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Research Proposal

Aircraft Cabin and Cabin System Refurbishing – Management of Technical Processes

CARISMA

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Abstract

The research project CARISMA is undertaken jointly by ELAN GmbH and Hamburg University of Applied Sciences. Its aim is to support the definition, implementation and test of technical processes for aircraft cabin and cabin system refurbishing. Successful implementation of these processes is required for certification of the company as design organisation following EASA regulations under AMC and GM to Part 21. Aim is to incorporate scientific problem solving techniques and modern computer tools. In this way an efficient and highly automated workflow shall be possible that accounts for the challenges of globally distributed engineering activities and merging subcontractors taking more and more responsibility and bigger work packages from the aircraft manufacturer.

Contents

Definitions

monument A monument is a large device in an aircraft cabin, positions on the floor plan in addition to the passenger seats. Examples of monuments are galleys and lavatories.

Abbreviations

CIDS	Cabin Intercommunication Data System
EASA	European Aviation Safety Agency (http://www.easa.eu.int)

FAR	Federal Aviation Regulations (http://www.faa.gov)
HAW	Hochschule für Angewandte Wissenschaften
OEM	Original Equipment Manufacturer. In the aeronautical industry, OEM refers to the aircraft manufacturers. Examples of globally present OEMs in this industry are e.g. Airbus, ATR, Boeing, Bombardier and Embraer.
SME	Small and Medium Enterprise. Definition: http://ec.europa.eu/enterprise/enterprise_policy/sme_definition/index_en.htm
TBC	To Be Confirmed
TSO	Technical Standard Order
VIP	Very Important Person
VVIP	Very, Very Important Person

1 Envisaged Cooperation and Industrial Environment

The company ELAN envisages to cooperate with Hamburg University of Applied Science (HAW Hamburg) with its Aircraft Design and Systems Group (Aero) on an investigation to optimise the "Management of Technical Processes in Aircraft Cabin and Cabin System Refurbishing". (**ELAN 2008**, **HAW 2008**, **Aero 2008**)

The **cooperation** will offer **ELAN** the opportunity of an unbiased outside view and practical scientific approaches of problem solving in aeronautical engineering. The cooperation will offer HAW Hamburg a view in every day cabin design and constructions as well as funding for conducting work towards a cooperative PhD. The cooperative PhD is envisaged between **HAW Hamburg** and **Universitatea "Politehnica" din Bucureşti** (PUB) in Romania. The envisaged PhD candidate is Mihaela Niță. HAW Hamburg will try to incorporate public funding into the project (**BMBF 2008**). This will reduce the financial burden on ELAN's side and will increase the financial flexibility on HAW's side. (**PUB 2008**)

ELAN (EDAG Lühmann Aeroengineering) GmbH is a young, expanding company. ELAN was created out of a joint venture of two companies: EDAG Sigma Concurrent Engineering GmbH and Lühmann Ingenieur AG. In early 2008 the two partners gave up their individual existences and merged to form ELAN under **EDAG** GmbH und Co KGAa. Prior to that EDAG Sigma was already a subsidiary of EDAG, while Lühmann was an independent company. Another subsidiary of EDAG is Albert Mühlenberg Apparatebau GmbH und Co KG also a formerly independent company. (**ELAN 2008**, **EDAG 2008**)

The portfolios of these three aeronautical engineering roots in the EDAG holding supplement each other in an ideal fashion:

Lühmann Ingenieur AG has been developing cabin interiors for the aviation industry for more than 40 years. Lühmann's expertise is in engineering work for Airbus Industrie in areas of compiling construction documents for all aircraft types in the form of technical drawings and accompanying part lists for new and modified constructions (**Lühmann 2008**).

EDAG Sigma GmbH looks back on more than ten years of experience in developing structural components for Airbus, on-board toilets for Dasell or VIP cabin interiors for Lufthansa Technik (http://www.lufthansa-technik.com go to " VIP & Executive Jet Solutions"). (**EDAG Sigma 2008**, **Dasell 2008**, **Lufthansa Technik 2008**).

Albert **Mühlenberg** Apparatebau GmbH und Co KG is one of the world's leading manufacturers of top quality, weight-optimized cabin interiors (**Mühlenberg 2008**).

EDAG GmbH und Co KGAa is the strong partner, providing the three SMEs with the experience they need to handle large projects (**EDAG 2008**).

