

Enhancement of Digital Design Data Availability in the Aerospace Industry

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Abstract

This paper presents the development of a roadmap to enhance the current utilisation of digital design data within the aerospace engineering discipline. Within companies, many decisions have to be taken throughout the product design and development based on accessing data and information. The quality and timeliness of such decisions depends on the data availability. Therefore, there is a need for enhancing the digital data availability in order to make better decisions in a shorter time, reducing the product lead time. This research project, which conducted in collaboration between Airbus in the UK and Cranfield University, has identified opportunities to exploit the access and sharing of digital data, specifically within the stress population through the use of Digital Mock-Up colouring and lightweight visualization.

Keywords:

Digital Design Data; Product Design; Aerospace Industry

1 INTRODUCTION

In the current global competitive environment, companies need to face and respond to many challenges. One of these challenges is the data explosion that has taken place in the last decade, involving the increase and integration of the outsourcing to the extended enterprise. Thus, companies need to manage increasing datasets, and have to allow their employees and partners to access, share, use and integrate it easily, at the right time, the right place, the right format and the right quality.

The massive quantity of data and tools represent the main barriers to the access of digital data. Thus, to compete, companies need to manage data as they are managing any other resource in the company and that they have to use the best of the technology. For instance, in the design process, 3D modelling has increased significantly and its access allows people to use the information much more rapidly. The improvements in terms of managing data tools and technology have helped companies to deal with this new challenge. However, the quantity and complexity of the tools and processes can make this data difficult to access.

With constant improvement of the technologies and the Internet revolution, digital data has become the source around which decisions are based. Specifically, in the design process, companies have to deal with a large amount of data and processes.

Entering a 3D world was a huge revolution but it creates numerous extra data. Engineering companies are significantly increasing their dependency on 3D data, in-line with its 3D as master policy. For instance, some of these companies proposed to eliminate 2D drawings through enriching the 3D.

As the quantity and quality of the data in the 3D model increases, the digital data accessibility and availability has to be reviewed in order to identify new customers and use of the data. The current issue of increased data volumes, more complex systems/processes and a wider spread extended enterprise make it difficult to clearly communicate, and enable everyone to take advantage of new technology, capability and flexibility provided by digital data. Thus, there is a need for enhancing the digital design data availability for its use in supporting product design, engineering and development, in order to make better decisions in a shorter time. Therefore this research project focuses on digital design data in the aerospace industry. The main aim of this research is to develop a roadmap to enhance the utilisation of digital data within the aerospace engineering discipline, both in terms of optimizing existing processes and identifying new methods of visual management techniques.

2 RELATED LITERATURE

Nowadays, data explosion is one of the most important problems that the companies need to manage. According to Walker [1], a business in 2007 needs to store ten times more data than in 2000. In the same way, Gartner Consulting estimated that in 2012, this factor will be increased by thirty. It is really important to understand that in the past 30 years, the information technology utilisation has become widely circulated, mostly within the design, engineering and manufacturing processes.

Thus, data management methods need to focus on the retrieval of data. Indeed, storing data is nowadays quite quick and easy but finding the data and information that you need in the vast quantity of stored data is definitely much more difficult [2].

It has been identified that up to 80% of product costs are defined during early concept design [3]. Engineering companies need to improve constantly their product life cycle by working on the triptych cost-quality-time. For instance, the last years have seen a diminution of a car life cycle from 10 years to only 4 to 6 years nowadays [4]. Thus, accessing and sharing digital data appears to be a key success factor in the centre of this significant change. Indeed, with the globalisation, companies have to work with suppliers and partners all over the world and sharing quality data in real time is a daily challenge [5].

In recent years, one of the major improvements in terms of sharing and accessing data was the implementation and utilisation of Virtual Reality (VR) resulting in reducing product development lead-time.

VR represents a model "which is not real, but may be considered to be real while using it" [6]. One of the main advantages by using VR is the replacement of the majority of real prototypes by a virtual one. Thus, the design can be reviewed and modified before any physical prototype is built [7]. Indeed, VR allows a simple visualization, representation and analysis of a complex 3D model [8]. Therefore, the utilisation of virtual systems implies a large improvement in terms of time, costs and quality, achieving a better integration of processes and focusing on the producibility and affordability. There are many different VR systems, crossing video games, gloves systems, head-mounted display systems, Digital Mock-up (DMU), graphical computers and many others.

