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

Analysis of the Process Chain for Cabin Conversion

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Diese Technische Niederschrift untersucht zwei Aspekte der Prozesskette für Kabinenumrüstungen: 1.) die Prozesskette, die in TN 1 identifiziert wurde, wird mit Dependency and Structure Modeling Werkzeugen, wie der Design Structure Matrix analysiert. Diese Analyse liefert den optimalen Ablauf der Prozesskette und zeigt die wichtigsten Prozesse auf. 2.) Die Fallstudienmethode wird benutzt, um die erforderlichen Input Daten zu identifizieren, die benötigt werden, wenn Kabinenumrüstungen für Nicht-Airbus-Kunden durchgeführt werden sollen. Die Untersuchung zeigt, dass mit den derzeit bei ELAN verfügbaren Ressourcen nur kleine Umrüstungen machbar sind.</td></tr>
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Abstract

Technical Note 3 continues the research on CARISMA with the topic Analysis of the Process Chain for Cabin Conversions, undertaken within a Completion Center. Based on the original research structure, defined in the research implementation, several topics were added and others were considered with special attention. The analysis focused rather on the analysis of the current capabilities of ELAN, while the vision Completion Center presented secondary importance. Two basic directions were investigated: *First*, the process chain identified in TN 1 was analyzed using Dependency and Structure Modeling tools, such as Design Structure Matrix. This delivered the optimal sequence of the processes within the process chain. In the same time it allowed the selection of the most important ones. *Second*, a case study approach was used to identify the required input information when cabin conversions are planned for non-Airbus customers. In order to perform this investigation, the available engineering input information sources were identified. This topic presented special interest for ELAN. The results confirmed that small conversions can currently be conducted at ELAN with the available resources.

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List of Abbreviations

AAP	Aft Attendant Panel
AC	Alternative Current
AIA	Aerospace Industries Association
AIP	Attendant Indication Panel
AIPC	Aircraft Illustrated Parts Catalog
AMM	Aircraft Maintenance Manual
AMTOSS	Aircraft Maintenance Task Oriented Support System
AP	Alternative Procedure (to DOA)
ARM	Aircraft Recovery Manual
ATA	Air Transport Association of America
BFE	Buyer Furnished Equipment
CAM	Cabin Assignment Module
CAS	Change Approval Sheet
C/B	Circuit Breaker
CCD	Catia Cadam Drafting
CCS	Change Control Sheet
CCSC	Commercial Customer Support Council
CD	Compact Disk
CDF	Customer Definition Freeze
CDL	Configuration Deviation List
CEN	European Committee for Standardization
CENELEC	Committee for Electrotechnical Standardization
CFK	Carbon (Kohlenstoff) Faserverstärkte Kunststoffe
CIB	Condor Berlin
CIDS	Cabin Intercommunication Data System
CIR	Engine Cleaning Inspection and Repair Manual
CMI	Component Manual Index
CMM	Component Maintenance Manual
CMMPL	Component Maintenance Manual Parts List
CPM	Consumable Products Manual
CSDD	Common Support Data Dictionary
CW	Calendar Week
DC	Direct Current
DEU	Decoder/Encoder Unit
DFM	

DIN	Deutsches Institut für Normung
DOA	Design Organization Approval
DMM	Domain Mapping Matrix
DSM	Design Structure Matrix
DSM	Dependency and Structure Modeling
DTD	Document-type Definitions
EADS	European Aeronautic Defense and Space Company
EASA	European Aviation Safety Agency
EC	Enhanced Cabin
EFPMS	Emergency Floor Path Marking System
EIPC	Engine Illustrated Parts Catalog
EM	Engine (Shop) Manual
EMMC	Engineering Maintenance & Material Council
EN	European Norm
EPCS	Engine Parts Configuration Management Section
EPSU	Emergency Power Supply Unit
ER	Emergency
ETSI	European Telecommunications Standards Institute
FAP	Forward Attendant Panel
FCOM	Flight Crew Operations Manual
FCU	Flush Control Unit
FEM	Finite Element Methods
FRM	Fault Reporting Manual
FIM	Fault Isolation Manual
FM	Flight Manual
GREDS	General Requirements for Engineering Design Suppliers
IBU	Integrated Ballast Unit
IEC	International Electrotechnical Commission
IFE	In-Flight Entertainment
ISO	International Organization for Standardization
ITCM	Initial Technical Coordination Meeting
ITU	International Telecommunication Union
KPI	Key Performance Indicators
LCD	Liquid Cristal Display
LLT P-Loc	Long Lead Time Preliminary List of Components
LOOP	List of Open Items
LR	Long Range
MA	Mitarbeiter

MAS	Modification Approval Sheet
MEW	Manufacturer Empty Weight
MMEL	Master Minimum Equipment List
MP	Modification Proposal
MPD	Maintenance Planning Document
MSN	Manufacturer's Serial Number
NDT	Non Destructive Testing Manual
NTF	Non Textile Floor
OBRM	On Board Replaceable Module
OBS	Organizational Breakdown
OHSC	Overhead Stowage Compartment
PD	Principle Diagram
PDR	Product Design Review
PI	Publications Index
PL	Project Leader
PO	Purchase Order
POA	Production Organization Approval
PPBM	Power Plant Buildup Manual
PPBMIPL	Power Plant Buildup Manual Illustrated Parts List
PRAM	Pre Recorded Announcements and Music
PSU	Passenger Service Unit
PTP	Programming and Test Panel
QM	Quality Management
RFC	Request for Change
RMO	Request for Modification
SA	Single aisle
SB	Service Bulletin
SBI	Service Bulletin Index
S/C	Subcontractor
SDCU	Smoke Detection Control Unit
SDS	Systems Description Section
SFE	Seller Furnished Equipment
SL	Service Letter
SRM	Structural Repair Manual
SSM	System Schematic Manual
STC	Supplemental Type Certificate
TAKSY	Technisch Administratives Konstruktionsdatenverwaltungs System
TD	Technical Dossier

TEM	Tool and Equipment Manual
TICC	Technical Information and Communication Committee
TO	Technical Offer
TN	Technical Note
TRS	Technical Repercussion Sheet
VCC	Video Control Center
VDE	Verein Deutscher Elektrotechniker
VSB	Vendor Service Bulletin
VSC	Vacuum System Controller
WB	Wide Body
WBM	Weight and Balance Manual
WBS	Working Breakdown Structure
WD	Wiring Diagram
WDM	Wiring Diagram Manual
WP	Work Package
WPSS	Work Package Subcontracting Specification
WTM	Work Transformation Matrix