2 Research Scope

Aircraft cabin refurbishing (or: retrofit; German: Umrüstung) is needed if a cabin is:

- outdated,
- worn out,
- needs to follow a new specification, e.g. because the aircraft was sold to a new owner,
- new aviation standards demand modifications to improve cabin safety.

ELAN envisages new challenges:

a) Contracts with **Airbus Industrie** could ask for the complete engineering work for aircraft cabin refurbishing. In the past Lühmann has worked on such tasks under guidance and project leadership of Airbus. In the future Airbus intends to subcontract bigger work packages, so that EDAG/ELAN will have to take up the responsibility of managing whole projects in house. Roughly the following tasks will need to be handled in such a situation (TBC):

   - planning the refurbishing with the customer,
   - inspecting the aircraft, documentation of conditions,
   - obtaining all relevant drawings, part lists, ..., from the OEM
   - planning the refurbishing project,
   - ordering parts, redesigning, constructing, preparing new drawings and part lists ...
   - supervising manufacturing and conversion,
   - handing over of the refurbished cabin to the customer.

Aviation 2007 gives a very practical insight into the day to day business of such projects (using the example of business aircraft refurbishing).

b) Cabin refurbishing projects of aircraft in the EDAG holding. Here it is envisaged to handle complete refurbishing projects of **Dornier 328** aircraft (**Wikipedia 2008**) by joining the forces (for the first time!) of aviation companies in the EDAG holding. Especially the "Lühmann root" will be responsible for the design and planning (see above) with Mühlenberg building and providing VIP interior monuments and parts.

The **scope of the refurbishing project** does not only comprise the cabin (and cargo compartment) itself as

- ATA 25: Equipment / Furnishings
- ATA 50: Cargo and Accessory Compartments

but also cabin systems as there are

- ATA 21: Air Conditioning
- ATA 26: Fire Protection
- ATA 33: Lights
- ATA 35: Oxygen
- ATA 38: Water / Waste
- ATA 44: Cabin Systems (I.e.: Units and components which furnish means of entertaining the passengers and providing communication within the aircraft and between the aircraft cabin and groud stations.)
- ATA 46: Information Systems

For a detailed definition of the systems according to the Air Transport Association of America see **ATA 2200**.

Cabin refurbishment means in principle:
- *installation* of new components, cables, hoses and tubes,
- *removal* of old components, cables, hoses and tubes,
- *modification* and *repositioning* of existing components, cables, hoses and tubes.

The modification effort caused by repositioning cabin items can be reduced e.g. if
- digital re-programmable cabin electronics are used based on data busses (Airbus: CIDS; **AIRFAX 2008**) or based on wireless technology,
- the aircraft was built based on cabin flexible zones and monuments allowing for flexible installation (Patent **WO/2006/087168**),
- the attachment points for monuments are adaptable (Patent **US7093797**).

3 Research Tasks

In an **initial task**, HAW's research will be based on a systematic description and critical review of current established processes at ELAN in aircraft cabin design and construction – in the light of the new challenges ahead. This comprises:

- work of the HAW researcher in different teams at ELAN in order to understand present activities, processes and techniques from practical own experience[1],
- interviews of experts and compilation of "best practices".

In order to meet **ELAN's** envisaged new challenges (as stated in Chapter 2), the company needs to address these **activities**:

1.) Certification of the company as "development organization" in accordance with aviation standards, requirements and Airbus demands.
2.) Definition of technical processes and their management.
3.) Application of the newly defined technical processes in a first refurbishing project.

HAW's **main research tasks** shall be with respect to ELAN's activities:
1.) to support ELAN's activities in a theoretical and practical way to obtain certification,
2.) to define technical processes and their management based on Airbus standards,
3.) to support the application of (2.) preferably on a cabin refurbishing project for the Dornier 328

With respect to 1.)
GRESS 2001 sets out Airbus requirements for subcontractors:
- **ISO 9001** certification by a third party
- **Part 21** approval

and if applicable
- any other manufacturer design organisation approval (DOA) or production organisation approval (POA)
- **Part 145** maintenance organisation approval
- other acknowledgements (TSO, etc.) from regulatory authorities or airworthiness or prime contractors.

HAW's task will be, in close cooperation with ELAN, to review these requirements and their implications with respect to management processes and to support the certification process.

