action plan for standard adoption and implementation.

[10] Brown J, Jiangang Z, Extended and virtual enterprises - similarities and differences, International Journal of Agile Manufacturing Systems, Volume 1, Number 1, 1999.

[11] Jardim-Gonçalves R, Agostinho C, Maló P, and Steiger-Garção A, 2005, AP236-XML: A framework for integration and harmonization of STEP Application Protocols, ASME-CIE2005: International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, 24-28 Sep 2005, Long Beach, California, USA.

[12] Peak RS, Lubell J, Srinivasan V, 2004, "STEP, XML, and UML: Complementary Technologies", Journal of Computing and Information Science in Engineering, Volume 4, Issue 4, 379.

[13] Jardim-Gonçalves R, Agostinho C, Maló P, and Steiger-Garção A, 2007, Harmonising technologies in conceptual models representation, International Journal of Product Lifecycle Management (IJPLM), Vol. 2 (2). pp. 187-205. ISSN 1743-5129.

[14] INNOVAFUN - EC INNOVA No.: 031139, 2008, Deliverable 2.1, Services for funStep standard adoption and design of new business practices.

[15] New Designs for Career and Technical Education Design Review No.61, http://newdesigns.oregonstate.edu/compendium/Organization/design61.htm, retrieved on 23 Sep 2008.

[16] Jardim-Gonçalves R, Onofre S, Agostinho C, and Steiger-Garção A, 2006, Conformance Testing for XML-based STEP Conceptual Models, ASME-CIE2006: International Design Engineering Technical Conferences & Computers and Information In Engineering Conference, 10-13 Sep 2006, Philadelphia, Pennsylvania, USA.

[17] Dalton-Taggart R, 2007, Interoperability—The CAD Vendors Speak Out, CADCAMNet magazine, http://www.caddigest.com/subjects/cad_translation/select/031507_cadcamnet_cad_vendors_speak.htm, retrieved on 24 September 2008.

[18] Van Wijk JJ, Views on Visualization, 2006, IEEE Transactions on Visualization and Computer Graphics, vol. 12 no.4, pp. 421-433, Jul/Aug, 2006.

[19] OMG, Model-Driven Architectures (MDA), http://www.omg.org/mda/, retrieved 24 Sep 2008.

[20] Atkinson C, Kuhne T, 2003, Model-driven development: a metamodeling foundation, Software, IEEE, vol. 20, Issue 5, pp. 36- 41, ISSN: 0740-7459, Sept.-Oct. 2003.

[21] Jardim-Gonçalves R, Grilo A, and Steiger-Garção A, 2006, Challenging the interoperability between computers in industry with MDA and SOA, Computers in Industry Vol. 57, Issues 8-9, Dec. 2006, Pages 679-689 Collaborative Environments for Concurrent Engineering Special Issue.

[22] InterOP NOE consortium, (2005) Deliverable DTG3.2: TG MoMo Roadmap.

[23] ISO/IEC FDIS 19775-1.2:2008 — X3D Architecture and base components Edition 2, Dec 2007.

[24] INNOVAFUN - EC INNOVA Project No.: 031139, 2008, Deliverable 2.3, Report on innovation: targeted solutions.