1 Introduction

1.1 Motivation

This Technical Note 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 the WP 3, described in the appendix of the collaboration contract between Hamburg Innovation GmbH and ELAN GmbH as follows (**CARISMA 2009**):

> ***WP 3: Analysis of the Process Chain "Cabin Conversion"***
> *Depending on the aircraft type as well as size and extend of the cabin conversion, identified process steps have to be investigated each in its unique depth and manner. For a selected cabin conversion example, the process chain should be described in sufficient detail. The elements of the process chain should be investigated based on the following criteria:*
> - *Technology*
> - *EASA Part 21 - DOA - Design Organisation Approval / certification*
> - *Costs*
> - *Time*
> - *Human resources*
> - *Infrastructure*
> - *Tools*
>
> *The question should be answered, which resources are available at ELAN and which resources in the frame of a "make-or-buy"-decision have to be build up in-house or bought externally.*

After the Kick-off Meeting on 18 November 2009, it was decided that the focus of WP 3 should change to the following points of interest for ELAN (**Kick-Off 2009**):
1.) Engineering input information (drawings)
2.) Structure and logistics of the company
3.) Form of deliverables

The background of this change in the research direction lies in the following reasons (**Kick-Off 2009**):

- It is interesting for ELAN to know which sources of engineering input information exist and how the work results can be achieved (if at all) based on this information.
- It is interesting for ELAN to know first what is missing with respect to the company organization and which improving actions can be adopted.
- It is interesting for ELAN to know which is the optimal way of creating the deliverables, considering the form in which the results are requested by the customer.

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 (TN) 3 covers a two folded research direction: *First*, the process chain identified in TN 1 is analyzed using Dependency and Structure Modeling tools, such as Design Structure Matrix. This delivers the optimal sequence of the processes within the process chain and selects the most important ones. *Second*, a case study approach is used to identify the required input information when cabin conversions are planned for non-Airbus customers. This confirms that small conversions can be currently conducted with the available resources.

1.3 Literature

A series of manuals for Airbus and Boeing aircraft have been often quoted in this TN. The aircraft manuals represent an important source of information, useful especially in the preliminary phases of a project, prior to the aircraft inspection. More important are the Structure Repair Manual (SRM), the Aircraft Illustrated Parts Catalogue (AIPC) and the Wiring Diagram Manual (WDM).

For identifying the list of manuals owned by an airline, an investigation towards the aircraft documentation was required. For this purpose Air Transport Association of America (ATA) specifications were investigated and often quoted.

A very high contribution to this TN was brought through the direct contact with ELAN engineers, who provided on site practical information with respect to the current ELAN status and working procedures.

1.4 Structure of Work

The Technical Note is comprised of 4 chapters, besides the introductory chapter.

Chapter 2 **Process Chain Optimization with the Dependency and Structure Modeling Methodology** – incorporates the results of the analysis of the process chain for cabin conversions, inside a completion center. Three types of analysis are here conducted: *First*, the Design Structure Matrix (DSM) optimization is performed through the partitioning algorithm, in order to obtain the right sequence of the processes. *Second*, the eigenstructure of the Work Transformation Matrix (WTM), obtained from the DSM is analyzed, in order to identify key processes. *Third*, a Cross Impact analysis is performed, in order to group the processes into five zones of influence.

Chapter 3 **Conducting Independent Cabin Conversion Design Activities at ELAN** – deals with 3 aspects: *First*, an overview on possible sources of engineering input information is presented. *Second*, the form of deliverables incorporating the engineering output information is proposed. *Third*, the internal work procedure at ELAN is described.

Chapter 4 **Case Study: A320 Cabin Conversion for Condor Berlin** – presents the investigation of a past conversion scenario conducted by ELAN for Airbus, under the hypothesis that a non-Airbus customer having the same requirements, contracts ELAN. This chapter states the problems and solutions encountered when drawings or parts lists are missing.

Chapter 5 **Virtual Case Study: B737 Cabin Conversion** – presents a selected conversion scenario for a B737 aircraft. Airbus aircraft are well known by the ELAN engineers. It was found interesting to analyze a simple refurbishing case for a non-Airbus commercial transport aircraft, in order to detect possible problems and find input information.

Each chapter presents an end-summary and comments the results obtained.

2 Process Chain Optimization with the Dependency and Structure Modeling Methodology

The process chain for cabin conversion identified in the TN 1 can be further optimized by using the Dependency and Structure Modeling methods. This chapter presents the Design Structure Matrix (DSM) approach for the cabin refurbishing process chain and applies the available algorithms with the aim to find the best combination of resources for a fast and cost efficient fulfillment of the engineering tasks.

2.1 The DSM Methodology

The DSM started in the 1980's from the idea of using graph theory in order to represent the sequence of design tasks of a complex engineering project as a network of interactions (**Steward 1991**). This network is represented by a quadratic matrix with identical row and column headings, containing relations and interactions in their nodes (see Figure 2.1).

		1	2	3	4	5	6	7
Offer	1	1						
Concept	2	1	2	1				
Definition	3	1	1	3	1			
Design	4	1	1	1	4		1	
Adjustment	5	1	1	1	1	5	1	1
Certification	6	1	1	1	1		6	
Handover	7	1	1	1	1		1	7

Fig. 2.1 Example of DSM showing the relations between the main phases of the process chain for cabin conversion (**Niță 2009**)

2.1.1 Types of DSMs and Their Application

There are several types of domains as well as relations which can be expressed through a DSM. This diversity leads to a DSM classification as shown in Figure 2.2.

Static DSMs do not depend on time, therefore the elements exist simultaneously. Such elements are components of a system, in which case the DSM is *component-based*, or members of a team, in which case the DSM is *people-based.* A static DSM analysis would provide results with respect to product decomposition or information flow among members of an organization (**Browning 2001, Bartolomei 2009**).