[1] This work shall be undertaken similarly to introducing a Trainee to the company and should include some hands on experience avoiding at the same time a repetition of tasks.

With respect to 2.)
research activities can start by looking at Airbus procedures for the development of new aircraft cabins (see Chapter 5) and Airbus requirements for subcontractors (see Chapter 6). Furthermore, a review of technical processes in other areas of cabin refurbishing (VIP cabin refurbishment, business jet cabin refurbishment, practice at Boeing) may provide further inside. This will be combined with general project management methods (**Burghardt 1988).**

HAW'S research will also investigate existing tools as introduced in Chapter 7 that support overall activities in cabin layout, design and refurbishment and will make proposals on how these tools could best be included into the technical processes at ELAN.

4 Research Relevance and Implications

All research tasks (Chapter 3) – although of managerial level – are highly practical (applied to real aircraft construction) and require a strong foundation and good knowledge in aeronautical engineering.

All research tasks in themselves are not new and are not breaking new ground. However, the combination of tasks is new:

- Airbus only now starts to outsource the bigger work packages. For this reason, it is not known today, how best to manage and to define the technical processes in aircraft cabin refurbishing applied to a working environment of an SME.
- Airbus has changed its outsourcing policy. Subcontractors are asked to further subcontract 20% ... 30% of the work "off-shore", i.e. to India. These new global processes have to be carefully included in the technical processes.
- ELAN and Mühlenberg have only recently settled under EDAG. A history of combining work at higher level under own responsibility (in an own design organization) does not exist yet.
- HAW's input is demanded to consider scientific approaches to problem solving:
    - System Synthesis Methods: Prognosis, State of the Art, Competition, Lessons Learned, Intuition, Brainstorming, Analogy, Design Methods, Technical Rules and Standards.
    - Systems Analysis Methods: Design Review, System Simulation, Mock Up, Prototyp.
    - Safety und Reliability Methods: Fault Tree Analysis (FTA), Dependence Diagrams (DD) or Reliability Block Diagrams (RBD), Markov Analyis (MA). Failure Mode and Effect Analysis (FMEA), Zonal Safety Analysis (ZSA), Particular Risk Analysis, Common Mode Analysis.
    - Knowledge Based Engineering (KBE).

The overall approach to the research project shall be scientific and shall comprise of:

- systematic investigation of the problem,
- review of all relevant information (electronic, printed, inhouse, by interview, ...),
- synthesis of several solutions of each subtask and selection of the best,
- application of the solution with a practical case,
- scientific documentation.

5 Airbus Procedures for the Design of New Cabins

While aircrafts are being designed once, aircraft cabins are designed several times. The first cabin to be designed – the "cabin zero" (**Dohrmann 2006**) – is treated like the first prototype of a new aircraft type. However for one new aircraft type there are several cabin variants: In general at least one for each customer respectively airline. The first cabin of these variants – the "head of version" – needs a lot of attention. Only later, production gets into more efficient serious production as more cabins are being made for the same airline, following the same specification.

Processes for cabin development at Airbus are specified in **AP2289**. AP2289 is entitled "Develop new Cabin & Cargo (DnCC)". It is related to **AP2254** "Design new Aircraft (DnA)" but shows more detail as indicated in Fig. 1 and Fig. 2.

