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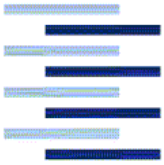

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CARISMA:
Aircraft Cabin and Cabin Systems Refurbishing,
Optimization of Technical Processes

Research, Analysis, Evaluation and Selection of Tools

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This Technical Note investigates several commercial tools for the use within a Completion Center. First, the most important tool categories are identified. Second, an evaluation of the most popular tools for each category is made. Third, two solutions fitting the Completion Center requirements are proposed. Furthermore, the report investigates possible solutions for additional issues, such as writing technical documentation, using 3D scanners for reverse engineering or using tools certified under Configuration Management II. The results show that for design and engineering, analysis and simulation it is better to use well established tools, while data administration tools can contain different modules, adaptable to the Completion Center needs. The selection process of data and resources management tools should be carefully conducted.</td></tr>
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Diese Technische Niederschrift untersucht verschiedene kommerzielle Werkzeuge, die in einem Completion Center erforderlich sind. Erstens, werden die wichtigsten Werkzeugkategorien identifiziert. Zweitens, wird eine Bewertung von den populären Werkzeugen für jede Kategorie gemacht. Drittens, werden zwei Lösungen vorgeschlagen, die für ein Completion Center geeignet sind. Weiterhin, untersucht diese Technische Niederschrift zusätzliche Lösungen für andere Aspekte wie technische Dokumentation, 3D Scanner oder Werkzeugzertifizierung durch Configuration Management II. Die Ergebnisse zeigen, dass es für Auslegung, Entwurf, Analyse und Simulation besser ist, etablierte Werkzeuge zu nutzen. Werkzeuge zur Datenverwaltung können viele Module enthalten, die sich an die Anforderungen des Completion Center anpassen. Von daher, sollen die Werkzeuge zum Daten- und Ressourcenmanagement sorgfältig ausgewählt werden.</td></tr>
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Abstract

This report covers the selection process of tools in order to meet the needs of a Completion Center. The areas of this study concern design and engineering, data management, quality management and resource management. Tools which provide assistance in these domains are known as Computer-Aided Design (CAD), Product Lifecycle Management (PLM) and Enterprise Resource Planning (ERP). The tool selection is based on different criteria which fit to each category of tools. The results show that a range of different tools needs to be adapted to the entire set of requirements throughout the process chain. Tools must be able to communicate and sometimes be linked to each other. All the management tools (for data or resources) have to be configured and customized according to the company needs and the CAD solution used. The report also investigates possible solutions for additional issues, such as writing technical documentation, using 3D scanners for reverse engineering or using tools certified under Configuration Management II. A catalogues of tools, briefly describing each meaningful tool, is presented in the appendix.

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List of Abbreviations

AECMA	European Association of Aerospace Industries
ASD	Aerospace and Defense Industries Association of Europe
ATA	Air Transport Association of America
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CBP	Core Business Processes
CCO	Cabin Conversion (Department at ELAN GmbH)
CFD	Computational Fluid Dynamics
CM	Configuration Management
CPDA	Collaborative Product Development Associates
CRM	Customer Relationship Management
DM	Data Modules
DS	Dassault Systèmes
DWG	Documentation Working Group
ECAD	Electrical Computer-Aided Design
ERP	Enterprise Resource Planning
EKM	Engineering Knowledge Management
FEM	Finite Element Methods
FEA	Finite Element Analysis
HCM	Human Capital Management
IT	Information Technology
ICM	Institute of Configuration Management
MRO	Maintenance, Repair and Overhaul
MCAD	Mechanical Computer-Aided Design
MPM	Manufacturing Process Management
MPS	Master Production Scheduling
MRP	Material Requirement Planning
NASA	National Aeronautics and Space Administration
PDM	Product Data Management
PLM	Product Lifecycle Management
RFID	Radio-Frequency Identification
SCM	Supply Chain Management
SDM	Simulation Data Management
SE	Simplified English
SEUC	Division at Airbus responsible for Upgrade Cabin Operations
VPM	Virtual Product Management

1 Introduction

1.1 Motivation

This Technical Note (TN) is part of the research project CARISMA which is aimed to deliver results for ELAN GmbH with respect to the vision „Completion Center". The subject treated here refers to WP 4, described in the appendix of the collaboration contract between Hamburg Innovation GmbH and ELAN GmbH as follows (**CARISMA 2009**):

> ***WP 4: Research, Analysis, Evaluation and Selection of Tools***
> *In the frame of the present activities of the CCO department, different tools are being used. Some of these tools are either specified by the ordering customer and have to be bought by ELAN. In other instances, tools of the customer can be used by ELAN through data links between ELAN and the customer. These tools are: CAD-Systems, databases and archives which can be used in the following domains:*
> - *Design and layout*
> - *Design and drawings (also for electric systems)*
> - *Quality management*
> - *Documentation*
>
> *Tools that provide assistance in these – and even more general areas – are known as:*
> - *Enterprise Resource Planning - ERP: Assistance in planning resources for the whole enterprise.*
> - *Product Data Management - PDM: Storage of data and documents as a result of the product development.*
>
> *For the determination of the required tools, necessary for the "completion center" scenario, the following approach is proposed:*
> - *Analysis and evaluation of the tools used at ELAN (e.g. tools for the layout design, such as tools of the company Pace: Pacelab Cabin, Retrogen, PSUGen).*
> - *Identification of other possible tools (e.g. tools for a 3D representation of the cabin), which could be useful for the process phases of a cabin conversion.*
> - *Research and evaluation of the available tools on the market.*
> - *Proposal of a range of tools for ELAN to adopt, having in mind past and future activities.*

1.2 Purpose of Work

The cooperation between ELAN GmbH and HAW Hamburg has the purpose to bring ELAN forward on its way to develop itself and to create the resources to receive greater work packages in the frame of cabin conversions, having in mind the vision „Completion Center".

Technical Note 4 aims to investigate suitable tools on the way of setting up a Completion Center. The outcome of this research is a range of good up to very good rated tools that are able to reduce rework and therefore optimize the processes inside the company. One of the most important arguments for the selection of new software was that an aircraft life – from design development

up to out of service – is in average at least 30 years. Data needs to be available during the whole lifecycle. Therefore, design tools in aeronautical industry must be able to read and access old and future data while ensuring a stable customer service throughout the whole aircraft lifecycle.

1.3 Literature

The primary sources of information for this work are the software‟s editor release notes. The characteristics and functionalities of each tool have been deducted according to the public documents available on their homepages. Additionally, the companies were contacted via E-mail or telephone in order to get more precise information.

An important contribution to this work was also brought by the ELAN IT service that supported the research by sharing information about the tools currently used at ELAN and some criteria of evaluation for the different software programs.

1.4 Structure of Work

The Report is comprised of five chapters, besides the introductory and the conclusion chapter.

Section 2 **Categories of Tools and Corresponding Requirements -** presents all relevant tool categories, including a short description of each category.

Section 3 **Tools Currently Used at ELAN** - lists the tools used today at Cabin Conversion department at ELAN. ELAN works mainly as a subcontractor for Airbus. This chapter also shows which tools are not available outside this context.

Section 4 **Evaluation of Relevant Commercial Tools** - presents commercial tools suitable for an independent Completion Center, some of which are able to replace the non-commercial tools previously used as an Airbus partner. The description of the functionalities of the different selected tools is followed by a short evaluation of the capabilities and a comparison between tools of a same category.

Section 5 **Selection of Best-Rated Tools for the Use within a Completion Center** - summarizes the most important results of the evaluation and proposes a range of tools to assist the Completion Center activities.

Section 6 **Case Study – Special Tools** - presents tools able to perform additional functions within a Completion Center. The functions mentioned in this chapter are not essential but can help by increasing the work quality and by saving time.

Appendix A presents exemplarily illustrations obtained with a rendering tool. Appendix B provides a general description of all the relevant tools mentioned throughout the Technical Note. The description includes references to the homepage of each tool manufacturer.

2 Categories of Tools and Corresponding Requirements

2.1 Design and Engineering

The category *Design and Engineering* refers to the Computer-Aided Design (CAD) tools. CAD tools are used to produce 2D drawings or 3D models.

The main utility of the tools in this category in a completion process is during the *Conversion Processing Cycle*, i.e. during the *Design Phase*, but also for generating the *Documented Technical Solution* in the *Offer Phase* (**Niță 2009**). The preliminary layouts required during the *Offer Phase* help clarifying the customer requirements and become very meaningful during the negotiations. However, in order to generate preliminary cabin layouts at this early stage a simpler tool, specialized only in this field may be a better choice rather than using the well established *CATIA* tool. The accuracy of drawing would not be the most important issue, but the way the layout itself can approximately look like. Therefore, for a CAD tool, the rendering and visualization capabilities become important during the *Offer Phase*.

It is to be noted that especially CAD tools need to be very well established on the market. The tool needs to be available and the versions compatible to each other throughout the entire lifecycle of the aircraft, in order to perform modifications to the original drawings.

2.2 Analysis and Simulation

Tools dedicated to Analysis and Simulation are called Computer-Aided Engineering (CAE) tools. CAE tools allow stress calculations or mechanical simulations for aircraft components.

The main contribution of the tools in this category inside the completion process chain is within *Design Phase* of the *Conversion Processing Cycle* (**Niță 2009**). The CAE tools are essential in a Completion Center due to the fact that stress calculations play a key role in certifying the design.

In most of the cases analysis and simulation tools need to be coupled with CAD programs, which provide the platform for the calculation. Compatibility problems may become an issue.

2.3 Data Management

All data produced by the Completion Center must be archived and managed. Factors like accessibility or controllability are vital. Tools able to respond to these requirements are called Product Data Management (PDM) or Simulation Data Management (SDM) when the stored data are the result of CAE tools.

The data management tools are important due to the fact that their use is required along the entire process chain of cabin conversion. The use of a qualified tool allows considerable time reduction during the design /redesign process.

Moreover, after product delivery, an aeronautical engineering company must ensure customer support services throughout the entire life of the respective product. Accordingly, PDM tools usually include a module called Product Lifecycle Management (PLM) with the capability to manage the entire lifecycle of a product from its conception, through design and manufacture, to service and disposal.

There are as many definitions of PLM and its derivatives as there are players in the world of product development, processes and project management. The PDM concept appeared before PLM.

The fundamental concepts of PLM are (**CIMdata 2010**):

1. Ensure universal, secure, managed access and use of product definition information.
2. Maintain integrity of product definition and related information throughout the life of the product.
3. Manage and maintain business processes used to create, manage, disseminate, share and use the information.

The main difference between PDM and PLM resides in more developed Project Management capabilities for PLM tools, while PDM tools are focused on technical data management, coming from design office (**ECP 2010**).

2.4 Resources Management

Tools serving Resources Management are called Enterprise Resource Planning (ERP). ERP is an integrated computer-based system used to manage internal and external resources including tangible assets, financial, material and human resources.

The advantages of adopting an ERP tool are (**Beguigneau 2003**):

- Reduced number of databases,
- Annulment of tasks related to information transmission,
- Enlarged process overview, allowing to:
    - reconsider and optimize all processes,
    - make optimized management choices,
    - increase transparency, traceability,
    - optimize trades.

ERP can also include other modules like PLM or Customer Relationship Management (CRM).

The features and the configurations of these tools are adaptable to best fit to the enterprise. However, for a company like a Completion Center, ELAN IT service recommends the two following tools (**Voigt 2010a**):

- *Sage ERP X3 Premium Edition*
- *SAP Business Suite*

Two other major ERP tools are:

- *Microsoft Dynamics*
- *Oracle E-Business Suite*

Appendix B provides a more detailed description of these tools.

3 Tools Currently Used at ELAN

Today ELAN‟s activities as subcontractor for aircraft manufacturers (like Airbus) or MRO‟s (like Lufthansa Technik) require the utilization of tools having the same functionalities as enumerated in Section 2. Additional tools are required by the customer for data transfer and data management (e.g. TAKSY).

3.1 Design and Engineering

The CAD tools used at ELAN for cabin refurbishing activities are:

- *CCD*
- *CATIA*

CCD is used only to generate 2D solutions, while *CATIA* can perform both 2D and 3D layouts. For reasons of compatibility today 2 different versions of the CAD tool *CATIA* are used: *V4* and *V5*. This software is well known at ELAN and its use is foreseen also for the future. It makes therefore little sense to provide here a detailed description of this tool.

3.2 Analysis and Simulation

Different commercial CAE tools are currently used at ELAN. Additionally, ELAN has access to some non-commercial Airbus-customized interfaces (see the list below). These modules are Airbus-in-house tools that are not available for an independent Completion Center.