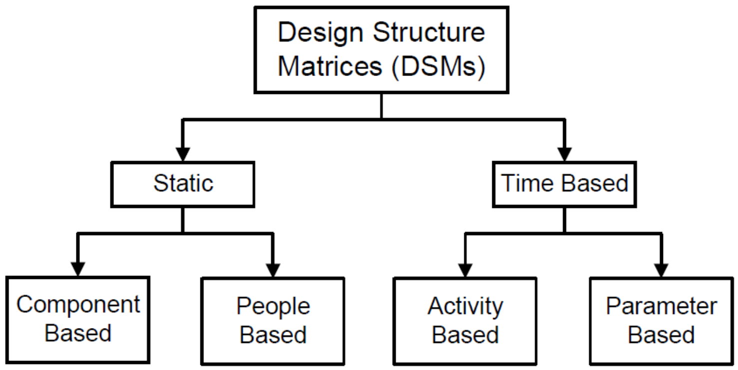


Fig. 2.2 Classification of DSM (based on **Browning 2001**)

Time-based DSMs consists of time dependent nodes. The elements of the matrix can be represented by *activities*. In this case the DSM analysis provides their optimal sequencing. The nodes (or elements) can also be represented by *parameters* related to system activities. An analysis of such a DSM would help identifying activities that influence the design parameters (**Bartolomei 2009**).

The way to *read* a DSM can be shown based on Figure 2.1:

- The *input information* can be read along the rows – i.e process 4 (design phase) receives information from processes 1, 2 and 3 (offer, concept and definition).
- The *output information* can be read along the columns – i.e process 4 (design phase) gives information to process 3 (definition).
- The *information exchange* is marked through the logical operator *true/1*.

The order can be inversed if the user decides to change this convention. In this case one can read the input information on the column and vice-versa. Usually this convention is indicated by an arrow mark above the matrix (as shown on Figure 2.1).

The logical operators only show the coupling between the nodes. It is possible to replace them by numbers in order to show the *degree of dependency* between the elements (**DSM 2009**):

- 1 – high dependency
- 2 – medium dependency
- 3 – low dependency

Browning 2001 and **Pimmler 1994** use positive and negative numbers, called *coupling coefficients*, to express the ranking of the interactions (see Table 2.1). Negative numbers need to be carefully implemented into the tools which optimize DSMs, as they may not function properly.

Table 2.1 Interaction quantification scheme (based on **Pimmler 1994**)

Information		
Required:	+ 2	Information exchange is necessary for functionality
Desired:	+ 1	Information exchange is beneficial, but not absolutely necessary for functionality
Indifferent:	0	Information exchange does not affect functionality
Undesired:	1	Information exchange causes negative effects but does not prevent functionality.
Detrimental:	2	Information exchange must be prevented to achieve functionality

The key factor in using the DSM methodology is the correct input of the logical operators, respectively coupling coefficients into the matrix. The researchers of this topic (**Pimmler 1994**, **Danilovic 2007**, **Browning 2001**, **Bartolomei 2008**) agree on the following preparing steps:

1. Clear definition of system boundary and functionality
2. Identification of system components

Proper fulfillment of Steps 1 and 2 make step 3 possible, which needs additional information from the members of the organizational staff and engineers:

3. Identification of interfaces between components

The engineers need to be questioned with respect to the type and frequency of interactions between the components, in order to estimate the right position and intensity of the coupling coefficient. The additional sub-steps are required:

3.1 Preparation of questionnaires
3.2 Gathering and analyzing the results
3.3 Implementing the results into the matrix

A Design Structure Matrix can only be used to analyze interactions between elements of the same type. In order to see for instance which team is suitable for which activity, one would need to combine a people-based DSM with an activity-based DSM and analyze the interactions as a whole. This analysis is possible in the frame of a *Domain Mapping Matrix (DMM)*.

A DMM is a rectangular matrix which examines interactions between two domains. The literature about DMMs indicates that there are at least 5 major domains which interact in product development (**Danilovic 2007**):

1. Goals

2. Product
3. Process
4. Organization
5. Tools

The interactions *inside* the five domains listed above are represented in DSMs. The interactions *between* the domains are illustrated with DMMs (see Figure 2.3).