Wang [9] describes the DMU as a virtual prototyping technology that comprises the use of virtual reality and others technologies to allow the building of the digital prototypes. The DMU is a 3D representation integrating all engineering, design, maintenance, and manufacturing requirements.

McBeth et al [10] emphasised that DMU utilisation has improved the sharing of data between the OEM and supply base. The DMU, if used daily by the design teams, can provide a dynamic representation of the current state of the product design evolution and employ to resolve issues. However, the main benefits are being gained in the manufacturing areas due to the improved communication between design and manufacturing during the design process. The DMU also provides benefits to predict the structural behaviour of a product, to forecast the aerodynamics, to design and test complex systems, to anticipate human interaction with the product and to predict the effectiveness of the maintenance [11]. In terms of work, using the DMU mainly improves speed, schedule shortening, technical quality, concurrence engineering approach and costs reduction [12].

Technology is increasingly used by companies and workers to help them to accomplish their daily tasks, to communicate with others and learn new competencies. To respond to the consistent spreading of the companies and the increasing numbers of suppliers, which need to work on a same project with people around the world, a new technology is born: the virtual meeting room [13].

This virtual environment is a huge improvement in terms of technology and exchange of information as it incorporates the feeling of "being there". Thus, this new type of collaboration allows the user to directly interact with the virtual environment as if it was a real room since it comprises audio, text communication, documents and characters [14, 15].

Several companies as Intel, Raytheon, BP and HP have started to develop and used this type of virtual room. They have even started to go further in the utilisation of the virtual room by using it not only for meetings but also for trainings, customers' relationship and private

collaboration. For these companies, this new technology has unique advantages such as maintaining peoples' attention, not feeling alone, seeing facial expressions, collaborating in real time, and solving problems more quickly than with current tools [16, 17].

However, this new technology is still expensive and in its pioneering days. It appears quite difficult to use this virtual room for the moment as its use is not enough instinctive and people need practice to navigate in the environment. But within five years, the virtual room will certainly take the same importance in the worker's life than the Web as it opens the world of the 3D Internet [13].

The literature review has highlighted that there is a lack of research projects focused on the enhancement of utilisation of digital data. Therefore this research project has attempted to fill in this research gap by developing a set of recommendation to enhance the current utilisation of digital design data especially in the aerospace industry.

3 RESEARCH METHODOLOGY

3.1 The Case Study Company

Airbus is a leading manufacturer of commercial aircraft in the world through innovation, cultural diversity and commitment. Specifically, Airbus in the UK is the centre of excellence in the design and manufacturing of aircraft wings. The design office at Filton - one of six within Airbus - manages the design of all wings for the whole Airbus family of aircraft. It is also responsible for the design integration of the landing gears and fuel systems [18]. Within such a multicultural company, employees need to work with partners and suppliers worldwide, exchanging knowledge, experience and ideas.

3.2 The Approach Adopted

The research project commenced with a familiarization stage through the literature and the use of informal interviews with key employees and regular visits to Airbus in the UK. The data collection focused on the processes, the customers and the uses of digital design data. This phase allows identifying the users of digital data and capturing their expectations and requirements. Figure 1 illustrates the adopted research methodology.

The different opportunities for improvements in terms of access and sharing of digital data have been identified through the data analysis phase.

To identify possible improvements in the utilisation of digital data within the design process, the most important step was to capture the requirements and expectations of the employees. It was really important to understand what they needed to achieve and the way they were actually working in order to capture any possible requirements that could help them to achieve their deliveries. Key representatives in different disciplines and aircraft programs were selected.

A semi-structured questionnaire was employed in this study, characterized by five main areas of focus: introduction, job description and tools used, access of digital data, Key Performance Indicators (KPIs) and facilities. The questionnaire was designed to capture the role and responsibilities of the interviewee, their daily tasks and the tools they use to accomplish their work.