Commercial CAE tools are:

- *Nastran*
- *Patran*
- *Abaqus*
- *ANSYS*

Airbus‟s interfaces for these tools:

- *Issy* (**I**ntegrated **S**tructure Mechanical **Sy**stem), using *NASTRAN*
- *Simulpac* (**Simul**ation of **P**anels in **A**ir**c**rafts), using *Abaqus*

- *Vital* (**Vi**rtual **T**est **A**na**l**ysis), using *ANSYS*

Appendix B provides a more detailed description for each of these and further tools mentioned throughout this report.

3.3 Databases and Accesses

Today ELAN does not possess a database of owned drawings. Nevertheless engineers have access to Airbus databases through several tools. They also have the authority to modify and release drawing data (see Table 3.1).

Table 3.1 Tools currently used at ELAN providing access to different databases

Tool's name	Editor	Description
TAKSY	Airbus tool	Allows the administration of drawings data
VPM	Dassault Systèmes (Commercial tool)	Allows access to *CATIA* objects in Airbus database
Primes	PTC for Airbus	Product Related Information Management Enterprise System: PTC *Windchill* (PLM tool) customized for Airbus.(**MCS 2002**, **Machine Design 2003**)
Zamiz	Acando (customized for Airbus)	Centralized archive with online access for over 20 000 users worldwide. In fact it is a browser which displays layouts in PDF files.
DVO-Browser	DVO (for Airbus)	Allows browsing of CCD files (also known as *DVO-CCDraft-Browser*)
DocMaster		Browser for Airbus databases.
AirN@v	Airbus (for airlines)	Maintenance tool. Provide access to aircraft manuals.
Airbus People	Airbus	Airbus portal for employees and on-site subcontractors (only in internal rooms)
SEUC-Recherche-Datenbank	Airbus	Provide access to the data base of the division at Airbus responsible for Upgrade Cabin Operations (SEUC)
Aircraft Manuals	Airbus	Database of Airbus Aircraft Manuals (see **Niță 2009**)
SB-COMP	Airbus	Tool for Service Bulletin management.

Most of these tools (except VPM) are customized for Airbus and are not available for independent Completion Centers. However, these tools are easily replaceable. For instance, the aircraft manuals can be accessed via customer airline, a PDM tool can be used for administrating owned drawings, and different browsers can be used for accessing data.

In addition to the tools mentioned above, Airbus provides several portals for collaborators to access the information in the most effective way. Thus the collaborators have a non-stop direct access to the documents and do not have to wait for an email or a CD. Figure 3.1 illustrates the three portals: customers, suppliers and employees (**Airbus 2007**).

Fig. 3.1 Portals for Airbus collaborators

The PDM or PLM tool chosen by the Completion Center will have to manage the documents inside the future ELAN‟s database through an intelligent interface. The tool would have to link the documents to the appropriate project. An additional browser dedicated to documents from external sources would also be required if the chosen PDM / PLM tool does not provide a satisfactory management.

4 Evaluation of Relevant Commercial Tools

4.1 Evaluation Criteria

4.1.1 Design and Engineering

Usually the work of a Completion Center is required late in the aircraft life. This is the reason why, due to the long aircraft lifetime, data can be very old and not compatible with the standards at the time of the cabin upgrade / conversion.

Additionally the CAD software of a Completion Center must be compatible with other necessary software (e.g. CAE for stress calculation) and with the data format from the manufacturer.

The quality of a CAD tool can be evaluated after the following criteria:

- Compatibility with other types of software (for simulation, for data management)
- Compatibility with other CAD software
- Compatibility with old/future versions
- 3D capabilities
- Rendering
- Operability

Currently *CATIA* is already established in aeronautical industry as the most common and reliable CAD software. Thus the only aspect that would be at this stage interesting to analyze in comparison to other similar tools is the rendering capability. Rendering has a special significance in cabin refurbishing activities. A close cooperation with the customer is required in order to understand the requirements. Tools allowing rendering and 3D visualization play a key role during the negotiation phases allowing time reduction in defining the preliminary design solutions. Comparison criteria in this case are:

- Compatibility with files from *CATIA* (current and future versions)
- Operability
- Duration of a medium difficult task
- Necessary computer power
- Ongoing modification possibility
- 3D visualization (with special equipment)

4.1.2 Analysis and Simulation

Today ELAN‟s work in CCO department does not include the simulation and analysis of the design. However, stress calculations of structures and simulations are performed at ELAN. In the view of a Completion Center, the CAE applications must be considered, first of all due to the increased importance of simulation throughout the certification process.

The major representatives of this category are: MSC Software (*Patran, Nastran, Adams* etc), ANSYS (*FLUENT*, etc) and SIMULIA (*Abaqus*) (see Appendix B for description).

The CAE tools can be evaluated after the following criteria:

- Compatibility with the CAD software CATIA (current and future versions)
- Operability
- Functionalities
- Calculation time

According to ELAN IT Service (**Voigt 2010a**), in the specific domain of FEM calculation, engineers tend to use the program to which they are familiar with. Moreover there is a huge variety of packages from each editor, that may include or not, the nonlinear analysis, post/pre processing, dynamics and motion, and other capabilities.

The choice of CAE tools is subjective: the feedback of the ELAN personnel using them would be the most legitimate criteria (**Voigt 2010a**).

4.1.3 Data Management

For reasons of traceability and collaboration, product‟s data must be strictly archived and managed. The challenges of these specialized applications are to let authorized people to access useful data, in the easiest way and without disturbing other users. Moreover, data from CAE tools need a special implementation in order to make the simulations repeatable (the hundreds of GB from the simulation cannot be stored for a long time).

Comparison criteria are:

- Database operability
- Access management for multiuser work

- Access management for suppliers
- SDM capabilities
- PLM capabilities (see Chapter 2.3)
- Implementation expenses

4.1.4 Resources Management

All solutions for Resources Management are adaptable to best fit to the company where they are deployed. This is the reason why the efficiency of the proposed modules can vary. In order to make the best selection, the performance of each tool must be tested by someone with a precise understanding of how the company works and what the company needs, or by someone having an important experience in software evaluation.

This report proposes a list of functions and particularities, which can assist the Completion Center activities. These functionalities, however, have not been tested. The study covers the following tools (see Section 4.2.3):

- *Sage ERP X3 Premium Edition*
- *SAP Business Suite*
- *Microsoft Dynamics*
- *Oracle E-Business Suite*

4.2 Evaluation Method

To allow easy comparison of the selected tools below, the following evaluation scale is used:

- 0 tool function is not present or really disappointing
- 1 tool function is basically performed
- 2 tool function meets all requirements
- 3 tool function ensures best performances

Each evaluation criteria receives a score from 0 to 3. The tool with the highest total score represents the best candidate.

4.2.1 Design and Engineering

Table 4.1 presents an evaluation of CAD tools with good visualization / rendering capabilities. As discussed in Section 2.1, for creating drawings *CATIA* is well established for both 2D (*CCD*) and 3D representations. For visualization requirements (as in *Offer Phase*), other tools may present better capabilities. Three tools were found as possible candidates for this case:

- *CATIA V5*
- *Rhinoceros V4*
- *Showcase 2011*

Table 4.1 Evaluation of CAD Tools with respect to rendering and visualization capabilities

Tool	Evaluation
CATIA V5 Editor: Dassault Systèmes (DS)	Compatibility with *CATIA* – current and future versions: Able to read all *CATIA* files created with previous and current release. Grading: **2** Operability: Very familiar to ELAN's engineers. Grading: **2** Duration of a medium difficult task: Depends on the experience of the engineers, on the complexity of the task. Grading: **1** Necessary computer power: Possibility to distribute the rendering task to many computers through the network. (**CATIA Rendering Secrets 2008**) Grading: **1** Ongoing modification possibility: Depends on the computer power. Grading: **0** Real time rendering: *CATIA V5 Photostudio* is for frozen rendering only. Grading: **0**
Rhinoceros V4 Editor: McNeel Modules to extend rendering capabilities: Brazil or VRay	Compatibility with *CATIA* –current and future versions: Trough .igs, .stp files or some complementary modules as *CATIA V5 3D to RHINO V4* by Datakit. Grading: **2** Operability: *—S easy to learn and use that you can focus on design and visualization without being distracted by the software." (**Rhinoceros 2007**)* Grading: **2**

Duration of a medium difficult task:

Friendly interface; depends on the complexity of the task.

Grading: **2**

Necessary computer power:

*—Fast, even on an ordinary laptop computer. No special hardware is needed." (**Rhinoceros 2007**)*

Grading: **2**

Ongoing modification possibility:

Depends on the computer power.

Grading: **0**

Real time rendering:

Not on current version (V4). Version V5 (under development) will have real time rendering capabilities.

Grading: **0**

Showcase 2011

Editor: Autodesk

Compatibility with *CATIA* –current and future versions:

*—Catia® V4 and V5, are now included with Showcase 2011 at no additional cost." (**Autodesk 2010a**)*

Grading: **2**

Operability:

*—Intuitive user interface." (**Autodesk 2010a**)*

*—No software expertise needed." (**Autodesk 2010b**)*

Grading: **2**

Duration of a medium difficult task:

*—Applying materials is so easy even a newcomer to visualization software can make 3D models look photo-real in just a few mouse-clicks". (**Autodesk 2010b**)*

Grading: **3**

Necessary computer power:

"Minimum/Laptop
• 2.4 GHz Intel® or equivalent AMD® processor
• 2 GB system RAM
*• Certified NVIDIA® or ATI™ graphics card with at least 512 MB graphics memory" (**Autodesk 2010a**)*

Grading: **2**

Ongoing modification possibility:

*—Save multiple design variations (...) means you can switch between versions during presentations at the click of a mouse." (**Autodesk 2010b**)*

Grading: **2**

Real time rendering:

*—Choose between simple background images or 3D environment that completely surround your model and enable you to move your creation around in a convincing and complementary setting." (**Autodesk 2010b**)*

Grading: **2**

Table 4.2 presents a summary of the evaluation results.

Table 4.2 Summary of CAD Tools evaluation

Criteria for the evaluation of the Tools for Visualization	*CATIA V5* DS	*Rhinoceros* McNeel	*Showcase* Autodesk
Compatibility with *CATIA* - current and future versions	2	2	2
Operability	2	2	2
Duration of a medium difficult task	1	2	3
Necessary computer power	1	2	2
Ongoing modification possibility	0	0	2
Real time rendering	0	0	2
TOTAL:	**6**	**8**	**13**

The results indicate that for rendering a suitable tool is *Showcase 2011* developed by *Autodesk*. The most important advantage presented by this tool is the possibility to perform on going cabin layout modifications. The tool has a good communication with CATIA, and can also import the results to a 3D visualization system (with video cameras and 3D glasses) (see Appendix B).

4.2.2 Data Management

The Data Management tool currently used by Airbus and its subcontractors is *TAKSY*. Diehl Aircabin for example uses *Teamcenter* (**AeroBrief 2010**). For the A380 the *VPM* platform is used. These tools appeared due to the need to work with an updated documentation database. This type of tool allows the administration of data; one can acknowledge the status of each drawing, the person who is responsible for approving it or can see (or print) the parts lists belonging to each top drawing.

The tools evaluated for ERP support are (see also Appendix B):

- *Innovator*
- *Windchill*
- *Teamcenter*
- *Enovia*
- *EMK*
- *SimManager*
- *Simulia*

Table 4.3 Evaluation of Data Management Tools

Tool	Evaluation
Innovator Editor: ARAS Particularity: This software is open source, so new requirements can be implemented with the help of a programmer.	Compatibility with *CATIA* – current and future versions: *—Prepackaged connectors for the major MCAD and ECAD systems including CATIA, NX, Pro/ENGINEER, SolidWorks, Solid Edge, Innovator, AutoCAD, PADS, OrCad, and others" (**Proe 2009**).* Grading: **2** Database operability: Online access. Manages CAD documents and all different file types including PDF, Office, multimedia & images such as TIF and MPEG (**Proe 2009**). Grading: **2** Access management for multi work: *—Secure simultaneous online access for global project teams and outsourced partners.* *User permissions limit visible information to a person's level of authorization." (**Aras 2010a**)* Grading: **2** Access management for suppliers: Allows secure suppliers access. Grading: **2** SDM Capabilities: No. Grading: **0** PLM Capabilities: Program management module (**Aras 2010b**). Grading: **2** CMII Compliant: CMII Certified with a 4-star rating. (out of 5 stars; best achievement so far: 4 stars) (**ICMHQ 2010**). Grading: **3** Others: Open source software. Certified for Windows (Microsoft Gold Certified Partner) (**Aras 2010b**). Grading: **3**
Windchill Editor: PTC	Compatibility with *CATIA* – current and future versions: Modules named *Windchill Workgroup Manager for CATIA V5* and *Windchill Workgroup Manager for CATIA V4* as well as other CAD majors. It will probably continue with future CATIA versions. Grading: **2** Database operability:

*—Web-based for easy enterprise-wide access, this PDM system supports geographically dispersed teams while managing critical processes such as change/configuration management and release to manufacturing" (**PTC 2010**)*

Grading: **2**

Access management for multi work:

Yes.