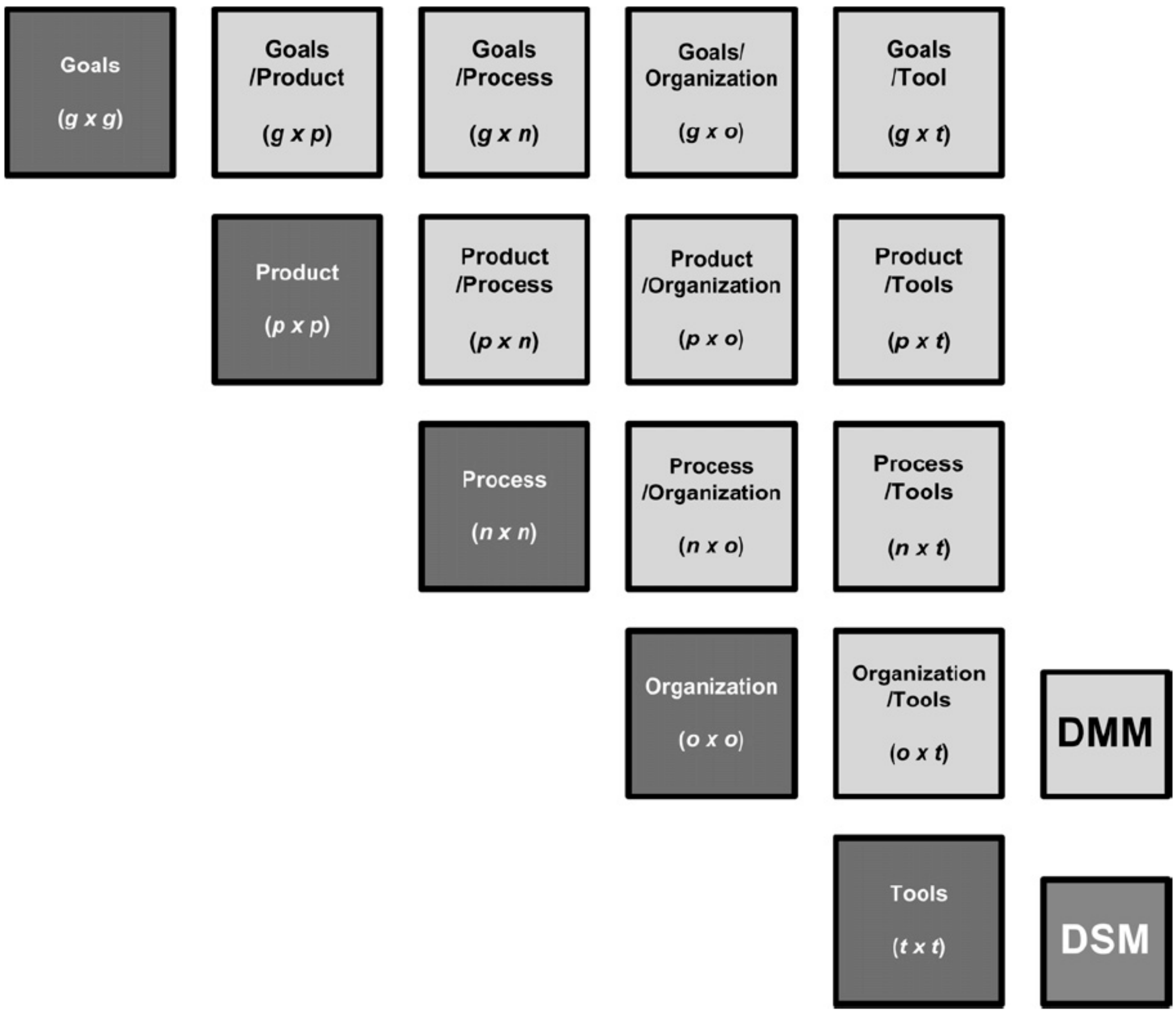


Fig. 2.3 DSMs and DMMs for the five project domains (**Danilovic 2007**)

DMM analysis methods are relatively new, thus the literature is limited. The advantage of expanding the analysis beyond single domain information gives however enough reason to consider the DMM approach. To summarize, the main characteristics of both DSM and DMM are listed in Table 2.2.

Table 2.2 Main characteristics of DSMs and DMMs (based on information gathered from **Danilovic 2007**, **Bartolomei 2008**, **Browning 2001**)

Criteria	Design Structure Matrix (DSM)	Domain Mapping Matrix (DMM)
Representation	Square matrix nxn	Rectangular matrix nxm
Analytical dimension	Single domain	Dual domain
Focus of analysis	Tasks Activities Parameters Components People Information flow Deliverable flow	Components/Organization Project/Organizational Structure Functionality/Product Architecture Information flow

2.1.2 Optimization Algorithms

Several analysis algorithms are applicable depending on the type of elements represented into the matrices. The aim of the investigation towards the DSM methodology is to apply it for the optimization processes required to perform an aircraft cabin conversion. The interest of this technical note is therefore to highlight and apply those algorithms suitable for activity based components analysis.

Niță 2009 identified a number of 148 processes for completing a cabin conversion (while considering a low degree of detail). The analysis of a great number of processes with the DSM method requires the automation of the optimization. Highly detailed DSMs use programmed algorithms and the computer aid.

If the purpose is to optimize the sequence of the activities, the suitable algorithm is called *partitioning* or *sequencing*. If the purpose is to assign proper personnel to specific tasks, the suitable algorithm is called *clustering*, as it allows grouping of the highly related elements into clusters (**Eppinger 2002, Bartolomei 2008, Danilovic 2007**).

Partitioning aims to reorder the sequence of the elements in order to obtain a *lower triangular matrix* (according to the convention from Figure 2.1, otherwise the algorithm would deliver an upper triangular matrix). This is achieved by manipulating the rows and columns of the matrix such that the coefficients move closer to the main diagonal and reduce the negative feedback between the elements. The result is a minimized waiting time between activities. The conclusion to be drawn (**Bartolomei 2008**) is that minimizing feedback eliminates the process iteration and spares time.

If we analyze the matrix in Figure 2.1 (reproduced in Figure 2.4 for a better visualization) we observe that coefficients above the diagonal indicate the necessity of a task to wait for the completion of another task which is to be fulfilled in the future.

The problem formalization can be expressed through the following exemplary question for element number 5: *Can process number 5 be fulfilled after processes 6 and 7? If yes, then insert 1. Do processes 1, 2, 3, 4 give information to process 5? If yes, then insert 1.*

		1	2	3	4	5	6	7
Offer	1	1						
Concept	2	1	2	1				
Definition	3	1	1	3	1			
Design	4	1	1	1	4		1	
Adjustment	5	1	1	1	1	5	1	1
Certification	6	1	1	1	1		6	
Handover	7	1	1	1	1		1	7

Fig. 2.4 Example of DSM showing the relations between the main phases of the process chain for cabin conversion (**Niță 2009**)

The following observations after analyzing Figure 2.4 can be extracted:
1. The *concept* phase can suffer modifications after the *definition* phase.
2. The *definition* phase can suffer modifications after the *design* phase.
3. The *design* is influenced by the *certification* requirements, and can later suffer modifications accordingly.
4. All phases provide information for the *adjustment* [1] phase.
5. All phases, besides adjustment and handover give information to *certification* phase.
6. *Handover* phase receives information from all other phases, besides adjustment, to which it gives feedback.

Applying the partitioning algorithm to the matrix in Figure 2.4 means reordering the phases in the most economical manner. Due to the fact that the dimensions of the matrix are small, a manual manipulation is possible. The following steps are required (based on **DSM 2009**):
1. Identification of the elements which do not receive information from the others (by looking for empty columns) and moving them to the right.
2. Identification of the elements which do not give information to the others (by looking for empty rows) and moving them to the left.

[1] The adjustment phase is seen as a phase gathering those activities which are aimed to improve the overall functioning of the company delivering the conversion (**Niță 2009)**

3. If after steps 1 and 2 there are no remaining elements in the DSM, then the matrix is completely partitioned; otherwise, the remaining elements contain information circuits, which can be further optimized

DSM 2009 provides a tool, developed at the Technical University in München, which can automate the process of partitioning. Figure 2.5 shows the partitioned matrix obtained with this tool from the original matrix shown in Figure 2.4.

		Offer	Concept	Definition	Design	Certification	Handover	Adjustment
		1	2	3	4	6	7	5
Offer	1	1						
Concept	2	1	2	1				
Definition	3	1	1	3	1			
Design	4	1	1	1	4	1		
Certification	6	1	1	1	1	6		
Handover	7	1	1	1	1	1	7	
Adjustment	5	1	1	1	1	1	1	5

Fig. 2.5 The partitioned matrix obtained from the original matrix shown in Figure 2.4

From the results obtained, the following conclusions can be extracted:

- The adjustment phase was moved at the end of the sequence; it is the last to be fulfilled, once it receives the feedback from all other phases.
- There are still coefficients above the diagonal (market in light blue) but they are required for the proper functioning of the system
- The light blue indicates that the information exchange is bidirectional, which means the three phases are coupled

Besides partitioning, another algorithm may be of interest when it comes to setting up a completion center. The *clustering* algorithm will be further illustrated, but its application is beyond the purpose of this technical note.