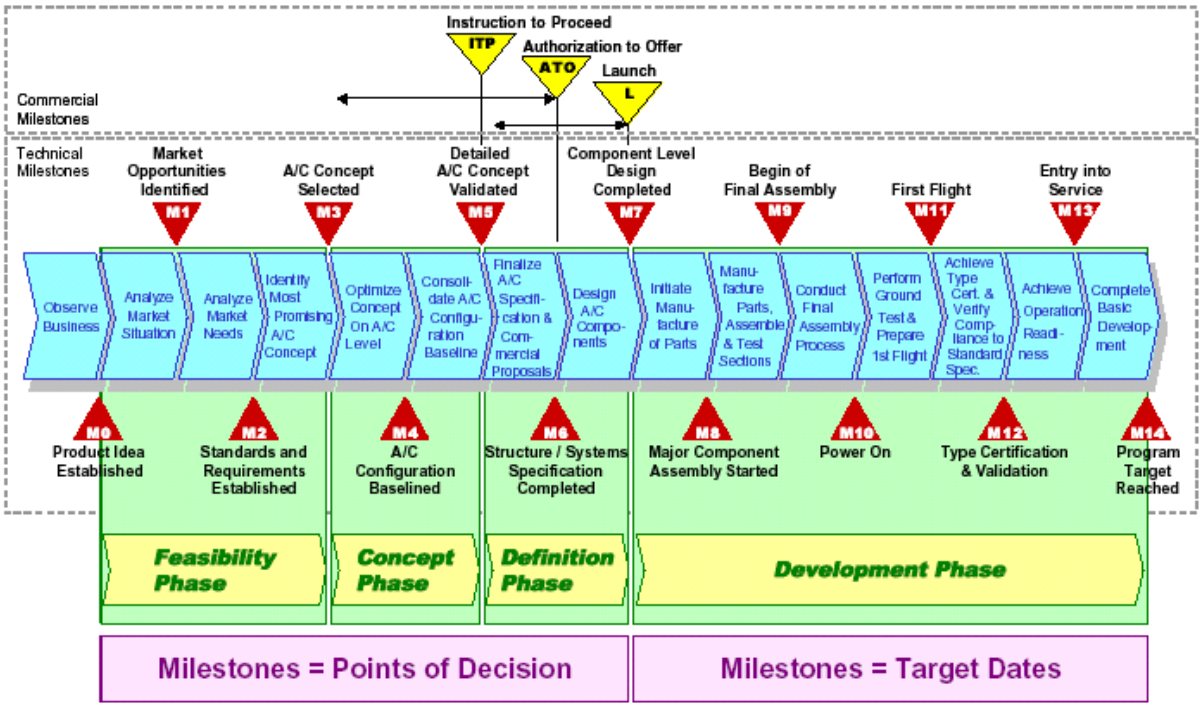

Fig. 1: Airbus: Develop New Aircraft: DnA-Milestones (**AP2254**)