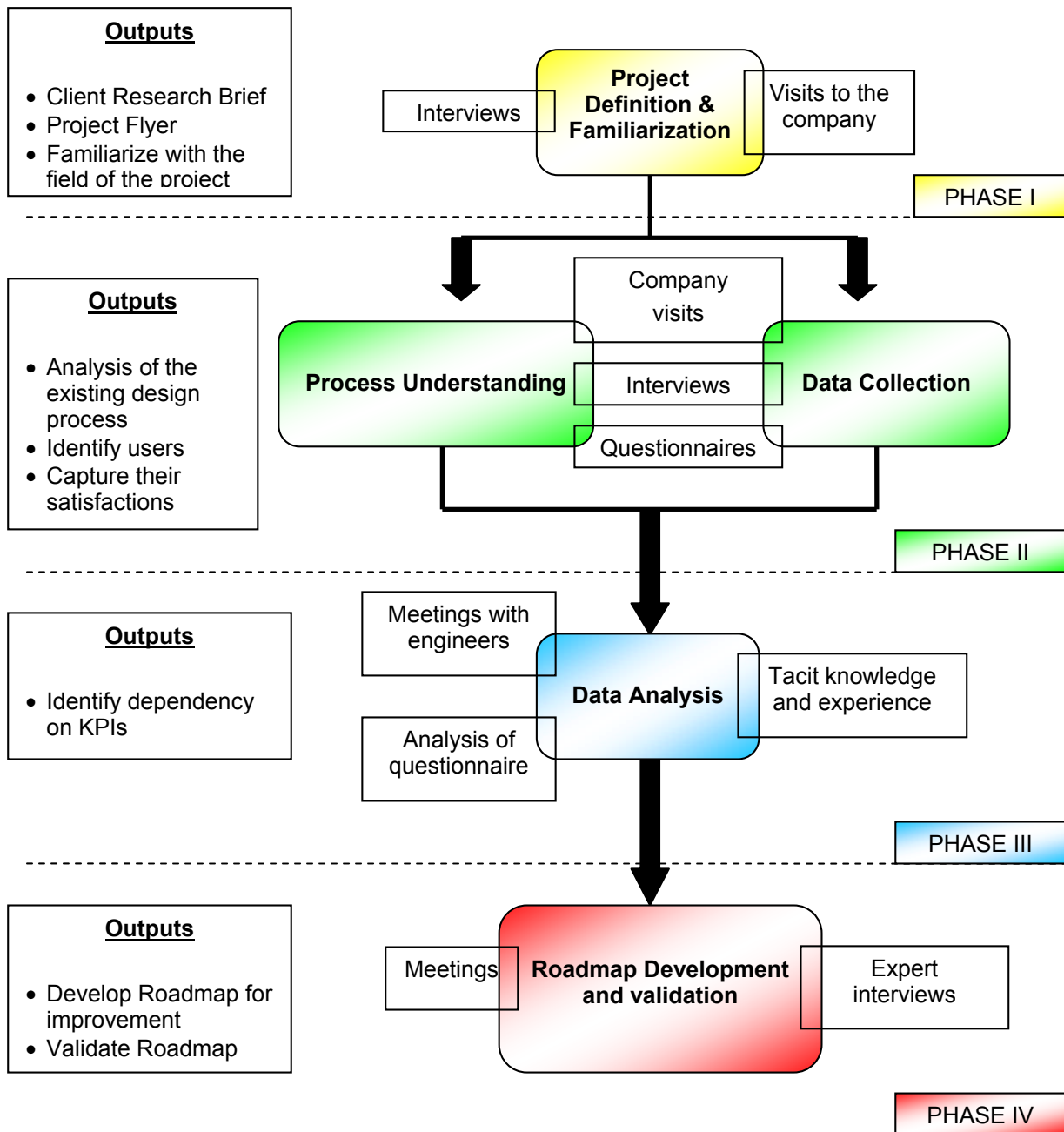


Figure 1: The Research Methodology Adopted

The following are samples of the questions employed in this study:

- What are the various tasks during your day to day job and what are the tools you need to achieve your job?
- What kind of digital design data do you need to access?
- What kind of digital data do you need to extract?
- From your point of view, what are the areas that could be improved?

In order to capture the satisfactions and requirement of Airbus in the UK employees in the design process, fifteen interviews were carried out with different aircraft program

representatives. The specific function representatives interviewed were Designers, DMU Managers, Engineering Program Managers, Lead Designers, Weight Engineers, Stress Engineers, Senior Design Integrators and Head of Product Enablement.