Grading: **2**

Access management for suppliers:

Module named *Windchill Supplier Management*.

Grading: **2**

SDM Capabilities:

No

Grading: **0**

PLM Capabilities:

Possible but not very capable (**Voigt 2010b**)

Grading: **1**

CMII Compliant:

*—Windchill was certified at one time but the CMII-compliant functionality, as demonstrated, was never deployed so they were decertified." (**Guess 2010**)*

Grading: **0**

Teamcenter
Editor: SIEMENS

Compatibility with *CATIA* –current and future versions:

—Capture, manage and share CATIA V5 data".

Can also load and migrate *CATIA V4* data to *V5* (**Siemens 2010a**).

Grading: **2**

Database operability:

Can classify and quickly retrieve existing parts for re-use. It is *Microsoft Office* compatible.

According to **Voigt 2010a** the Web client does not have a good performance.

Grading: **1**

Access management for multi work:

*—Secure and scalable distributed team environment" (**Siemens 2010b**)*

No temporary access (**Voigt 2010b**).

Grading: **1**

Access management for suppliers:

*—Teamcenter automates the process of supplier integration and manages supply chain design and process data at a granular level". (**Siemens 2010c**)*

However, according to **Voigt 2010a**, the suppliers have to buy the license or use the very limited Webclient.

Grading: **1**

SDM Capabilities:

According to CPDA (Collaborative Product Development Associates, Design/Simulation Council of industry analyst firm) report:

> *„No other solution scored higher than Teamcenter in 24 of 27 subcategories".*

Other vendors were ANSYS, SIMULIA, MSC. Software and Altair (**Siemens 2010d**).

Grading: **3**

PLM Capabilities:

> *—Teamcenter is the world's most widely deployed PLM system, backed by Siemens PLM Software's leadership in delivery"*

It has a package dedicated to aerospace industry (**Siemens 2010e**).

Grading: **2**

CMII Compliant:

CMII Certified with achieved a 3-star rating (out of 5 stars; best achievement so far: 4 stars) (**ICMHQ 2010**).

Grading: **2**

ENOVIA

Editor: Dassault Systèmes

Compatibility with *CATIA* – current and future versions:

Only works with *CATIA V5 R18* or later.

Grading: **0**

Database operability:

Through a web connection.

Grading: **2**

Access management for multi work:

No temporary access (**Voigt 2010b**).

Grading: **1**

Access management for suppliers:

No temporary access (**Voigt 2010b**).

Grading: **1**

SDM Capabilities:

No.

Grading: **0**

PLM Capabilities:

> *—Asworld leader in 3D and Product Lifecycle Management (PLM) solutions, the Dassault Systèmes group brings value to more than 90,000 customers in 80 countries." (**ENOVIA 2010**)*

Grading: **2**

CMII Compliant:

> *—ENOVIA started the assessment process several years ago*

*but never completed the required upgrades." (**Guess 2010**)*

Grading: **0**

EMK
Editor: ANSYS

Compatibility with *CATIA* – current and future versions:

No.

Grading: **0**

Database operability:

*—The repository can be hosted on a dedicated server, distributed across external resources such as file servers, or hosted on a desktop machine. Data in the repository consists of folders, sub-folders, and other data objects that are organized in a navigation tree to fit your particular needs." (**Ozen 2009**)*

Grading: **2**

Access management for multi work:

*—Acess to data objects in EKM can be controlled by setting permissions through configuration management policies (checkout/check-in) that are applied at the object-level." (**Ozen 2009**)*

Grading: **2**

Access management for suppliers:

There is no dedicated module for sharing data with suppliers. However, data managed by *EKM* are results from simulation and are (generally) not necessary for suppliers.

Grading: **0**

SDM Capabilities:

Dedicated SDM tool.

Grading: **3**

PLM Capabilities:

No

Grading: **0**

CMII Compliant:

No

Grading: **0**

Others:

*—EKM also supports data handling of other ANSYS products, in-house codes, and non-ANSYS tools." (**Ozen 2009**)*

Grading: **0**

SimManager
Editor: MSC Software

Compatibility with *CATIA* – current and future versions:

No.

Grading: **0**

Database operability:

*—Intelligent search and retrieval" (**SimManager 2010**)*

Grading: **2**

Access management for multi work:

> *—Can support thousands of users running hundreds of simulations per day across globally distributed working environments." (**SimManager 2010**)*

Grading: **2**

Access management for suppliers:

There is no dedicated module for sharing data with the supplier. But data managed by *SimManager* are results from simulation and are not necessary for suppliers.

Grading: **0**

SDM Capabilities:

> *—Asthe world's proven and scalable solution for enterprise simulation management, SimManager accelerates simulation, makes results more reliable, and allows engineers to simulate more in order to develop truly innovative products." (**SimManager 2010**)*

Grading: **3**

PLM Capabilities:

No

Grading: **0**

CMII Compliant:

No

Grading: **0**

Others:

> *—Integrated access to SimManager from MSC applications including SimXpert, SimDesigner, Patran, ADAMS, and EASY5. Compatibility with any other CAE application through web-browser interface, including ANSYS, Abaqus, Hyperworks, Matlab and other popular tools". (**SimManager 2010**)*

Grading: **1**

SIMULIA

Editor: Dassault Systèmes

Compatibility with *CATIA* –current and future versions:

> *–SIMULIA delivers a scalable portfolio of Realistic Simulation solutions including the CATIA Analysis applications (…)". (**SIMULIA 2010a**)*

Grading: **1**

Database operability:

> *—The simulation processes and resulting data are fully searchable and the form-based interface makes it easy to share simulation details—such as simulation properties, parameters, execution status, and history of activities—and launch reviews of simulation results to team members and managers for collaborative, rapid decision making." (**SIMULIA 2010b**)*

Grading: **2**

Access management for multi work:

Yes
Grading: **2**

Access management for suppliers:

> *—Combined with ENOVIA technology, our Scenario Definition product enables you to access current CAD or CAE models, define simulation scenarios, manage simulation data and results, integrate third-party or in-house methods, and collaborate on performance-based decision making." (**SIMULIA 2010c**)*

Grading: **2**

SDM Capabilities:

> *—The simulation processes and resulting data are fully searchable" (**SIMULIA 2010b**)*

Grading: **3**

PLM Capabilities:

No
Grading: **0**

CMII Compliant:

No
Grading: **0**

Others:

> *—SIMULIA SLM also works with simulation authoring applications developed by SIMULIA, Dassault Systèmes, third parties, and customers via a Connectors Framework. (...) Connectors are currently [Jan. 16th, 2008] available for Abaqus Unified FEA, CATIA, and a variety of third-party applications such as Nastran, HyperMesh, AcuSolve, and STAR-CD. Customers can also easily configure Connectors to their specific applications." (**SIMULIA 2008**)*

Grading: **1**

Table 4.4 summarizes the evaluation. The *EKM*, *SimManager* and *SIMULIA* tools are dedicated to Simulation Data Management, while Innovator, *Windchill*, *Teamcenter* and *Enovia* are PDM tools.

Table 4.4 Summary of CAD Tools evaluation

Criteria	*Innovator* Aras	*Windchill* PTC	*Teamcenter* SIEMENS	*ENOVIA* DS	*EKM* ANSYS	*SimManager* MSC Software	*SIMULIA* DS
Compatibility with CATIA	2	2	2	1	0	0	1
Database operability	2	2	1	2	2	2	2
Access management for multi work	2	2	1	1	2	2	2
Access management for suppliers	2	2	1	1	0	0	1
SDM capabilities	0	0	3	0	3	3	3
PLM capabilities	2	1	2	2	0	0	0
CMII compliant	3	0	2	0	0	0	0
Others	3	0	0	0	1	1	1
TOTAL:	**16**	**9**	**12**	**7**	**8**	**8**	**10**

4.2.3 Resources Management

The selected candidates for an ERP solution were:

- *Sage ERP X3*
- *SAP Business Suite*
- *Oracle E-Business Suite*
- *Microsoft Dynamics*

An ERP tool can have a great impact on the companies‟ efficiency. Such a tool allows controllability and traceability of all processes and tasks necessary for managing the engineering work. Usually the tools integrate some standard modules dedicated to different operations, e.g. Customer Relationship Management (CRM), Human Capital Management (HCM), Product Lifecycle Management (PLM), Supply Chain Management (SCM), etc. The number of these modules can be customized according to the companies‟ needs. New dedicated modules usually can be customized and integrated to the standard version.

Table 4.5 presents the main characteristics of each selected ERP tool. For choosing the best candidate a very good understanding of the process chains (for both engineering and management) is required. This allows the (vital!) coupling between the tool functionality and the tasks behind each process.

Table 4.5 Evaluation of Resources Management Tools

Tool	Description
Sage ERP X3 Premium Edition -40 countries and 150,000 users worldwide -Sage Group PLC : 6.2 million customers and more than 25 years of experience.	PDA Applications Access with a simple browser. Travelling data is encrypted. Complete integration with Microsoft Office. Can export and manipulate data in Office standard format. Allows access to certain information for partners. Allows up to 1 500 users at the same time. Customer Relationship Management module. Adapts to the current IT environment. Users can continue to work normally during installation of the new system. Easy to activate new functions and to connect new users to the system. Constant software improvements via secure update procedure. 8 international legislations embedded (China, France, Germany, Italy, Portugal, Spain, United Kingdom, USA) Module for Human Capital Development strategy. Automatic reading of documents (For example to process bills)
SAP Business Suite SAP was created in 1972 and has clients in more than 120 countries. It is used by Airbus.	Supplier and Customer Relationship Management modules. Product Lifecycle Management module. Human Capital Management module with Talent management function. Contains a module dedicated to Travel Management (Examine the travel planning, helps expedite the change process, provides a web application for travelers with reporting dashboard…). Supply Chain Management module. Unified approach to total quality management. Enterprise Asset Management function.
Oracle E-Business Suite Oracle is the world's largest enterprise software company.	Customer Relationship Management (CRM) module (which has more than 50 CRM-specific applications). Email Center which is a comprehensive e-mail response management system (classifying incoming e-mails and routing them to qualified agents, and by automatically suggesting one or more responses). Travel & Expense Management module. Human Capital Management module with integrated Talent Management (applications *iRecruitment*, *iLearning*…). Project Collaboration module to provide real-time access to information for

	answering to project-based questions, such as: • What tasks, issues and changes are assigned to me? • What are the priorities and their due dates? • When must I communicate progress on my work? • Where can I access documents I require for my work? *iSupplier Portal* that structures all supplier communication through a secure internet-based portal. Supply Chain Management module. No information about the integration to the current environment.
Microsoft Dynamics More than 20 years of experience.	Able to connect to another ERP solution (Headquarters). Allows employees access to update relevant data through the web portal. Supply Chain Management module. Customer Relationship Management module. Complete integration with *Microsoft Office*. Can be hosted by Microsoft or a Microsoft Certified Partner. Customization allowed in C++ or C#. Only compatible with *Microsoft SQL Server* or *Windows Server*. Good integration with other Microsoft products and third-party products. It offers 10 years of support (**Microsoft 2010b**).

It seems that *Microsoft Dynamics* is an interesting candidate. Besides the advantage of using a common programming language for customization, it also provides a very good integration with *Microsoft* products.

In a 2007 analysis that compared the impact of enterprise software applications on people's productivity, *Microsoft Dynamics* users on average scored *Microsoft Dynamics* 18 per cent higher than *SAP* users scored *SAP* applications (**Microsoft 2010c**)

5 Selection of the Best-Rated Tools for the Use within a Completion Center

5.1 Evaluation Results

For the domain of *Engineering Design* the best CAD tool is ***CATIA***. For its large panel of modules, its interface, its precision, its longevity and its orientation to aeronautic industry *CATIA* is the optimum choice for a Completion Center. The strongest argument is the wide use in the aeronautical industry and the accumulated experience in using this tool, including inside ELAN. The currently most used version (*CATIA V5*) is, however, weaker with respect to the rendering capability. For this task, the best rated tool is *Showcase 2011,* edited by *Autodesk*. Design visualization is especially important for a Completion Center, during the *Offer* phase. Still, it must be noted that *CATIA V6* has progressed in the rendering task and that *Rhinoceros V5* will be soon commercialized with real-time rendering capabilities.

After the evaluation of the tools having *Data Management* capabilities, it appears that the two best software are ***Teamcenter*** and ***Innovator***. It appears however that *Teamcenter*'s Webclient is not very capable. The suppliers could not access data through a simple web-interface: instead they would have to have their own *Teamcenter* license (**Voigt 2010b**). On the other side *Innovator* has weaknesses in SDM capabilities. These can be, however, easily overcome by adjoining dedicated software like *SimManager* or by adding this functionality to the standard version, as *Innovator* is an open source program.