While partitioning is suitable for *time-dependent* elements, **clustering** is suitable for *time-independent* systems, such as product architecture or project organization (**Danilovic 2007**). Clustering focuses on identifying groups of items. It is, for example, useful when the elements of the matrix are people, which need to be grouped in teams. When it comes to designing a product,

another application of the clustering algorithm is in the system decomposition and can help identifying the sub-components suitable for the system modularization.
The procedure is similar to partitioning: columns and rows are reordered with the purpose to underline the elements which are highly interconnected. Interactions between clusters are, in the same time, minimized (**Bartolomei 2008**).

Partitioning and clustering are algorithms suitable for DSM analysis. When it is required to analyze the interaction between two domains within a DMM, the algorithms need to be adapted. **Danilovic 2007** provides an analysis with respect to applicable algorithms for DMMs. His conclusions are summarized in Table 2.3.

Table 2.3 Comparisson between DSM and DMM (based on **Danilovic 2007**)

Dimensions	Design Structure Matrix (DSM)		Domain Mapping Matrix (DMM)
	Partitioning analysis	Clustering analysis	
Partitioning algorithm	Block diagonalization / Triangularization	Clustering in blocks along the diagonal	Move items to clusters
Result of the analysis	Sequence of items, activities	Clusters of items	Clusters of items
Visualization of dependencies	Feedback and circuits Loops of items Parallel items Sequence of items	Clusters of items Dependencies of clusters	Clusters of items Dependencies of clusters
Key words	Tasks Activities Information flow Deliverables flow	Parameters Components People Organization Information flow	Components/Organization Project/Organizational Structure Functionality/Product architecture Information flow

2.2 Analysis of the DSM for the Process Chain for Cabin Conversion

In the previous sub-chapter a DSM analysis was already performed on the coarse matrix (illustrated in Figure 2.1, respectively Figure 2.4) with the purpose to exemplify the functioning of the partitioning algorithms. The following paragraphs will apply the algorithm for the fine matrix, which includes all the processes identified in **Niță 2009**. Other two types of analyses are as well illustrated: the eigenstructure analysis and the cross impact analysis.

2.2.1 Partitioning Algorithm

The processes were introduced in the EXCEL tool (**DSM 2009**) and the algorithm was run. By manipulating the rows and columns, a minimal feedback process configuration was obtained. The detailed before and after process layout is shown in Appendix A. Figures 2.6 and 2.7 show an overview of the results.

This analysis required a long preparation time and the main difficulties consisted of:

- understanding the dependencies between each process,
- inserting them into the matrix,
- having a clear view over the whole complex structure.

After overcoming these difficulties and running the algorithm, the following conclusions were extracted:

- Definition, Design and Certification phases are coupled (light blue); they create an information cycle which needs iteration, and therefore further optimization.
- Other small couplings exist between the teams for engineering, certification and quality assurance.
- A detailed analysis of the matrix and of each of the illustrated dependency allows a better understanding of the results.

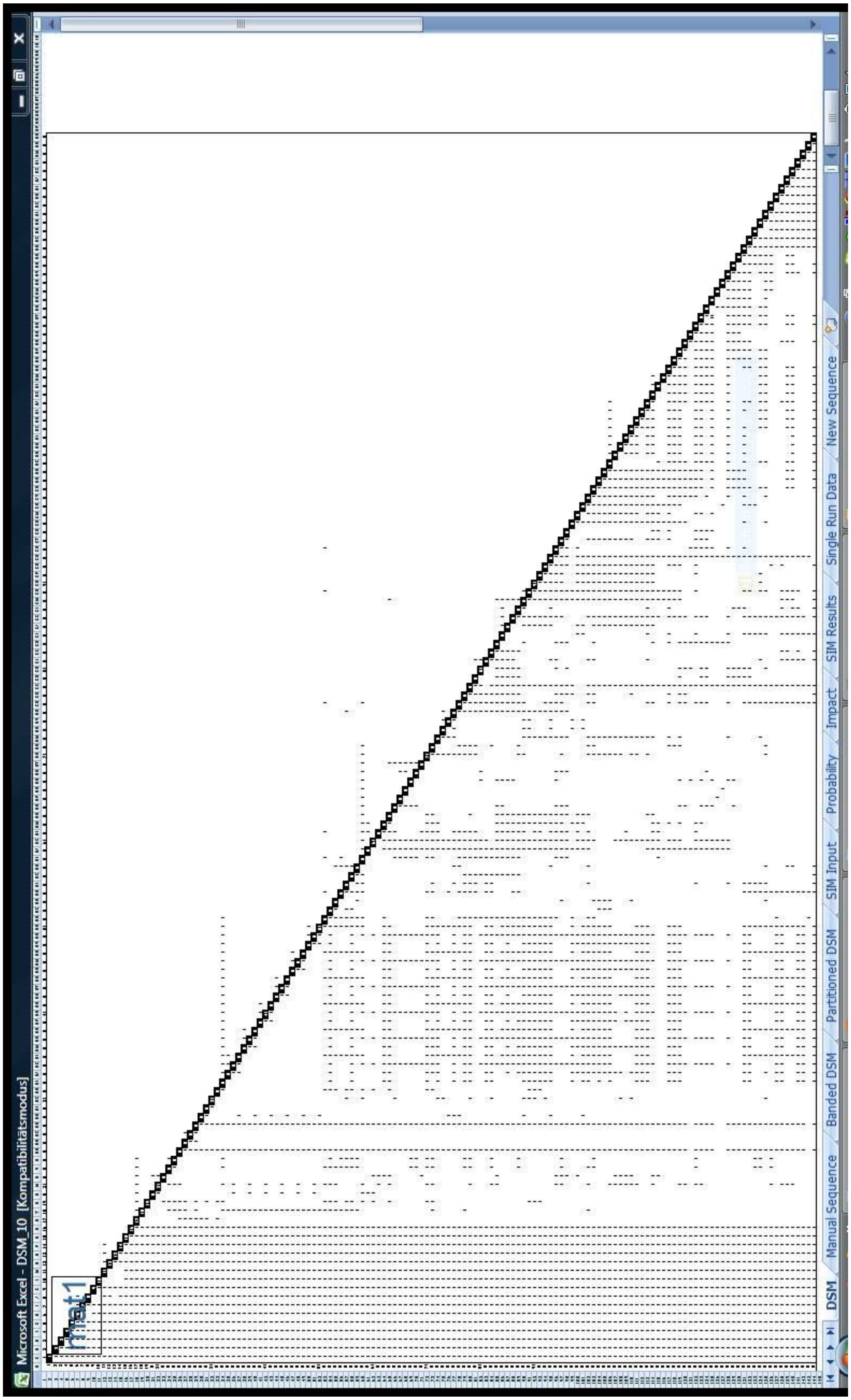


Fig. 2.6 The DSM for the detailed process chain – before running the partitioning algorithm