Finally, the last phase represents the creation of a roadmap, giving a set of recommendations and improvements necessary to improve the digital data use process. The roadmap was validated by a set of experts present in the company in order to improve and accept the proposed solutions.

4 THE ROADMAP DEVELOPMENT

The roadmap has provided several areas for improvement. This paper presents three areas, which are the improved access to 3D models for stress engineers, the DMU colouring and the use of a lightweight visualization. There are another four areas of improvement that can be obtained from Bouin-Portet [19]. These areas were selected based on the short-term implementation, the technical feasibility and the rapid return on investment.

4.1 The Stress Issue

In Airbus in the UK, not all stress engineers have direct access to native 3D. The stress population has two specific requirements in the access to the 3D model. They need to have access to the 3D model for:

- Visualizing the 3D Model such as Assemblies or components in order to understand how it fits together. Thus, they need to have a global view of the model.
- Obtaining components measurements and dimensions in order to perform the stress and finite analysis. Therefore, they need to have access to a Detailed View with a specific accuracy.

However, the stress engineers may need to work with large volumes of 3D data. Therefore, they need assistance from designers who have CATIA access to find the necessary 3D information for them. Accordingly, a possible lead-time improvement has been identified for both the stress and the design population. Indeed, it was evaluated that stress engineers and designers could save between 2 and 2.5 hours per week by having a direct access to the 3D model.

4.1.1 Global View Solution

For the visualization requirement, two solutions were investigated: the use of a lightweight visualization format and the use of product view. A lightweight visualization is a light-view format of the 3D Model, created from the CATIA Model. Product View is the software that allows seeing the 3D Model through a Product Data Management (PDM) system. Both can allow the stress engineer to have a global view of the 3D model. After an in-depth study of both solutions, it appears that the best solution is the use of the lightweight visualization format, as the Product View solution cannot visualize large assemblies, due to restriction of the PDM capabilities.

The use of a lightweight visualization will allow the user to have a quick global view of the 3D model. Moreover, one of the most significant advantages to use such a format is that a user does not need any training to access it. The user needs only to install a viewer to visualize the files.

4.1.2 Detailed View Solution

For the measurement requirement, the solution of lightweight visualization is not appropriate since it is not accurate enough. Thus, three different solutions were investigated: the use of CATIA, the use of the DMU and the use of Product View. The conclusions of this investigation are the following:

- The DMU turned out to be not enough accurate to take measurements.
- CATIA could allow taking measurements but it involves at least a four full days training to get an

access and it seems complex for people who do not use it daily.

- Product View seems to be the good solution but the accuracy needs to be checked.

In order to investigate if Product View has enough accuracy to obtain components measurements and dimensions, a test was carried out to understand the limitations of Product View. Thus, a stress engineer calculated the necessary measurements in CATIA and in Product View in parallel for the same component in order to make a comparison in terms of measurement and ease of use.

The conclusions of using Product View were the following:

- Component measurements can be obtained within 0.001 mm accuracy
- Easy to do measurement
- Quicker than CATIA to load a part
- Just need a PC and not a Unix Station

The direct time saving of using both a lightweight visualization and Product View was estimated at one hour a week for the stress engineers and two hours a week for the designers.

4.2 The DMU Colour

The case study employees need to have an easy access to some information located in the Product Data Management System. For instance, they would need to have a global view on the maturity phase, the released information of components and assemblies to monitor the design progress, or they would need to identify the parts from a certain supplier. Moreover, they need to see this information at a part level visualizing at section such as the Trailing Edge.

Nowadays, to access this kind of information, employees need to extract it from the PDM system and transfer it in an Excel sheet. Then, they reorganize it in order to keep the data they need and make the information easier to read. This is an inefficient process which can be improved upon through better integration between the data source and the visualization tools.

The solution proposed is to colour the DMU in order to highlight any attribute required by the customer for example, the different levels of maturity of design data and Data for Manufacturing (DFM) phase by parts or the parts according to a specific supplier.

A script already exists to colour the DMU. However to apply this macro, employees need to generate a KPI table, open the DMU in CATIA, run the macro manually from the KPIs table and save the file in another folder. It is why the solution has not been deployed yet within Airbus in the UK. Thus, the goal is to automate the macro and combine the results with the lightweight visualization to allow the management population and the non-CATIA specialist to access easily this kind of information.