The *ERP* tools are more difficult to compare. All the tools analyzed here provide almost the same functions. Only a test can show how the functions are accomplished and how easy it is to use them. In the end, the price, the availability and efficiency of the support service together with testing the software can best decide which is the most suitable for a Completion Center. In this report the two best candidates found are ***Sage ERP X3 Premium Edition,*** for its PDA Applications and its function of Automatic reading of documents, and ***Microsoft Dynamics,*** which provides the possibility to customize the software in C++ or C#.

5.2 Proposal of a Range of Tools

Two solutions are proposed here: one that fulfills all the functions required within a Completion Center efficiently (*Solution 1*) and one that contains selected tools used by Airbus (*Solution 2*) (**Dassault 2009** and **SAP 2010**) (see Table 5.1).

Table 5.1 Proposal of a range of tools

	Solution 1	Solution 2
Design and Engineering	*CATIA + Showcase 2011*	*CATIA*
Analysis and Simulation	*Patran + Nastran*	*Patran+Nastran*
Data Management	*Innovator + SimManager*	*ENOVIA + SIMULIA*
Resources Management	*Sage ERP X3 Premium Edition*	*SAP*

The better solution is *Solution 1*. For CAD the well established *CATIA* is the most reliable choice. The combination of *CATIA* with *Showcase* allows better rendering and design visualization. The combination *Patran – Nastran* seems an optimum choice for design analysis and simulation, especially due to its popularity among ELAN engineers (**Voigt 2010a**), as well as throughout the aerospace industry. *Innovator*, developed by *ARAS*, is an open source tool for PDM with a 4 stars rating from CMII. A combination with *SimManager* allows managing simulation data as well. A suitable ERP tool was found to be *Sage ERP X3*. However, the large palette of alternatives requires a deeper analysis when making the choice.

Solution 2 is a suitable solution for large companies. Tools which fit the needs of big companies are rarely the tools which best fit the requirements of medium enterprises. The difference between the two solutions lies in the PDM and ERP tools. If ELAN coordinates its changes towards becoming a Completion Center with the infrastructure of the mother company EDAG, in this case SAP (already in use at EDAG) is a better solution for ERP. *ENOVIA* (i.e. VPM) is a tool used by Airbus for A350 and A380 projects. Some of the ELAN employees already have experience with this tool.

6 Case Study – Special Tools

6.1 Digital Mock-up and Rendering

This section presents selected alternatives to additionally support the engineering and design activities within a Completion Center. The selected topics covered by this section are 3D scanners, virtual reality, language conversion, technical documentation and Configuration Management.

6.1.1 3D-Scanners

Aircraft manufacturers deliver (directly or through the airline) the necessary technical documents to the Completion Center in charge of the refurbishing. **AIE 2010** states that in the end the Completion Center receives the CAD data based on an agreement between the Completion Center (or the airline) and the aircraft manufacturer. The capability of digitalizing the aircraft would represent in this case additional information useful especially in the preliminary phases of the refurbishing project.

Today 3D scanners exist and their precision of 0.05 mm is often enough. Some devices are even able to capture the colors of the surface. Table 6.1 describes the technical capabilities of selected 3D scanners using LASER technology:

- *ZScanner 800*, created by ZCorporation,
- *REVscan*, created by Creaform (for reverse engineering),
- *MAXscan*, created by Creaform (for large parts).

Table 6.1 Description of portable LASER scanners

	ZScanner 800	REVscan	MAXscan
Weight	1,25 kg	980g	1,27 kg
Dimensions	171 x 260 x 216 mm	160 x 260 x 210 mm	172 x 260 x 216 mm
Measurement	25 000 measures/s	18 000 measures/s	18 000 measures/s
Laser Class	II (eye safe)	II (eye safe)	II (eye safe)
Resolution	0,05 mm (X, Y, Z axis)	0,1 mm (Z axis)	0,1 mm (X, Y, Z axis)
Accuracy	Up to 40 µm	Up to 50 µm	Up to 50 µm
ISO	20 µm + 0,1 L/1 000	20 µm + 200 µm/m	20 µm + 25 µm/m
Outputs format	.dae, .fbx, .ma, .obj, .ply, .stl, .txt, **.wrl**, .x3d, .x3dz, .zpr	.dae, .fbx, .ma, .obj, .ply, .stl, .txt, **.wrl**, .x3d, .x3dz, .zpr	.dae, .fbx, .ma, .obj, .ply, .stl, .txt, **.wrl**, .x3d, .x3dz, .zpr
Compatibility with *CATIA V5*	Yes. (.wrl is a *CATIA V5* compatible format)	Yes. *HSM* (*Handyscan Scanning Module for CATIA V5*) available from Creaform	Yes. *HSM* (*Handyscan Scanning Module for CATIA V5*) available from Creaform

When using these devices for scanning the aircraft cabin, the main inconveniences are:

- The time required for the scanning process is quite high.
- It scans only what it sees (unlike a medical MRI).
- The result is a single part and not an assembly.

There are also non-LASER-based optical measurement equipments able to digitalize an aircraft cabin. Compared to LASER technology such equipments are globally performing better, but only under specific conditions. Some characteristics of the 3D-Digitizer *ATOS II* (middle class) designed by GOM (Gesellschaft für Optische Messtechnik) are quickly compared below to the *MAXscan*:

- The measurement capability for *ATOS II* is 1 400 000 measures/s. It is faster than the *MAXscan* (with only 18 000 measures/s) but it is able to scan only up to 3,2 m² in 1 second and afterwards it is necessary to move the device which is much heavier : 5,2 kg for *ATOS II* and only 1,27 kg for *MAXscan*; with *MAXscan* the scan is continuous.
- The accuracy of the *ATOS II* is better but the device must be at least at 0,73 cm far from the target, so the point spacing is at least 0,12 mm (while this value is 0,1 mm for the *MAXscan*).
- The cable of the *ATOS II* is 30 m long but the *MAXscan* does not need any cable (during the measurement).

To conclude, 3D scanning fits better today for scanning single parts and not a complete cabin. It is used for reverse engineering (old designs without 3D models), aerodynamics or stress analysis (3D scanning of original models for finite element analysis), maintenance (damage assessment) and control by companies such as Boeing, Pratt & Whitney and Rolls Royce (according to **Creaform 2010**). These devices can also be used for single parts design activities and can help to include an existing component (trolley, cutlery, lamp, etc.) into a digital mock up.

6.1.2 Virtual Reality

This paragraph investigates the possibility of using a program dedicated to virtual reality representations. Virtual reality means reproducing a real time rendering, with enough accuracy and quality, and visualizing it in 3D through a special device (e.g. 3D glasses).

The company *Serious Factory* has developed a tool for business jets (in cooperation with a company having today the exclusivity for using this tool for business jets) which complies with these functions. The compatibility with the CAD software *CATIA* is not complete and the

"importation of the model made with *CATIA V5* can be made through many converters" (**Serious Factory 2010a**) – that means a long work, processed by a dedicated team (rather subcontracted).

Serious Factory 2010b provides examples of movies obtained with this tool. When the cabin rendering is done in real time, the image quality is not as high as when the rendering film is recorded. Nevertheless *Serious Factory* has new versions under development that promise to improve these aspects.

6.2 Language Conversion

Producing technical documents in different languages can be a requirement for a Completion Center, especially if customers or companies dealing with the work embodiment are placed also outside the European space. In this case it is essential that all the terminology is translated correctly. Translation software can help but only a human translator with a solid understanding of the specific field can provide reliable solutions for a technical translation.

Nevertheless some software enables the reuse of previously created translations.

There is translation software available, with specific aviation industry dictionaries and the possibility of customizing an own dictionary:

- *Systran Premium Translator* (bi-directional with English)(Between $800 and $1000) (**Systran 2010**)
- *Translution Pro* (around $100 per year) (**Translution 2010**)

The translation can also be subcontracted to specialized organizations as:

- Universe (**Universe 2010**)
- Trusted Translation (**Trusted 2010**)

6.3 Technical Documentation

For automating the process of creating technical documentation that fits with customer"s specifications an international specification utilizing a Common Source Database is available: the S1000D.

6.3.1 Origin of the Specification S1000D

The concept of this specification was originated in the early 1980s as an aerospace standard within the Aerospace and Defense Industries of Europe (ASD) formerly known as AECMA. At that time, most civil airline projects were being documented in accordance with specification ATA 100 with military projects following various national specifications. With the development of information technology, the AECMA Customer and Product Support Committee established a Documentation Working Group (DWG), having the task to report on current documentation practices and to recommend a unified method of documentation for air vehicle projects. The DWG recognized that the only internationally accepted specification in the aerospace field was ATA 100.

It was therefore decided to attempt to harmonize civil and military documentation using ATA 100 as a source document. The S1000D Steering Committee, which now has the full responsibility of maintaining the specification, includes members from military and industry from various countries (**S1000D 2010a**).

6.3.2 Objectives of the Specification S1000D

The development of the S1000D is organized around the following objectives (**Tirème 2010**):

- reduced costs,
- more economical organization for logistics,
- definition of common rules for all participants on a same project,
- improved interoperability,
- improved clarity of content and reduced translation costs by using Simplified English (SE), standard also supported by the ASD.

The most common benefits are (**S1000Db**):

- ease of data exchange, smaller, SGML/XML based files structures,
- linking capability with source data
- re-use of data
- reduction in update costs
- reduction in document distribution costs, availability of multiple delivery methods

A very meaningful advantage is that the S1000D is non-proprietary, based on open standards.

6.3.3 Tools Using the Specification S1000D

The S1000D only defines the structure of the Data Modules (DM) which contain various information (produced in SGML or XML). Programs using the S1000D have to produce and manage the Common Source Database which is a "store" for the containment and management of DM.

Following software use the S1000D to produce technical publications:

- *Siemens Teamcenter*
- *Adobe Framemaker*
- *PTC Arbortext*

A solution to produce these documents can also to subcontract this work. For example the company Continental DataGraphics Limited – CDG (**CDG 2010**) produces technical publications with the specification S1000D.

6.4 Tool Certification under Configuration Management II

6.4.1 Background

Configuration Management (CM) serves to ensure that configurations conform to their requirements. Configuration management was introduced in the 1960s to resolve the inability of defense contractors to build a second product identical to the prototype. The Institute of Configuration Management was formed in 1984 and in 1988 the CM process was renamed Configuration Management II (CMII). It was adopted for the first time in the aeronautical industry in 1997.

Today CMII answers the question, how the processes of a business must be organized and which rules are necessary, so that the fewest possible mistakes, rework and unnecessary activities are avoided.

In Germany GfKM (Gesellschaft für KonfigurationsManagement mbH) is since 1999 the European partner of the CMII Research Institute of Configuration Management and carries out CMII courses and certifications within Europe. The courses abstracts can be consulted on GfKM main page (**GfKM 2010a**).

Both ***organizations*** or ***individuals*** and ***software tools*** can receive a CMII Certification. Organizations can be certified in 5 process maturity steps from "Unaware" to "Excellent" according to the status of CMII implementation.

Individuals must run through 5 certification levels - from CMIIB (Basics) until CMIIP (Professional) certification. The internationally acknowledged certifications provide evidence about the individuals' skill level regarding CM and CMII (see Figure 6.1).

The first four levels – from CMII Basics until CMII Advanced – are rewarded with a certificate that has a permanent effectiveness. It is only required to assist to the corresponding courses – from 1 until 8 and the course 13 dedicated to software (see Figure X). The last level – CMII Professional – requires the completion of the course 16, as well as to publish a CMII paper and to attend CMII conference. This level also needs to be refreshed every 3 years by the attending course 9 and a CMII Conference or by presenting or publishing CMII-related paper (**GfKM2010b**).

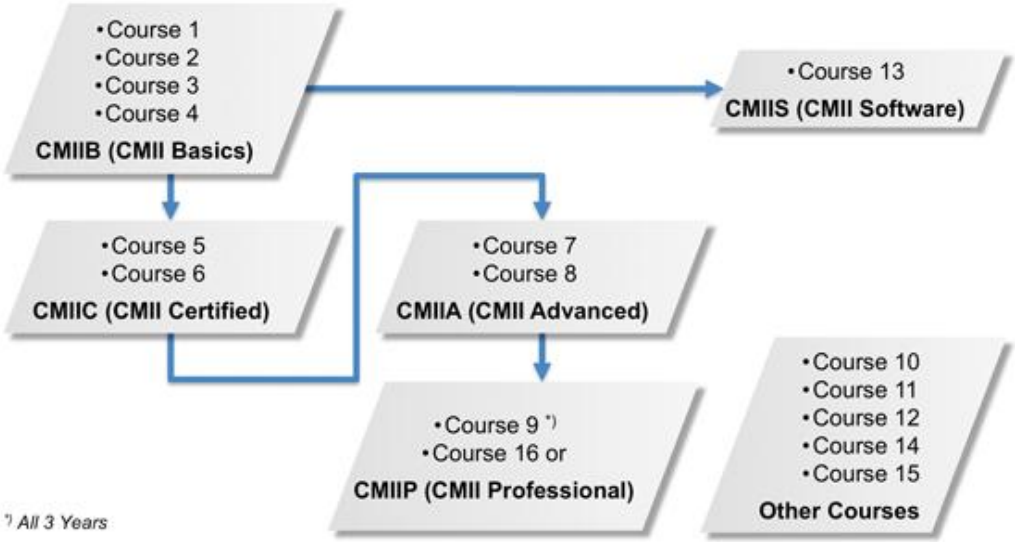

Fig. 6.1 CMII Certification Levels (**GfKM 2010b)**

Software Tools must be in general capable of automating CMII principles. The detailed requirements are listed in a standard called CMII Standard 400 Tool Rating Criteria (**GfKM2010c**). Depending on the amount of CMII functionality that the tool contains, it receives one or more "stars", up to a maximum of 5 (see Table 6.2).