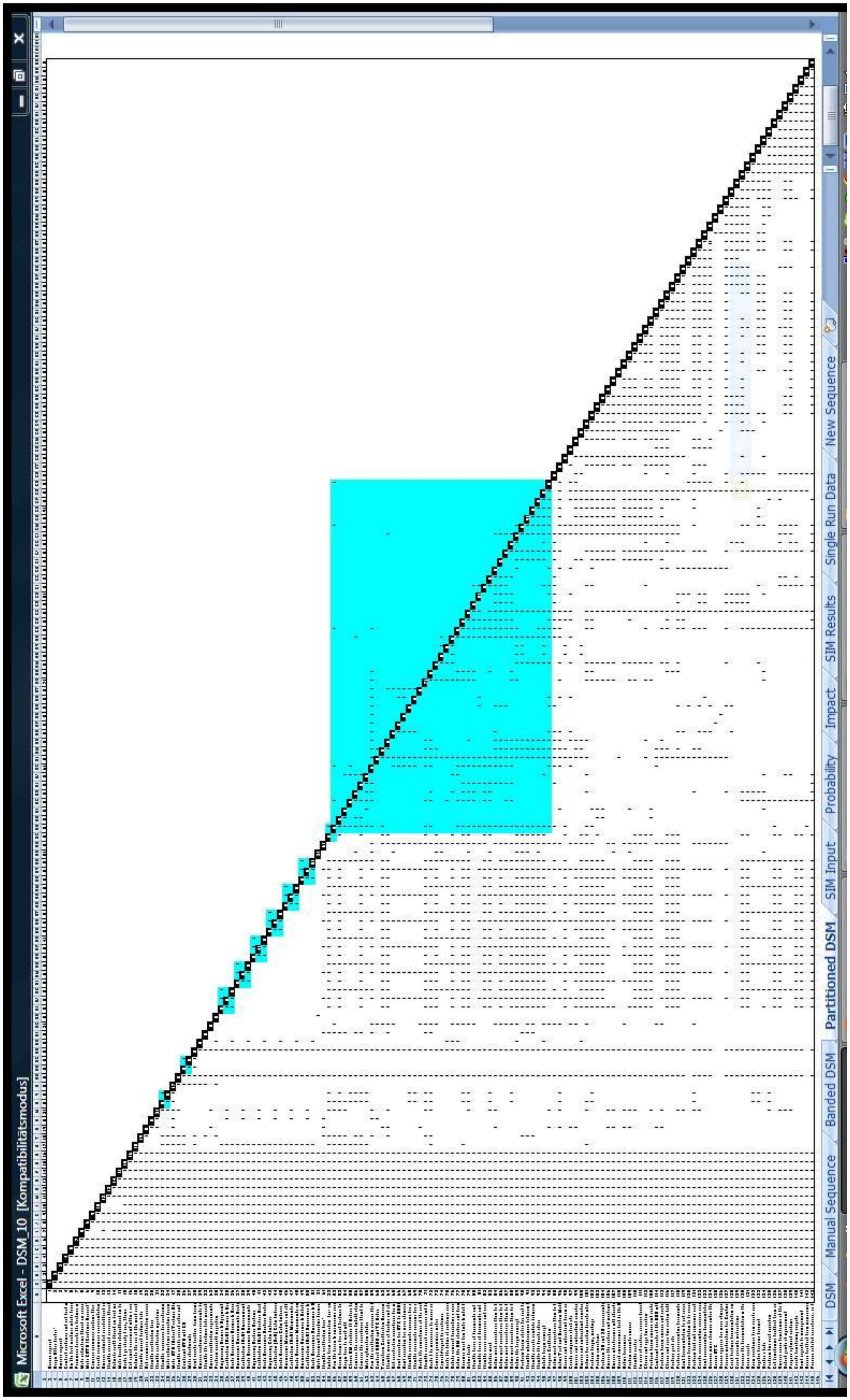


Fig. 2.7 The DSM for the detailed process chain – after running the partitioning algorithm

2.2.2 Eigenstructure Analysis

When aiming to optimize a large number of processes, it helps conducting an analysis which allows the extraction of the most important ones. The eigenstructure analysis for DSMs was developed by Smith and Eppinger in **Smith 1997**. In our case it helps underlining those processes which have a major influence on the system.

The eigenvalues and eigenvectors determine the nature of the convergence of the design process in a similar way with the aircraft dynamics:

- the eigenvalues give information about the rate of convergence,
- the eigenvectors give information about the shape of the natural motion.

An interesting similarity between the dynamical behavior of a physical system and the behavior of the tasks/processes of an engineering system can be noticed. In both cases large magnitude positive eigenvalues give information about the convergence of the system.

Another interesting analysis is to optimize the duration of the development time (**Smith 1997**):

- Serial tasks can be evaluated by summing their individual times.
- Parallel tasks can be evaluated by finding the maximum of those task times.

In this case a Work Transformation Matrix (WTM) (**Smith 1997**) needs to be used. Each iteration causes rework; the amount of rework is quantified through this matrix. The off diagonal elements of WTM represent the strength of dependence between tasks – for our analysis, the rework necessary for each task. The diagonal elements represent the time that it takes to complete each task during the first iteration (see Figure 2.8).

(a) Strength of Dependence Measures **(b) Task Times**

Fig. 2.8 Work Transformation Matrix (WTM) (**Smith 1997**)

The eigenstructure analysis of the process chain was performed on the WTM under the consideration that the amount of rework is 100%. In this way the problem became simpler to handle (by inserting 1 instead of proportions of 1) and the results were covered by the largest safety margin possible. The steps for conducting the analysis were:

1.) Building the WTM.

2.) Calculating the eigenstructure i.e. eigenvalues and eigenvectors of the matrix.
3.) Interpreting the magnitute of the eigenvalues.

The results are summarized by Table 2.4.