The use of the colour in the DMU will allow Airbus to gain significant time in review meetings and in their daily work, to have better tracking, control and monitoring, and to have visual management in-line with a lean engineering approach. However, due to the nature of the requirements and benefits, it is quite difficult to quantify and measure these savings in terms of time and money.

The implementation of the DMU colour solution will require achieving the following stages:

- Automatic creation of KPIs in line with customers requirements
- Creation of a script to automate the macro
- Save the files as lightweight visualization to make it available to non CAD users

It will then be possible to colour the DMU with different colour according to specific criteria and to make it accessible easily to the management population.

4.3 The use of lightweight visualization

The lightweight visualization is an interactive visualization tool used in a PC environment. It allows a global view of the 3D model in a non-CAD environment and complements the Digital Mock-Up. However it cannot assist structural analysis. The main audience of this tool are the non-CAD users, the management population and most of the engineering population such as stress engineers, lead designers and program manager. Nowadays, hundreds of people are currently using the lightweight visualization in a recent aircraft program.

In Airbus in the UK, the lightweight visualization files are currently created manually two or three times a week. The users can access these files with user rights.

The proposed solution involves the following steps:

- Automate the creation of lightweight visualization files by writing a script. It represents one to two weeks of work
- To update the files every day
- Create a portal or a Webpage to allow people to access it and to get a better control
- Communicate this new tool through Splash screens, Team managers, Presentation in the digital data sharing facilities...

Thus, the first stage in the implementation of this solution will involve the creation of a script to allow the automatic creation of lightweight visualization at a section level.

Many benefits are associated to the use of the lightweight visualization format. A user does not need any software application to access it and can visualize large geometry once the files are created. To maintain data integrity and Intellectual Property Rights, the user cannot share the files easily by sending presentation for instance, which allows a better control and tracking of the information. The lightweight visualization can also allow visualising a particular configuration, a product structure. Finally, one of the most important advantages of such a format is that it allows to non-CAD users to gain an access to the 3D model with an ease of use and without any training, improving communication, encouraging management in 3D world, and supporting the concurrent engineering and single source approach of Airbus.

5 VALIDATION

The Digital Wing team and the users of the digital design data carried out the validation of the recommendations. However, a workshop with a set of 12 experts was organized to present the proposed solutions. DMU Managers, Mock-Up Integrators, PDM Support, Application Support, Head of Product Enablement, Digital Data Manager, Digital Data Capability and Enablement, and Digital Data Quality and Performance Managers were involved in this workshop. The workshop commenced with presenting the problems and the proposed solutions as well as a discussion for each of the areas of focus.

The workshop members were enthusiastic and interested in the proposed improvements. Several issues of focus emerged from the discussion. For instance, for the stress issue; it appears important to find an official document proving that Product View has the right accuracy to allow measurements.

The DMU colouring is considered as really useful. The Head of Product Enablement "This solution shows that the DMU is really powerful but not used at its plain capabilities". Some employees would like to implement this information such as the materials to differentiate between metallic/composite and supplier sources.

6 ROADMAP IMPLEMENTATION: FIRST STEPS

After the validation of the proposed roadmap, several steps have started in preparation for the implementation of the DMU colour and the lightweight visualization changes.

6.1 DMU Colour

In order to develop an automated DMU colouring capability, a pilot was presented against a sample dataset of an aircraft. To allow the development of a sample dataset, several tasks needed to be performed. First, a KPIs table was created automatically, including the part number associated to the stage of maturity or DFM. Then a macro that was already created was applied to this KPIs table. Finally, the files created were saved as lightweight visualization to facilitate its access and make it available to non-CAD users. The DMU colour differentiated the parts that are released (Green), those that are waiting to be released (Amber) and those that are in-work (Red).

6.2 Use of lightweight visualization

In order to develop the lightweight visualization solution and to allow an easy access to the files, several actions have been put in place. The technical side of the implementation includes:

- Formalizing a structure breakdown,
- Setting up a secure space to store the files by locking off the X-drive for a better control and security,
- Creating a script for CATIA to create the lightweight visualization files automatically,
- Creating an interface for an intranet webpage.