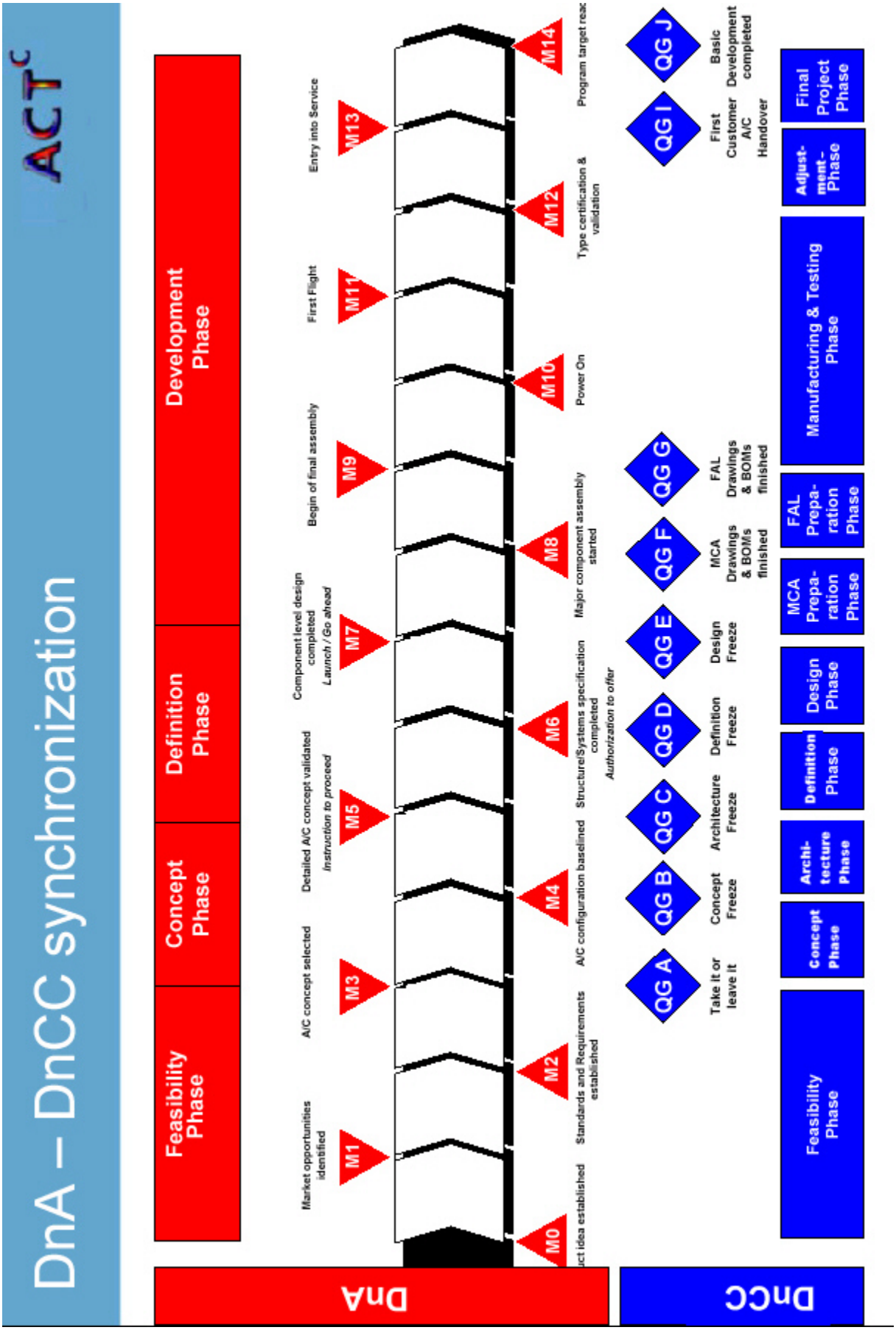

Fig. 2 Project phases and Quality Gates in the Design of new Cabin and Cargo systems (**Gisecke 2005**)

Definitions of "cabin", "cargo" and "customisation" are taken from **Gisecke 2005**:

Cabin
The cabin is the compartment and interior surrounding passengers and crew but also all systems functions and services that ensure save and comfortable operation both in flight and on the ground.

Note:
The cabin is ...

- ... THE highly customised part of the aircraft, a complex work field to be managed including conception, definition, validation, testing, delivery and after sales support.
- ... the direct interface to passenger/airline, it plays a major role for customer satisfaction.
- ... individual design, service and branding, essential tool for airlines to differentiate from competitors.

Cabin components consist of:

- monuments (galleys, lavatories, stowage compartments)
- lining (ceiling, panels)
- seats and misc. equipment (carpets, curtains…)
- systems (cabin communication, air conditioning, lighting, inflight entertainment [IFE], safety systems, water supply and toilet systems) according to **ATA 2200** (as shown above).

Cargo
The cargo compartment comprises all functions ensuring safe and on-time luggage and freight transport.

Customisation
Customisation is the process of tailoring aircrafts to individual needs and wishes of an airline by integration of predefined options and individual customer requests into a basic aircraft model or specification.

6 Airbus Requirements for Subcontractors

Any work of a supplier with Airbus Industrie will be governed by a contract and appendixes. Further requirements will accompany the contract:

- AP1013 (GRESS 2001)
- Purchaser Technical Specification
- **ABD0100** and when applicable **ABD0200**
- GCP2000 (General Conditions of Purchase)

- other relevant general documents

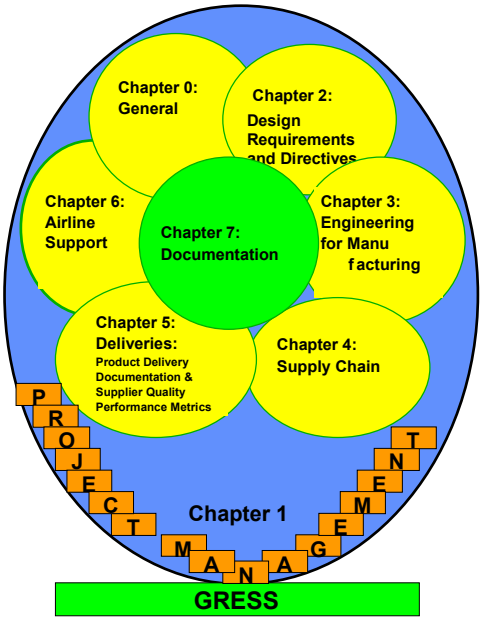

Fig. 3: Content of AP1013 (**GRESS 2001**). In addition: Chapter 1: Project Management

AP1013 (**GRESS 2001**) sets "the General Requirements for Project Management, Design Requirements and Directives, Engineering for Manufacturing, Supply Chain, Deliveries (Product Delivery Documentation and Supplier Quality Performances Metrics), Airline Support, and Documentation which are applicable to Airbus Industrie Suppliers for Equipment and System." AP1013 is part of the Airbus Industrie Contract and sent to Suppliers at the early stage of the Request For Proposal process. AP1013 is applicable in its entirety.