Table 6.2 Rating Scale for CMII Compliant Tools

5-Star Rating Scale for CMII Compliant Tools					
1	2	3	4	5	Criteria
*					The tool provides the mandatory elements of functionality required for CMII certification.
	*				The tool provides at least 25% of the remaining elements of desired functionality.
		*			The tool provides at least 50% of the remaining elements of desired functionality.
			*		The tool provides at least 75% of the remaining elements of desired functionality.
				*	The tool provides 100% of the remaining elements of desired functionality.

6.4.2 Summary of Tool Requirements

Certifiable tools under CMII are tools from the following categories:

- Product Lifecycle Management (PLM/PDM)
- Enterprise Resource Planning (ERP)
- Document Management
- Project Management
- Software Configuration Management
- Change Task Tracking
- Change Management

The certification steps to be followed are (**GfKM2010c**):

1.) Product manager or another responsible person is CMII certified (successful participation in Courses 1 to 6).
2.) The tool fulfills the 44 minimum requirements contained in the catalogue of criteria.
3.) The responsible person can show how the minimum requirements plus possibly other requirements have been implemented in the standard version (out-of-the-box) of the tool. The demonstration (i.e. tool certification) can take place either at GfKM (Gesellschaft für KonfigurationsManagement mbH) in Stuttgart or at the Institute of Configuration Management (ICM) in Phoenix, USA.

Referring to Table 6.2, there are 44 mandatory elements of functionality of a tool complying with CM II. These requirements are connected with 17 Core Business Processes (CBP):

1.) As-Planned and As-Released Baselines

2.) 4-Tier, 9-Step Development Process
3.) Naming, Numbering and Reuse
4.) Validation and Release Records
5.) Changes and Revision Records
6.) Information Systems
7.) Facilities
8.) Security, Safety and Environmental
9.) Business Program Management
10.) Research and Development Engineering
11.) Marketing, Sales and Contracts
12.) Supply Chain Management
13.) Order Fulfillment and As-Built Records
14.) Support, Operation and Maintenance
15.) Human Resources and Training
16.) Financial Accounting and Reporting
17.) Process Oversight and Internal Audit

Table 6.3 presents selected tool functionalities for each process, which are mandatory for the CMII certification.

Table 6.3 Selected tool functionalities mandatory for CMII Certification (**GfKM2010c**)

CBP ID	Tool functionality
1	*Baselines for End-Item products* **P**hysical item hierarchies are defined by bills of material which are treated as documents and identified by type, number and revision level. **C**licking on the ID number of a physical item results in an option to see the item itself or an option to see its metadata. **M**etadata for each physical item includes its documented requirements, source and cost information, item type, handling codes, control codes and so on. *Baseline Changes* **E**ach document has an effective date (which may or may not be the same as its release date). **C**licking on the ECN number results in an option to see the ECN or an option to see its detailed implementation plan. *Baselines for facilities systems and the enterprise* **E**nterprise requirements extend from business regulations and a strategic business plan at the top levels, to operating standards and procedures at the lower levels.
2	**W**ork packages for developing an end-item product are derived from its physical item hierarchy and the documented requirements for each item at each level. **T**he work breakdown structure for development is created and maintained within the as-planned/as-released baseline.
3	**A**ll primary items are assigned an internal identification number, including purchased items which may also carry the supplier's ID number. **I**nterchangeable items with different ID numbers are cross-referenced in an "equivalent item" record.
4	**E**ach relatively simple document is co-owned by a creator and a designated user. **E**ach complex document is owned by a creator and a cross-functional team of users.

5	**S**tandardized forms are used as templates to guide new releases and changes through the required steps of the closed-loop change process. **A** standard problem report form is used to report problems, describe the associated environment and the sequence of steps which led to its occurrence.
6	**R**equired functionality for enabling software tools is driven by the business process infrastructure and core business processes. **E**nabling software tools provide functionality needed to ensure that information repositories are secure and access is limited to authorized personnel.
7	**T**he operational status of each facility, each closed-loop system, each repairable item and each replaceable item is routinely updated and known at all times (NM[1]).
8	**I**n the interest of security, all assets are categorized and/or classified and protected in accordance with their level of importance (NM).
9	**A**ll work on a business program is accomplished via the core business processes, which includes monitoring cost and schedule performance (NM).
10	**R**esearch and development are jointly responsible for creating and maintaining standard part catalogs to be used across all business programs (NM).
11	**C**ommunications between Sales and other activities are achieved via the business process infrastructure, which includes translations from as-sold to as-built units (NM).
12	**P**lanning bills are derived from as-planned/as-released baselines and used to drive material scheduling systems such as ERP (NM).
13	**R**etained work authorizations include positive evidence that the finished items conformed to their documented requirements (NM).
14	**L**ogs are used to track the activity associated with each in-service item being operated and maintained (NM).
15	**J**ob responsibilities and required skills for each position are defined in position guides and are available on-line (NM).
16	**C**ost accounting is activity-based and costs are collected from the forms used to authorize and control work (NM).
17	-

[1] NM=Non-Mandatory

6.5 Outsourced Work

This paragraph aims to summarize the main implications of the decision to subcontract part of the work inside a Completion Center. The different tasks that can be outsourced by a Completion Center conducting only the engineering work are:

- Work embodiment in the aircraft subject to conversion,
- 2D or 3D rendering,
- Technical documents elaboration, according to international standards,
- Translation of the documents in different languages,
- Customization of the tools,
- Training programs for employees (e.g. in Configuration Management).

The main advantages of such a decision are:

- The work is performed by specialists.
- Additional permanent work force is spared and made available for other tasks.
- Specialized tools are not required.

Some disadvantages are listed below:

- Necessity to build an interface for information sharing (with the involved risks)
- Necessity to constantly control the work regarding all aspects especially time or costs.
- Necessity to provide input information and constant support.

7 Summary and Conclusions

This report analyzes the main categories of tools required inside a Completion Center and evaluates the best candidates found for each category. These categories are:

- Design and Engineering
- Analysis and Simulation
- Data Management
- Resources Management

Design and Engineering refers to CAD tools. The best established CAD tool in aeronautical design and engineering is *CATIA*. For cabin conversion activities a CAD tool needs to have also good rendering and visualization capabilities. ELAN currently uses *CATIA*, and the use of this tool is seen as indispensable also for the future. For an Airbus independent condition *CATIA* would need to be combined with a tool able to render the designed objects.

Analysis and Simulation refers to CAE tools. Several tools are well established in this area: *Patran*, *Nastran*, *Ansys*, *Abaqus*. ELAN already accumulated experience with *Nastran* and *Patran*.

Data Management tools are called PDM (Product Data Management) or PLM (Product Lifecycle Management). ELAN currently uses *TAKSY* and *VPM* under Airbus licenses. For the vision Completion Center several candidates were investigated: *Innovator*, *Teamcenter*, *ENOVIA*, *EKM*, *SimManager* and *SIMULIA*.

Resources Management tools are called ERP (Enterprise Resource Planning). Such a tool needs to be tailored according to the company‟s needs and a special attention needs to be paid when selecting it. The ERP tools chosen for the evaluation were: *Sage ERP X3 Premium Edition*, *SAP Business Suite*, *Oracle E-Business Suite* and *Microsoft Dynamics*.

PDM and ERP tools become essential for reducing rework, for avoiding delays, thus for optimizing the functioning of design organizations. Configuration Management II (CMII) provides criteria for evaluating such software tools. It also provides an integrated approach towards business management. For a Completion Center such an approach helps to accommodate change and keep requirements clear, concise and valid.

The capabilities of all selected candidates from each category were compared. The sources of information used to evaluate the tools might have been to a certain extent subjective, as each tool editor aims to sell its product, by especially underlining in their release notes the advantages of

using their tool, rather than being objective about it. Such release notes often lack precision, consequently making room for interpretations. This is especially valid when it comes to judging compatibility problems. A correct evaluation can be performed only by testing each tool. The results of this report can be therefore seen as a primary filtration, delivering best candidates for a more detailed evaluation. At this stage, the detailed evaluation for each category of tools should be performed by a specialized user from ELAN, very familiar to the requirements for the respective tool category, together with an IT specialist.

A very important criterion that was not included in the analysis is the price of every solution. The reason is that the prices highly depend on the number of licenses or on the degree of customization, and is mainly the result of a negotiation.

Based on this limited evaluation, this report concludes that the following solution is the most suitable for the use within a Completion Center:

- CAD tasks performed with *CATIA* and then exported to *Showcase 2011* for the in-house rendering.
- Analysis and Simulation tasks with *Patran* – meshing of the *CATIA* model and analysis setup for the solver *Nastran*.
- Data Management with *Innovator* but linked to *SimManager* to manage the simulation data as well.
- Resources Management performed with *Sage ERP X3 Premium Edition*.

The combination *CATIA – Showcase* was recommended as it represents a complete solution for all design and engineering activities, including the *Offer* phase. For design analysis and simulation the *Patran-Nastran* combination is popular, not only in the industry, but also among ELAN engineers. However, *ANSYS* also provides a lot of CAE dedicated modules. *Innovator* is an open source tool with a 4 stars CMII certification. It was found to be the best candidate for a PDM solution. Tools for Resources Management can be subject to customization. For ERP tools, as well as PDM tools the CMII criteria can be applied when selecting it. Following this research a suitable ERP candidate for a Completion Center is *Sage ERP X3*.

Complementary functions, which can be outsourced or performed in-house with the help of dedicated tools, were additionally analyzed at the end of the report. Such functions are: writing technical documentation and translating them in different languages, the use of 3D scanners for certain parts or certification under CMII. These functions are not essential but can save time. Therefore they should be considered for the final selection of tools.

For writing technical documentation there are tools able to automate this process, on the basis of the *S1000D* standard. There are also tools able to automate the translation process of technical

documentation into other languages. Nevertheless, a human translator would need to check the produced results. 3D scanners, LASER or non-LASER based, are able to scan parts and import them into *CATIA*. Currently they are not able to scan a whole cabin and the result is a single part and not an assembly, yet it can be used for instance for reproducing the profile of a sidewall panel (lining). Additionally to rendered videos produced with *Showcase* from *CATIA*, an additional marketing solution (but rather costly) is to subcontract a company able to produce virtual reality videos. Regarding the CMII concept it must be noted that not only tools can be certified according to the CMII standards, but also people and organizations. The certification process is based on several criteria defined in standards. A minimum number of requirements needs to be fulfilled in order for an organization to receive the CMII certification.

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Appendix A

Rendering with Rhinoceros V4

Below four examples of rendering performed with the software Rhinoceros V4 and the complementary module Brazil are presented. Only trial versions were used with the standard material database. The computer used is a laptop having a dual core processor (Intel Core 2 Duo T7500 at 2.2 GHz), a classic/no-professional graphic card for laptop (GeForce M8600GT with 256 Mo of dedicated memory and 1280 MB of shared memory), 3 GB of RAM (DDR2 PC2-5300 at 667 MHz) and Windows 7 32-bit.