Table 2.4 The processes with the largest eigenvalues

Process ID	Process Title	Eigenvalue
50	Organizing team for certification	6.43
51	Organizing team for quality assurance	2.21
52	Planing the Design & Engineering process	2.21
53	Assigning Teams for each technical field	2.31
106	Analyzing electrical and mechanical loads	1.62
113	Performing design analysis and verification	1.62
121	Perform test and compliance verification	1.00

Within a Completion Center, it seems that certification, along with quality assurance play a key role along with the planning the design and engineering process and the team selection. A second major importance is represented by the tasks grouped under the design analysis and verification. The results are plausible, especially when considering the way EASA developed the DOA requirements. For EASA the self control capability of each design organization presents a major importance.

2.2.3 Cross Impact Analysis

Another type of analysis which can be performed based on the DSM is the Cross-Impact Analysis. The data is analyzed by means of a Cross Impact Matrix, as illustrated in Figure 2.9. The red numbers represent the strength of the influence exercised by each factor / task over the rest of the factors / tasks. It is assumed for our analysis that the influence is always either 1 or 0. Depending on the convention, the tasks are either passive or active. The aim of the Cross-Impact Analysis is to identify several meaningful influence zones and the processes belonging to them. The values representing the strength of the relations are summarized per row and per column. The results are graphically represented as shown in Figure 2.10. There are five meaningful zones which can be identified:

1.) **Zone I: Reactive Processes** – Changes of elements in this area have a strong influence on the system; they give a lot of information to the rest of the components.

2.) **Zone II: Dynamic Processes** – Changes of elements in this area have an important influence on the system; the information exchange is strong on both sides.

3.) **Zone III: Impulsive Processes** – Elements in this area have a small influence on the system but are strongly influenced by other system changes.

4.) **Zone IV: Low Impact Processes** – Elements in this area have a small influence on the system and are poorly influenced by other system changes.

5.) **Zone V: Neutral Processes** – Elements in this area find themselves at the intersection with other domains; neutral means safe from unexpected effects.

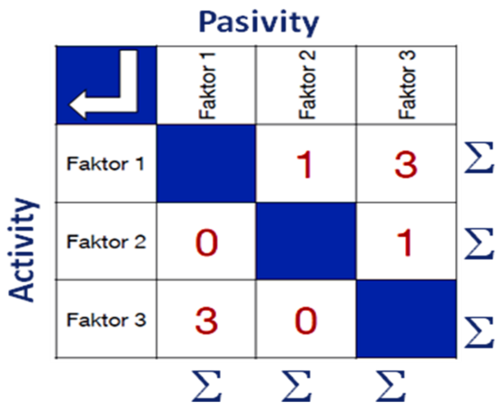


Fig. 2.9 Cross Impact Matrix example (based on **Phleps 2009**)

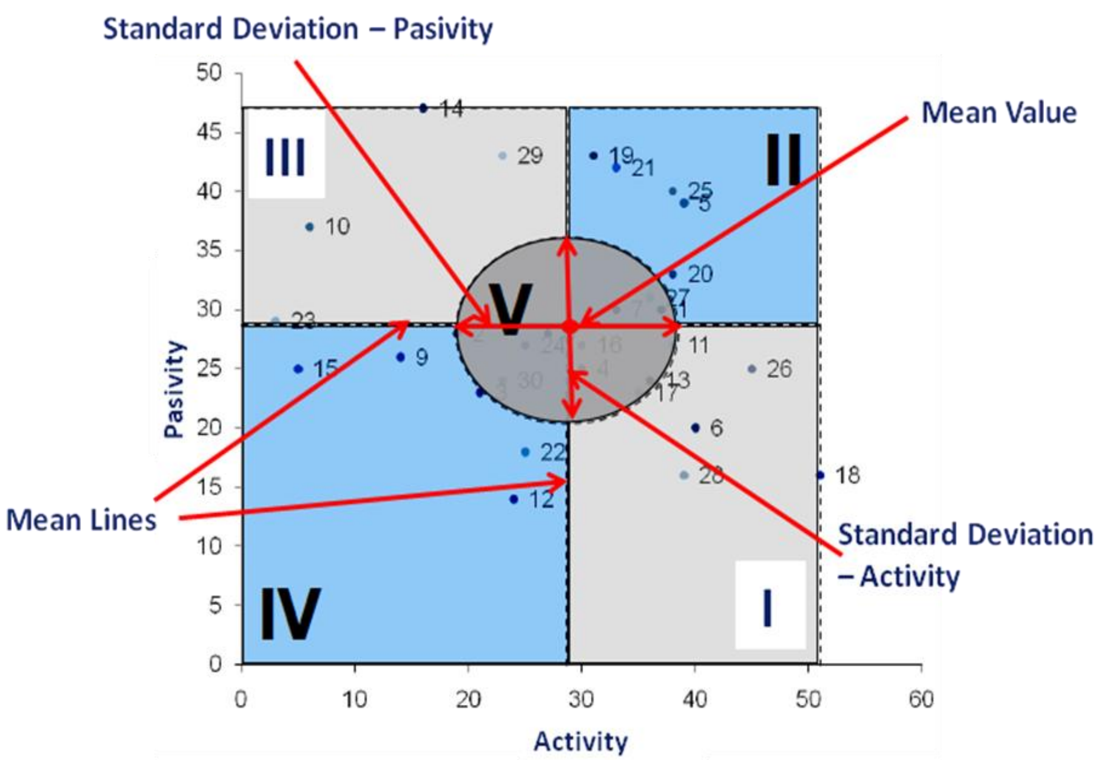


Fig. 2.10 Cross Impact diagram (based on **Phleps 2009**)

Based on the DSM, the following results for the parameters describing the diagram were obtained through EXCEL calculation (see Table 2.5):

Table 2.5 Results for the parameters describing the Cross-Impact diagram

Partitioned DSM	**Activity**	**Pasivity**
Summ	5271	5271
Mean Value	36.86	36.86
Standard Deviation	40.067	19.147
Minimum	0	0
Maximum	142	85

Due to the large number of processes the diagram is not easy to interpret. However 'clouds' pf processes can be identified. The diagram is shown in Figure 2.11 and an overview of the results in Table 2.6.