GRESS 2001 demands the establishment of detailed project management at the supplier in Chapter 1 of the document:

PROJECT MANAGEMENT
1.1 Project management Introduction
1.2 Supplier Project Organisation
1.3 Supplier Project Development Planning
1.4 Supplier's contributing parties Monitoring and Control
1.5 Project Management Process for Design Validation and Verification
1.6 Project Management Process for Maturity
1.7 Project Management Process for Supportability and Support Products/Services
1.8 Strategy for Obsolescence Management
1.9 Configuration Management
1.10 Risk Management
1.11 Resource Management
1.12 Project Monitoring and Control
1.13 Information Management

1.14 Electronic Data Interchange
1.15 Product/Process Assurance
1.16 Experience Capture and Record
1.17 Final Review

In the past, systems equipment vendors where using a number of Airbus Directives (ABDs) that where applicable to design of systems equipment. These ABDs were developed over several years and had grown in content and in number. For any given equipment contract, the vendor was required to use a (sometimes small) part of each ABD that he receives. The remainder was, at best, superfluous to a given equipment contract and, at worst, was conflicting and confusing. For new systems and/or equipment contracts the old ABD information was reformatted into two easier to use documents. **ABD0100** concerns systems equipment supplier issues, and **ABD0200** concerns airframe manufacturer systems designers issues. In some cases parts of the **ABD0200** can also be used for system suppliers. **ABD0200** is based on **ARP4754** – a document from the Society of Automotive Engineers. As such it becomes clear that Airbus is working with internationally accepted standards for aircraft and system development. **ARP4754** is quoting **ARP 4761** and **RTCA/DO-160D** (and other documents) combining in this way the most important internationally accepted documents for system development.

7 Computer Tools for Cabin Layout, Design and Refurbishment

Basic **drafting tools** for cabin layout, design and refurbishment are CCD (Catia Cadam Drafting), CATIA V4 and CATIA V5.

With respect to Airbus, excess to a large **data base** (running on a host computer at Airbus) is necessary to extract the required aircraft data. For each aircraft part a dataset (Bauunterlage) is required, consisting of: drawings, part list, engineering change note, and control sheet (Bauteilsteuerungsblatt). Planning the refurbishment has to be achieved without the aircraft being present, because it is still in operation during that time. So the datasets are the only means for the engineer to prepare the refurbishment.

Computer **tools** were designed **that support the generation of cabin layouts**. These tools are applied during early aircraft design (for generation of the standard layout) or during negotiations with customers (for generaton of an individual cabin layout).

Already in the 80th **expert systems** have been used in aeronautical engineering. **Alsina 1987** applied expert systems to wing design. XKL was an early expert system for the configuration

of the layout of passenger cabins (**Kopisch 1993**) and was based on PLAKON (**Cunis 1991**) a special expert system called configuration system.

Pacelab Cabin of Pace Aerospace Engineering and Information Technology GmbH (**PACE 2008**) is a standard aircraft cabin configuration tool. It significantly streamlines the modelling and positioning of cabin interior items as well as the utilization of results by applying a consistent knowledge-based approach. Pacelab Cabin is applied at Embraer (**Presse-Box 2008**) and at Sukhoi Civil Aircraft Company (SCAC) for the Sukhoi Superjet 100 (**BDLI 2008**). Airbus has sponsored a tailored development of Pacelab Cabin to suit Airbus' needs. This much extended version is however not available in public. Pacelab Cabin was reviewed by **Seeckt 2004** at HAW Hamburg.

"PACE has developed **specialized solutions for cabin conversion** and upgrading which largely automate the generation of retrofit drawings and delta part lists. By flexibly linking and comparing pre- and post-statuses of cabin interiors (also extending to cabin systems like passenger service channels, floor-mounted systems, etc.), our software allows to assess different conversion strategies based on comprehensive data. The latter includes detailed lists of new, recycled, unchanged, and surplus parts, retrofit drawings of pre-status and post-status including grid references, and delta part lists. These may be exported conveniently to bills-of-material or PDM systems." (**PACE 2008**)

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