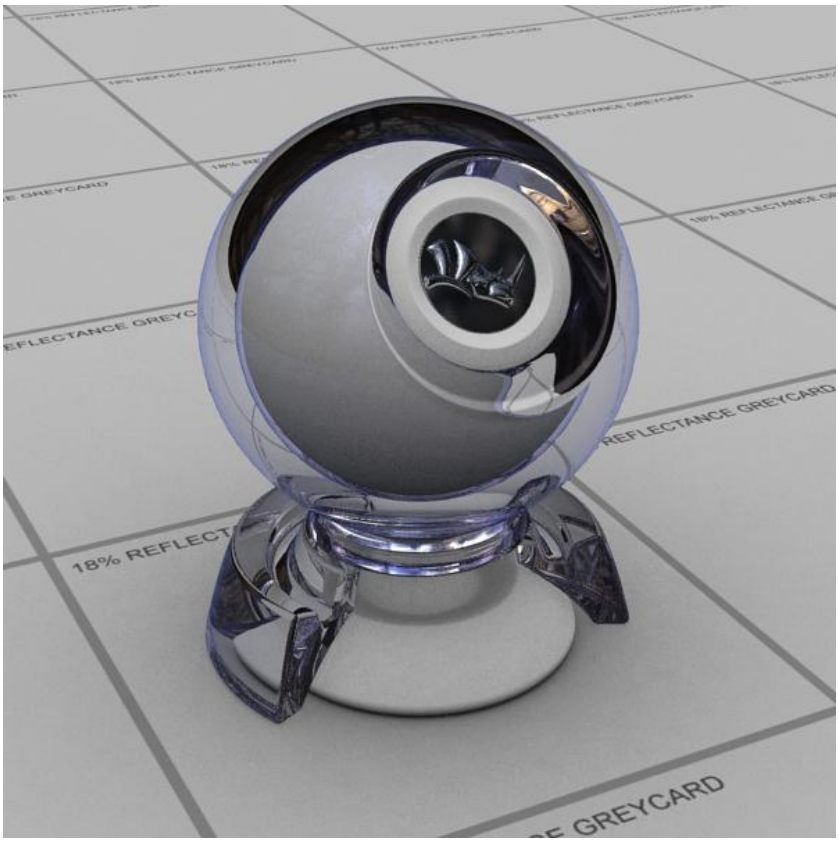

Fig. A.1 Rendering with *Rhino V4* - *Brazil* - Material: Glass

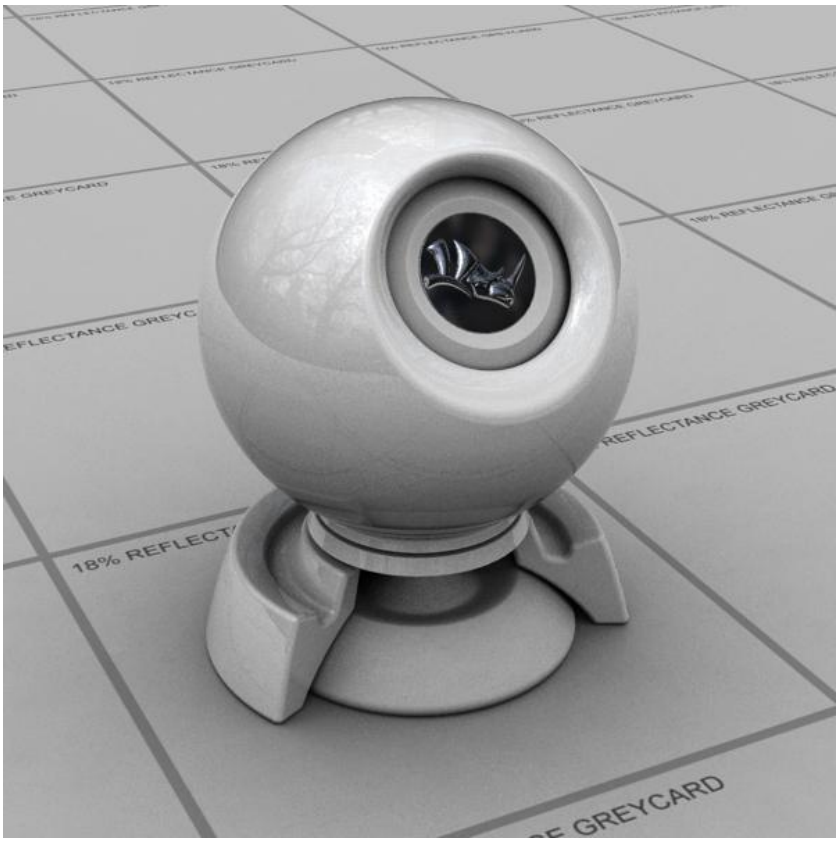

Fig. A.2 Rendering with *Rhino V4* - *Brazil* - Material: Porcelain

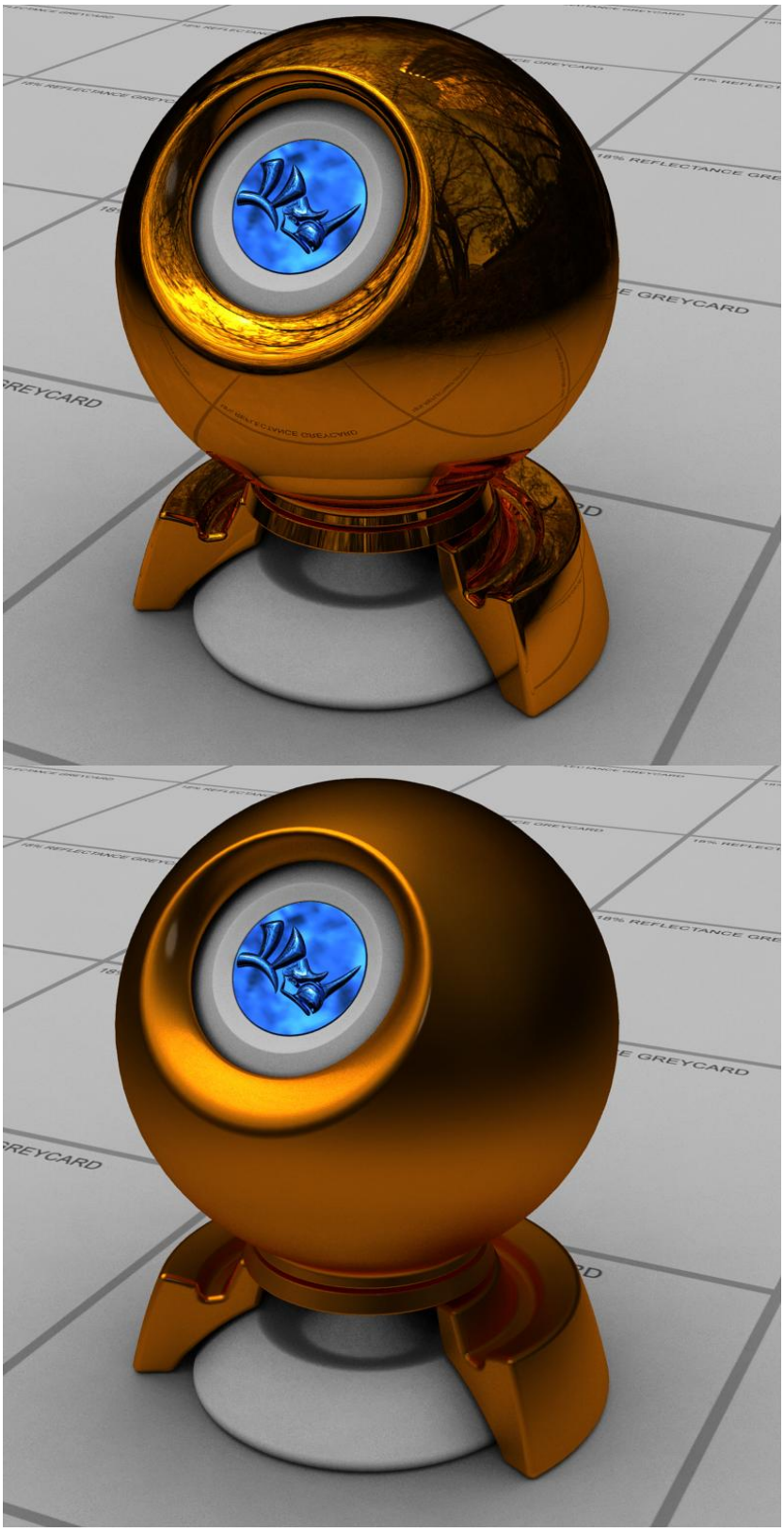

Fig. A.3 Rendering with *Rhino V4* - *Brazil* - Material: Orange Chrome with and without glossiness

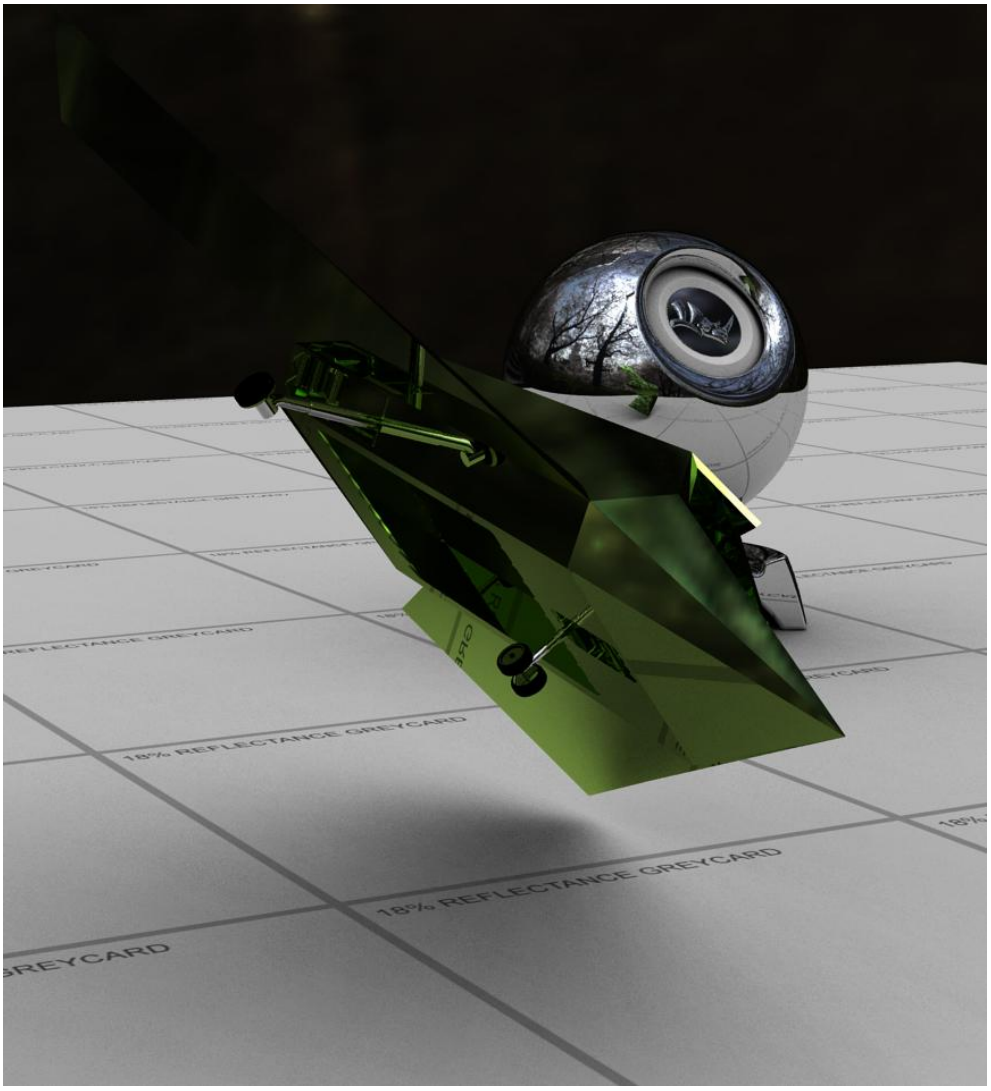

Fig. A.4 Rendering with *Rhino V4 - Brazil* - 2nd model designed in *CATIA V5*

Appendix B

Summary of Tools' Descriptions

B.1 Design and Engineering Tools

CATIA

Editor: Dassault Systèmes

URL: http://www.3ds.com

Originally developed by the manufacturer Dassault for in-house use only and named *CATI* for *Conception Assisté Tridimensionnelle Interactive* in 1977, it was renamed *Computer-Aided Threedimensional Interactive Application* in 1981 to sell the software trough an exclusive distribution agreement with IBM. The V4 only runs on UNIX stations (AIX, HP-UX, IRIX, Solaris) and the V5, commercialized since 1999, also runs also on Microsoft Windows. The last version, V6, runs only on *Microsoft Windows*.
CATIA can be applied to a wide variety of industries, from aerospace, automotive, and industrial machinery, to electronics, shipbuilding, plant design, and consumer goods. The variety of specialized modules is the main advantage of this solution.

Rhinoceros

Editor: McNeel

URL: http://www.rhino3d.com

Rhinoceros is a stand-alone commercial 3D modeling tool very popular in industrial design, architecture, marine design, jewelery design, reverse engineering and multimedia and graphic design industries. *Rhinoceros* specializes in free-form non-uniform rational B-spline modeling. Plug-ins developed by McNeel include *Flamingo* (raytrace rendering), *Penguin* (non-photorealistic rendering), *Bongo* (animation), and *Brazil* (advanced rendering). Over 100 third-party plugins are also available.