The two first steps were performed. The third step is waiting for being performed by the Data Exchange Department, which means that in short-term the files will be created manually. The last step includes a specific request to allow the creation of the webpage. Finally, in order to deploy the tool, the communication chosen includes a presentation to key managers with a demo in the facilities available, emails and splash screens and possibly an article in the company internal magazine.

7 CONCLUSIONS

The roadmap to enhance the current utilisation of digital design data within the aerospace industry was presented. There are opportunities to enhance the digital data availability in order to make better decision in a shorter time to reduce the product lead-time.

The paper focuses on three main areas including the Stress, the Digital Mock-Up (DMU) colour and the potential use of the lightweight visualization. The proposed solutions were developed and validated, presenting the best way to achieve the goal, considering

the short-term implementation necessary to get immediate benefits and the technical feasibility of the new change.

The initial stages of implementing the developed roadmap have commenced within Airbus in the UK. The main benefit achieved by implementing the new solutions will be time savings for the digital design data users.

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9 REFERENCES

- [1] Walker, D.M. (2007). How Data Works. White Papers and Research.
- [2] Teradata (2006) – Master Data Management. Available: <http://www.teradata.com/t/pdf.aspx?a=83673&b=145653> (Accessed on June 18, 2008)
- [3] Shehab, E., Abdalla H., 2006, A Cost Effective Knowledge-Based Reasoning System for Design for Automation, Proceedings of Instn Mech Engrs (IMechE), Part B: Journal of Engineering Manufacture, 220 (5): 729-743.
- [4] Netto, A.V. and De Oliveira, M.C (2004). Industrial application trends and market perspectives for virtual reality simulation. Revista Producao, Vol. 4, No 3.
- [5] Bennis, F. et al. (2005). Virtual Reality: A human centered tool for improving Manufacturing. In: Proceeding of Virtual Concept 2005 Conference, Biarritz, France.
- [6] Hand, C. (1994). Other Faces of Virtual Reality. In: East-West International Conference on Multimedia, Hypermedia and Virtual Reality.
- [7] Bao, J.S. et al. (2002). Immersive Product Development. Journal of Materials Processing Technology, 129, p. 592-596.
- [8] Monacelli, G. (2003). VR Applications for reducing time and cost of Vehicle Development Process. ATA –TORINO, Vol. 56; Part 7/8, p. 236-241.
- [9] Wang, G. G. (2002). Definition and Review of Virtual Prototyping. Journal of Computing and Information Science in Engineering, Vol. 2, No. 3, p. 232-236.
- [10] McBeth, C, Tennant, C and Neailey, K (2006). Developing products in the global environment using digital technology – A case study. ICE Proceedings, 25 July 2006.
- [11] DassaultSystemes (2006) – Digital Mock-Up Revolution in the Air. Available: www.cdcza.co.za/DMU%20in%20Aerospace_FINAL_Eng.doc (Accessed on June 16, 2008)
- [12] Giordano, P. (2002). Innovative Technologies in the AIT Process: The Digital Mock-Up for Integration and FMECA Modelling for Troubleshooting Support. In: 1st ESA Space System Design, Verification and AIT Workshop, Estec, Noordwijk.
- [13] LAW (2007) – Virtual Room 101. Available: <http://www.law.com/jsp/legaltechnology/pubArticleLT.jsp?id=900005497672> (Accessed on July 5, 2008)
- [14] Casanueva, J. and Blake, E. (2000). Presence and Co-Presence in Collaborative Virtual Environments. Technical Report CS00-06-00, Department of Computer Science, University of Cape Town.
- [15] Mogensen, P. and Gronboek, K. (2000). Hypermedia in the Virtual Project Room – Toward Open 3D Spatial Hypermedia. In: 11th Conference on Hypertext and Hypermedia, San Antonio, Texas, p113-122
- [16] BusinessWeek (2007) – The Virtual Meeting Room. Available :http://www.businessweek.com/technology/content/apr2007/tc20070416_445840.htm (Accessed on July 23, 2008)
- [17] HP (2006) – HP Virtual Rooms Available: http://h10076.www1.hp.com/education/hpvr/hpvr_orderfaq.htm (Accessed on July 15, 2008).
- [18] <http://www.airbus.com>
- [19] Bouin-Portet, M (2008). Enhancement of Digital Data Availability in the Aerospace Industry. MSc Thesis, Cranfield University.