Rhinoceros‟ popularity is based on its diversity, multi-disciplinary functions, low learning-curve, relatively low cost, and its ability to import and export over 30 file formats, which allows *Rhinoceros* to act as a 'converter' tool between programs in a design workflow.
The version 4.0 runs only on *Microsoft Windows (*2000, XP, Vista, 7) but *Rhino OSX* for *MAC OS X* systems is in development and *iRhino 3D* can be used to visualize a model on an iPhone, iPad or iPod touch ($3.99, only for .3DM up to 50 MB files). The version 5.0, faster and with more capabilities than the 4.0, is also in development.

Fig. B.1 Designed in *Rhinoceros* and rendering with *Brazil* (**MPAVLOS 2010**)

Showcase

Editor: Autodesk

URL: http://www.autodesk.de

It is a 3D visualization software for real time rendering, able to transform digital prototypes into realistic imagery and immersive presentation. *Showcase 2011* allows to evaluate designs in context and to save alternative configurations. The extensive material and scene library allow quick modifications and the real time capabilities provide realistic imagery in 3D environments. The function Storyboard Timing allows programming a complete presentation with environment switching, alternative changes, behavioral triggering, or camera position changes when the function Movie Creation allows exporting the slides as movies or interactive Flash files. The Showcase 2011 software supports industry-standard 3D CAD formats, geometry tessellation, photorealistic materials, HDRI environments and lights.

Fig. B.2 Rendering with Showcase 2011 (**Autodesk 2009)**

B.2 Analysis and Simulation Tools

Nastran

Editor: MSC.Software

URL: http://www.mscsoftware.com

The first version has been created 47 years ago under the name **NA**SA **Str**uctural **An**alysis. Today it is commercialized in two versions: *MSC Nastran* for stress, dynamics, or vibration simulation and *MD Nastran* for multidiscipline analysis. In addition to all the capabilities of *MSC Nastran*, *MD Nastran* offers a complete set of nonlinear analysis capabilities in both implicit and explicit solution technology, thermal and exterior acoustics and also the coupling analysis between various disciplines such as thermal structural and fluid structure interaction.

Patran

Editor: MSC.Software

URL: http://www.mscsoftware.com

It is a pre/post-processing software for Finite Element Analysis (FEA), providing solid modeling, meshing, and analysis setup (loads, boundary conditions, etc.). *Patran* can works with MSC.Software"s analysis solvers and third-party solvers like *Abaqus* and *ANSYS*.

Abaqus

Editor: Dassault Systèmes

URL: http://www.simulia.com/

Abaqus is a software package for FEA developed by HKS Inc. of Rhode Island, USA in 1978 and now marketed under the SIMULIA brand of Dassault Systèmes.
Abaqus refers today to:

- *Abaqus/Standard* – solver for static and low-speed dynamic analysis.
- *Abaqus/Explicit* – solver for high-speed, non-linear, brief transient dynamic events analysis.
- *Abaqus/CFD* – solver which provides Computational Fluid Dynamics (CFD) capabilities.
- *Abaqus/CAE* – pre/post-processing software to create, edit, monitor, diagnose, and visualize *Abaqus* analyses.
- *Abaqus for CATIA V5* – to bring *Abaqus* capabilities directly into the *CATIA V5* environment.
- *Abaqus Multiphysics* – to allow Coupled Eulerian Lagrangian, Hydrostatic-Fluid-Mechanical, Piezoelectric-Mechanical, Structural-Acoustic, Electrical-Thermal, Thermal-Mechanical, Thermal-Fluid-Mechanical and Structural-Pore Pressure calculations.

ANSYS

Editor: ANSYS

URL: http://www.ansys.com/

The company was founded in 1970 by Dr. John Swanson and was originally named Swanson **An**alysis **Sys**tems, Inc. Since 2000 it has acquired a number of companies, including ICEM CFD Engineering, CADOE, CFX, Century Dynamics, Harvard Thermal and Fluent, Inc.
Today the products known under the generic name of ANSYS 12 are:

- Featured Products:
  - *ANSYS Mechanical* – solution for structural linear/nonlinear and dynamics analysis. It provides complete set of elements behavior, material models and equation solvers and allows thermal analysis and coupled-physics capabilities involving acoustic, piezoelectric, thermal-structural and thermal-electric analysis.
  - *ANSYS Structural* – for pure structural simulations. It has nonlinear structural capabilities as well as all linear capabilities.
  - *ANSYS Professional* – for structural mechanics: with linear structural and dynamics capability and nonlinear thermal capability, or with linear structural dynamics and thermal capability as well as a basic structural nonlinear capability.
  - *ANSYS DesignModeler* – provides tools for construction of geometry from the ground up or for preparing CAD models for an analysis.
  - *ANSYS SpaceClaim Direct Modeler (SCDM)* – to manipulate CAD models from 3rd party systems as well as models directly build within *ANSYS SCDM* with all changes occurring in real time on the screen.

- *ANSYS Meshing* – highly automated meshing environment for the use of mesh types like Tetrahedral, Hexahedral, Prismatic inflation layer, Hexahedral inflation layer, Hexahedral core, Body fitted Cartesian.
- *ANSYS DesignXplorer* – provides probabilistic parametric analysis to determine which parameters are really influencing the behavior of the system.
- *ANSYS CFD* – provides access to both *ANSYS FLUENT* and *ANSYS CFX* capabilities.
- *ANSYS CFX* – powerful CFD code: laminar to turbulent (including transition), incompressible to fully compressible, subsonic to trans- and supersonic, isothermal or with heat transfer by convection and/or radiation, non-reacting to combusting, stationary and/or rotating devices, single fluids and mixtures of fluids in one or more phases (incl. free surfaces).
- *ANSYS FLUENT* – CDF solver, leader in the number of complex physical models offered for solution on unstructured meshes. It provides multiphase modeling, chemical reaction modeling (also in turbulent conditions), heat transfer, phase change and radiation analysis, acoustic analysis and has dynamic mesh capabilities.
- *ANSYS CFD-Post* – post-processor for ANSYS fluid dynamics products. It can generate images to illustrate the flow (including 3D images).
- *ANSYS Explicit STR* – explicit dynamics product that is fully integrated into a unified environment capable of incorporating a range of multiphysics solutions, including electrical, thermal, mechanical and CFD.
- *ANSYS AUTODYN* – explicit analysis tool for modeling the nonlinear dynamics of solids, fluids, gas and their interaction.
- *ANSYS LS-DYNA* – explicit solver for relatively slow-speed impact-related analysis.
- *ANSYS EKM* – SDM tool (see Chapters 4.1.3 and 4.2.2).

- Pre-processing Tools:
  - *ANSYS ICEM CFD* – Complete meshing suite (advanced CAD/geometry readers and repair tools, highly tolerant of imperfect/over detailed CAD data, advanced mesh diagnostics, interactive and automated mesh editing, output to a wide variety of CFD and FEA solvers, and multi-physics post-processing tools,).
  - *ANSYS MeshMorpher* – can perform rapid modifications of an existing design. It allows four different transformations: Face Translation, Face Offset, Edge Translation, Edge Offset.
  - *TGrid* – specialized preprocessor used to create unstructured tetrahedral and HexCore meshes for complex and very large surface meshes.
- Stand-alone Solvers:
  - *ANSYS Multiphysics* – solution for both multiphysics and single-physics analysis. It includes structural, thermal, fluid and both high- and low-frequency electromagnetic analysis. The product also includes solutions for both direct and sequentially coupled

physics problems including direct coupled-field elements and the *ANSYS Multi-field* solver.
    - *ANSYS Rigid Dynamics* – add-on module that works directly with *ANSYS Structural*, *ANSYS Mechanical*, and *ANSYS Multiphysics*.
    - *FLUENT for CATIA V5* – brings fluid flow and heat transfer analysis into *CATIA V5* environment.
    - *ANSYS POLYFLOW* – general purposed finite-element-based CFD software product for the analysis of polymer processing and glass forming, particularly well-known for its extensive library of viscoelastic fluid models.
    - *ANSYS ICEM CFD Cart 3D* – high-fidelity inviscid analysis package for conceptual and preliminary aerodynamic design, successfully used in external flow aerodynamic simulations by the NASA.
    - *ANSYS Fatigue Analysis* – allows to perform stress analysis with more complex loads and materials than traditional tools.
- Specific Applications:
    - *ANSYS AQWA* – addresses the vast majority of analysis requirements associated with the hydrodynamic assessment of all types of offshore/marine structure.
    - *ANSYS ASAS* – structural finite element system performing global structural assessment of most types of marine structures
    - *ANSYS Icepak* – CFD software based on *ANSYS FLUENT* for electronics thermal management.
    - *ANSYS TurboGrid* – provides mesh creation tailored specifically to the needs of bladed geometries (turbomachinery).
    - *ANSYS BladeModeler* – used to design axial, mixed-flow and radial blade components in applications such as pumps, compressors, fans, blowers, turbines, expanders, turbochargers, inducers and others.
    - *ANSYS Vista TF* – turbomachinery tool that provides rapid initial analysis of rotating machinery before proceeding to more rigorous and detailed 3-D fluid flow simulations.
    - *ANSYS Airpak* – used to quickly and accurately model airflow, contaminants, and thermal comfort. It streamlines the application of *ANSYS FLUENT* to ventilation problems.
    - *ANSYS Composite PrePost* – provides functionality for the analysis of layered composite structures. It allows users to identify the exact orientation of every layer of the composite and to create ply books.

B.3 Data Management Tools

Innovator

Editor: Aras

URL: http://www.aras.com

Innovator is a suite of open source business ready solutions for PLM, Enterprise Quality Management and Global Supplier Management. The software is developed on *Microsoft .NET* and certified for *Microsoft Windows Vista*, *Windows 7*, *Windows Server 2008 and Microsoft SQL Server 2005*. It relates all product information (mechanical, electrical, software, firmware, etc) in a single representation. Innovator delivers project portfolio visibility for phase-gate development processes by providing adapted functionality for both executives and team members. Aras solutions interoperate seamlessly and are designed to be run as either stand-alone enterprise applications or integrated with other ERP or PLM/PDM software to complement and extend existing systems.

Windchill

Editor: PTC

URL: http://www.ptc.com

Parametric Technology Corporation (PTC) was founded in 1985 and provides PLM, CAD, content management and dynamic publishing solutions to more than 50 000 companies worldwide (manufacturing, publishing, services, government and life sciences industries).
Windchill is an integrated suite of PLM applications. In the late 2008, PTC announced that *Windchill* had over 600,000 active maintenance paying seats.
Below a quick description of modules available in *Windchill*:

- **Content and product data management**
  - *Windchill PDMLink* – Manages and controls product information and processes through the product lifecycle.
  - *Windchill MPMLink* – Allows design and manufacturing engineers to concurrently develop manufacturing processes and engineering designs.

- *Windchill Supplier Management* – Helps companies select suppliers and manufacturers to create an Approved Manufacturer List and Approved Vendor List.
- *Windchill PartsLink Classification and Reuse* – An internal design library that allows companies to better reuse parts and part designs.
- *Windchill Archive* – Archive and restore selected information from the *Windchill* database.
- *Windchill Business Report Author* – Uses *Cognos 8 Business Intelligence* to create and modify reports.

- **Collaboration and project management**
  - *Windchill ProjectLink* – For managing product development projects.
  - *ProductView Lite* – Visualization collaboration capabilities that are included with *Windchill PDMLink* and *Windchill ProjectLink*.
- **CAD and software integration**
  - *Windchill Workgroup Manager for MCAD* – Incorporates design information from different MCAD packages into Windchill.
  - *Windchill Workgroup Manager for ECAD* – Incorporates design information from different ECAD packages into Windchill.
  - *Windchill Integration for Rational ClearCase* – Manage and synchronize software source code that's in Rational ClearCase.
- **Enterprise integration**
  - *Windchill Enterprise Systems Integration* – Synchronize information between Windchill and ERP systems.
  - *Windchill Info*Engine* – Standards-based integration tools.

Teamcenter

Editor: Siemens PLM Software

URL: http://www.plm.automation.siemens.com

Teamcenter is a PLM tool that aims to connect people throughout the lifecycle of a product with a single source of product and process knowledge (i.e. the designer / manufacturer). A quick description of Teamcenter capabilities is listed below:

- Bill of Materials Management
- Community Collaboration – allows sharing PLM information and applications in real time between the different key participants.

- Compliance Management – Teamcenter supports regulatory compliance mandates across multiple industries, ranging from product records management and archiving to document and records retention management:
  - Environmental Compliance (REACH, WEEE, ELV and RoHS)
  - Medical Device Compliance (US FDA - 21 CFR Part 11, 21 CFR Part 820)
  - Records Management (RMA – DoD 5015.2)
  - Configuration Management (CMII)
  - Export Control (ITAR)
- Content & Document Management – allows to work with Microsoft Office through an advanced interface and to use language as SGML and XML to generate publications, and comply with S1000D standard.
- Engineering Process Management – converts multi-CAD data into the CAD-neutral JT format automatically. Can also bring parts from different CAD systems into a visual mockup, where changes can be viewed in real-time.
- Enterprise Knowledge Foundation – brings together company‟s planning, engineering, manufacturing and service people within a single, collaborative knowledge management environment.
- Lifecycle Visualization – provides a view of products throughout their lifecycle with a scalable family of solutions that allow participants to visualize product data in 2D and 3D formats.
- Manufacturing Process Management
- Platform Extensibility Services – set of platform extensibility services to help to realize value from Teamcenter quickly and cost-effectively.
- Portfolio, Program & Project Management – help to organize resources and drive activities by executing projects against clearly defined goals.
- Reporting & Analytics – basis on which to establish, measure and analyze key performance metrics to drive processes throughout the product lifecycle.
- Simulation Process Management – can manage CAE specific geometry, meshed models, run ready decks, results, and reports.
- Supplier Relationship Management – automates the process of supplier integration and manages supply chain design and process data; allows stakeholders to have access to suppliers‟ information.
- Systems Engineering & Requirements Management – provides all individuals and functional teams with visibility to each requirement, and the knowledge behind it, throughout the lifecycle.

ENOVIA

Editor: Dassault Systèmes

URL: http://www.3ds.com/fr/products/enovia

Dassault Systèmes is a world leader in 3D and Product Lifecycle Management solutions since more than 25 years. One of DS six brands, ENOVIA delivers collaborative PLM solutions. The last version, the V6, includes:

- A Single PLM Platform for Intellectual Property Management – global collaboration via a secure HTTP connection.
- Lifelike Experience – intuitive interface, everybody can easily search information, communicate, collaborate and experience products in 3D online.
- Ready-to-use PLM Business Processes
- Lower Cost of Ownership – standards compliance allows easy integration with existing systems and modeling of business processes.

ENOVIA can be customized to fit to the needs of each customer, but the complete fields which can already be covered are:

- Sales and Marketing
- Program Management
- Supplier Management
- Quality Management
- Product Integration and Synthesis – provides a collaborative environment for product developers and reviewers to validate a digital mock-up and understand the factors that determine its quality, performance and cost, reducing the need for physical mock-up.
- Systems Engineering – all developments are centralized on a single product definition, so that allows various engineering disciplines to work together.
- Product Analysis and Simulation – can be integrated to *CATIA*, *Abaqus* and *SIMULIA*.
- Product Architecture – linked easily to *CATIA* to bring collaboration capabilities.
- Internal System Design – linked easily to *CATIA* to bring collaboration capabilities.
- Assembly Structures – allows ongoing changes and various configurations of a same product to be followed and synchronized across the all supply-chain, constantly monitoring product performance and costs implications of design decisions
- Manufacturing – supports **Design-for-Manufacturing** approach in order for design and manufacturing processes to be optimized concurrently, to reduce overruns, delays and last minute changes. Operations can be defined into the PLM system and can be simulated (*CATIA*) for evaluation, validation and illustration. More precise: the operation can be

simulated and recorded into *CATIA*; the movie file can be linked to the product and shared through *ENOVIA*).

- Service and Support – As the Design-for-manufacturing approach, *ENOVIA* supports **Design-for-Maintainability** approach to anticipate in the design maintenance operations, design changes and various configurations. *ENOVIA* also allows a good communication from engineering to in-service through Services Bulletins publication in order to track changes.

Comment: The website does not provide a detailed description of *ENOVIA*"s capabilities, system requirements and licensing. Solutions to get more information can be to explore the various community blogs, to participate to an E-Seminar or to directly speak with users of the system.

EKM

Editor: ANSYS

URL: http://www.ansys.com/products/ekm

ANSYS Engineering Knowledge Manager (*EKM*) is a tool for simulation-based process and Simulation Data Management (SDM).
The functions of the different versions of EKM are listed in Table B1 (**ANSYS 2010**). The different versions are scalable to best fit to the customer needs.

Table B.1 *EKM* version feature comparison

Feature	ANSYS EKM Desktop	ANSYS EKM Workgroup	ANSYS EKM Enterprise
Release Number	ANSYS 12.1	ANSYS EKM 2.0	ANSYS EKM 2.0
Installation and configuration requirements	Included in ANSYS 12.1	Out of box installation and usage, preconfigured with software components	Customized configuration, mix and match from the list of supported software components
Licensing (FlexLm-based standard ANSYS licensing)	Single user	Server, named users and simultaneous users	Server, named users and simultaneous users
Repository location	Local machine	Central server	Central server
User scalability	Single user	10- or 15-user configurations	Unlimited multiple users
Simulation data management feature scalability	Basic	Extended	Unlimited
Automated metadata extraction for ANSYS simulation files	Yes	Yes	Yes
User-defined property association	Limited functionality available	Yes	Yes
Advanced search	Yes	Yes	Yes
Keyword search	File name-based search available	File name-and-content-based search available	File name-and-content-based search available
Simulation Details report	Yes	Yes	Yes
Comparison report	Yes	Yes	Yes
Authentication mechanism (Windows® domain server or LDAP)	No	Yes	Yes
Dependency and pedigree	No	Yes	Yes
Change management, revision control, version control	No	Yes	Yes
Process management (the creation and publishing of simulation workflows)	No	Yes	Yes
Simulation collaboration using ANSYS EKM software as a web portal for publishing applications	No	Yes	Yes
Configuration/extension of metadata extraction and support for third-party simulation codes and other file formats	No	Yes	Yes
Object lifecycle	No	Yes	Yes
Bidirectional integration with commercial PLM/PDM systems	No	Yes	Yes
Integration with job submission	No	Yes	Yes
Distributed services (enables cache and batch services)	No	No	Yes

SimManager

Editor: MSC.Software

URL: http://www.mscsoftware.com

MSC.Software Corporation was formed in 1963 and is specialized in structural mechanics and multi-body simulation. *SimManager* is the MSC.Software‟s solution dedicated to SDM. The portfolio includes the following versions:

- *SimManager Workgroup Edition* – allows asset cataloging, simulation model and process repurposing or reuse, and provide meaningful and contextual search capabilities. This solution is based on a client-server architecture to be easily deployed and to allow access to the data according to the roles defined to each user.
- *SimManager Enterprise Edition* – adds further value through modules that enable effective process management and automation over the simulation content management functionality that comes with the Workgroup Edition. This edition provides PDM integration via *OpenPDM* technology[1] to synchronize design and analysis communities. It provides compatibility with other CAE application through a web-browser interface including *ANSYS*, *Abaqus* and other popular tools. The solution also enables engineers to manage and track evolving simulation assembly models over the lifecycle of a product development program.

In all editions, *SimManager* enable users to scale up or down their solution depending on their needs.

SIMULIAPLM

Editor: Dassault Systèmes

URL: http://www.3ds.com/products/simulia

SIMULIA is the Dassault Systèmes brand that delivers a scalable portfolio of Realistic Simulation solutions. *SIMULIAPLM* is dedicated to the management of data produced by the simulation process. The main functions covered by *SIMULIAPLM* are:

[1] Solution developed by Prostep AG to provide communication between different PLM and PDM systems both within a single company and partners.

- Traceability and Audit Trail: provides easy access to information that answer to the question “Who did what, why, how and when?”.
- Backup and Archival: manages simulation data in a safe and secure environment.
- Collaboration: provides quickly relevant data to teams that need it.
- Process Automation: A process can be automated successfully only if the data used in the process is under formal management and if the process has reached an acceptable level of maturity.
- Scenario Definition: to simulate a lifecycle including maintenance operations and various configurations.

B.4 Resources Management Tools

Sage ERP X3 Premium Edition

Editor: Sage Group plc

URL: http://www.sageerpx3.com

Sage is an English company founded in 1981 and engaged in development, distribution and support of management software and services for midsized and smaller businesses.
Sage ERP X3 is an international ERP system with choice of languages, currencies, enterprises, locations and legislations. The main functions are listed in Figure B3 (**SAGE 2010**):

Fig. B.3 Description of *SAGE ERP X3* functions

In Figure B3, MPS/MRP means Master Production Scheduling and respectively Material Requirement Planning, and RF data acquisition refers to the identification system by Radio-Frequency also known as RFID.
The main difference between the Standard Edition and the Premium Edition is the capability of managing several legislations only in the Premium Edition and also the fact that the Premium Edition is easily adaptable for a subsidiary of a group.

SAP Business Suite

Editor: SAP AG

URL: http://www.sap.com

SAP is a German software development and consulting corporation founded in 1972 which provides enterprise software applications and support to businesses of all sizes. *SAP Business Suite* is composed of the following components:

- *SAP CRM* – includes marketing resource management, sales, and multiple communication channels (voice, e-mail, chat, text messaging and fax).
- *SAP ERP* – includes the following applications:
  - *SAP ERP Financials* – financial management software for reporting, controlling of cash flow and evaluating financial risk.
  - *SAP ERP Human Capital Management* – automates the processes of workforce analytics, workforce process management, workforce deployment and talent management.
  - *SAP ERP Operations* – covers the procurement process and integrates business partners. It also covers the inventory management, the transportation management and logistics.
  - *SAP ERP Corporate Services* – includes maintenance, project, travel, and quality management. And also includes Environment, health and safety management by providing internationals rules and legislations.
- *SAP PLM* – global PLM solution which is not evaluated in this report because it has not been recommended or seen in others Completion Centers.
- *SAP Supply Chain Management* – can model the existing supply chain to drive it real-time (demand, safety stock, distribution planning, etc). Features include order fulfillment, procurement, transportation, warehousing and manufacturing.
- *SAP Supplier Relationship Management* – helps to monitor and evaluate suppliers, includes Catalog Management, Contract Management, and Supplier Collaboration.

Oracle E-Business Suite

Editor: Oracle

URL: http://www.oracle.com/us/products/applications/ebusiness

Oracle is a multinational corporation founded in 1977 and specialized in data management systems as well hardware as software.
Oracle E-Business Suite includes the ERP products as well as Supply Chain Management (SCM) and Customer Relationship Management (CRM) applications. Each application (more than 150) is licensed separately so companies can select the combination that is suitable for their business processes. The main applications included are:

- *Oracle CRM* – includes real-time and historic analytics (pre-built reports and dash boards or customized) for tracking and analyzing key performance indicators.
- *Oracle Financials* – includes include General Ledger, Cash Management, Payables, Receivables, Fixed Assets, Treasury, Property Management, Financial Analyzer and a self-service expenses function.
- *Oracle Human Capital Management* – global, Web-based, single system. Includes a flexible payroll engine, one central training catalogue (on-line), forums and chat rooms, a recruiting solution and a talent management solution.
- *Oracle Procurement* – provides a shopping system that allows employees to manage and track their own orders while the Purchasing department retains central control. Also include a internet portal for communication with suppliers, different analytics (including the extended supply chain costs like transportation, insurance, etc) and supplier performance evaluation.

Microsoft Dynamics

Editor: Microsoft

URL: http://www.microsoft.com/dynamics

Microsoft was founded in 1975 and their key products are *Windows* and *Office*. The Microsoft Business Solutions group was formed after the acquisition of Great Plain Software in 2001 and Navision in 2002.

The Microsoft Business Solutions are very familiar with Microsoft environment (*Windows* and *Office* at the condition to have recent versions) but only run on *Windows Server* platforms and with *Microsoft SQL Server* databases.

> *–Every solution in our line of familiar and adaptable enterprise resource planning (ERP), customer relationship management (CRM), and retail management products works like and with Microsoft software your people use every day."(**Microsoft 2010d**).*

The different solutions under the name Microsoft Dynamics are the following:

- *AX* – Solutions for midsize and larger organization that works with familiar Microsoft software. Formerly Axapta, it has been extended after the acquisition in 2009 of Fullscope Inc. (process manufacturing solution), Computer Generated Solutions Inc. (professional service solution to manage projects, resources, financial transactions and billing) and LS Retail EHF (store management with point-of-sale, merchandising, ERP capabilities). The three ready licensing options are named Business Essentials, Advanced Management and Advanced Management Enterprise. A lot of functions for Human Resource Management are only available as additional components.
- *CRM* – Divided in three CRM solutions: Sales, Customer Service and Marketing.
- *GP* – (formerly Great Plains Software) for growing and midsize companies. Also available in Business Essential and Advanced Management editions, it is possible to add modules.
- *NAV* – (formerly Navision) for small and midsize organizations looking for a complete ERP solution (fast, easy and simple). It covers Sales and Marketing, Human Resource Management, Project Management and Service Management. Provides industry specific functions. Is easy and simple to customize.
- *POS* – for retail store management.
- *RMS* – is a Retail Management System for small and mid-market retailers.
- *SL* – business-management solution for midsize organizations specialized to help project-driven. Available in Argentina, Chile, Mexico and United States in English and Spanish.