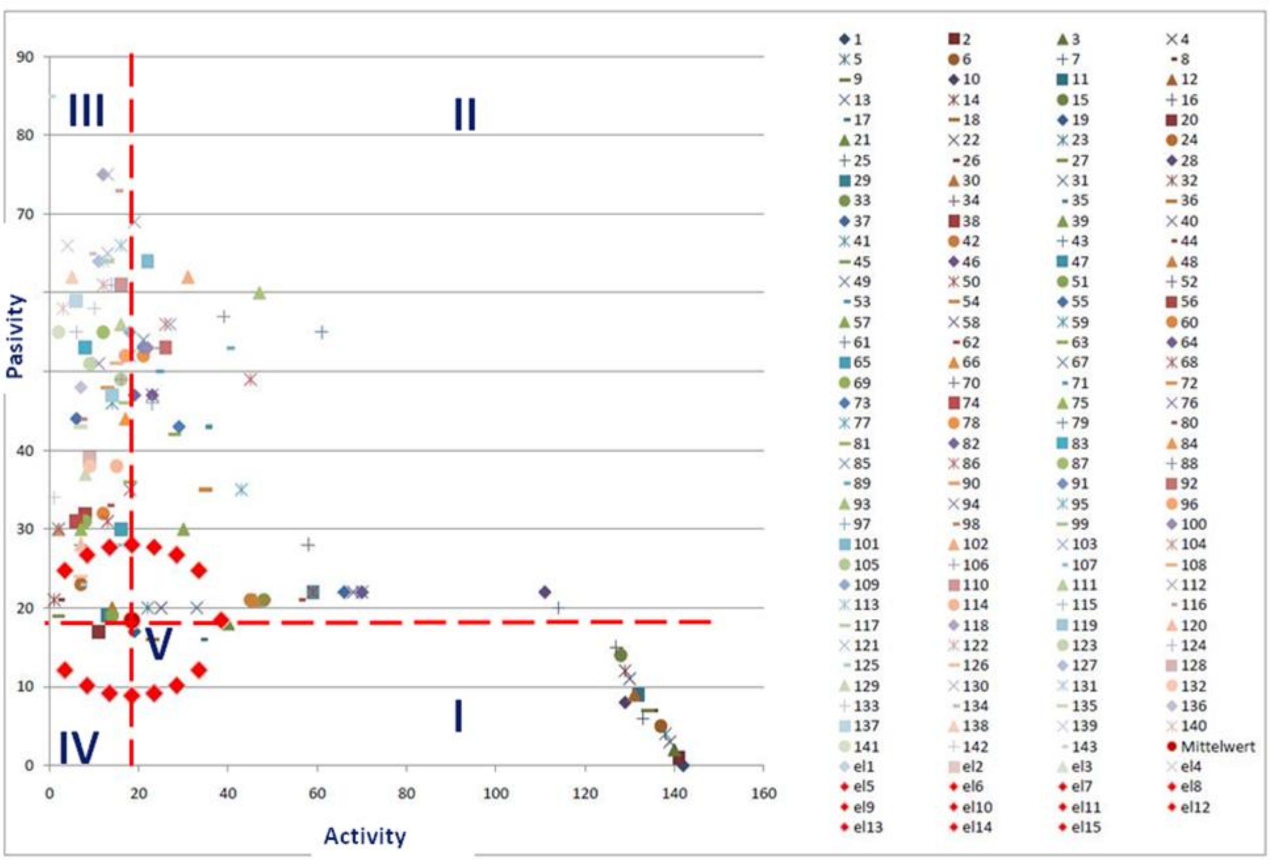


Fig. 2.11 The Cross-Impact Diagram based on the DSM

Table 2.6 Selected processes for each zone of influence

Processes in zone I	(2) Assign Offer Leader (126) Receive approval for major changes (9) Concieve preliminary solutions for discussing it with the customer (baseo on the first meeting) (10) Create preliminary representation of the solutions found (12) Identify required resources (based on the first meeting) (14) Make feasibility studies (16) Get signed agreement
Processes in zone II	(94) Validate design concept (87) Define work procedures for quality assurance (79) Define tasks (definition phase) (93) Identify feasible choice (when it comes to interferences) (design phase) (73) Conceive preliminary models(concept phase) (61) Identify certification basis (concept phase) (54) Plan the design and engineering process
Processes in zone III	(137) Analyze overall functioning of the DO (133) Register Lessons Learned (75) Verify the fulfillment of the customer request (139) Propose optimized solutions (for the functioning of DO) (143) Prepare updated procedures for the functioning of the DO (138) Detect points of improvement (of the DO) (119) Send documentation to EASA (to get approval)
Processes in zone IV	(27) Make adjustments of the DTS after confronting it with CR
Processes in zone V	(17) Write DTS (18) Estimate the size of the work package (24) Make estimations regarding design effort (30) Perform aircraft inspection (31) Write document describing diagnosis (32) Identify the technical fields involved in the design process (concept phase) (62) Analyze certification requirements (concept phase)

Processes in zone I, like feasibility studies or getting the signed agreement, strongly influence the rest of the processes: unless the contract is signed and the technical proposal accepted, the rest of the processes are not run anymore.

Processes in zone II, like validating the design concept or identifying the certification basis, are very important for the functioning of the system and require a lot of information from the rest of the processes.

Processes in zone III, like proposing solutions for an optimized functioning are processes which require a lot of feedback information from the rest of the processes, while their influence may be important in the future, and not for the respective project / iteration.

Processes in zone IV, like adjusting a document, once new information is available, have a low impact on the system.

Processes in zone V, like estimating the size of the work package and design effort, are in the neutral zone. They are important for the system, but the results are rather expected.

2.3 General Interpretation of the Results

The partitioning algorithm – a DSM based optimization algorithm – delivered the optimal sequence of the basic processes inside the completion center. This algorithm had as an objective minimizing the feedback information. However, due to the high number of processes, the partitioning algorithm had to be run several times, and the results may still be locally invalid. Another point which influences the accuracy of the results is the fact that these processes are rather general processes; most of them can be further divided into sub-processes / subtasks. In this case an overall analysis with DSM would be impossible due to the large number of relations which need to be established. In this case the matrix would be too large, and the automation of the relations input is not possible. It makes more sense to conduct such an analysis on smaller DSMs characterizing a smaller subsystem, comprising of one or several phases.

The eigenstructure analysis, based on the WTM extracted from DSM, started with the idea of finding similarities between the functioning of an engineering system and the dynamic behavior of an aircraft. The way such a system oscillates is similar with the ‘oscillations’ inside a design organization, when rework is required. The results underlined those processes with the largest eigenvalues, i.e. with the greatest influence on the engineering system. This analysis can be further extended if for each process the rework load is fractionally expressed. This type of analysis on WTM is especially suitable for reconversion tasks, as it allows the estimation of how much work is required for the rest of the cabin items if one item is being replaced / reconverted. It also allows the calculation of the total time or the partial times for performing the cabin conversions.

The cross impact diagram delivered groups of processes belonging to five spheres: reactive, dynamic, impulsive, low impact and neutral. Indeed the process chain assumes tasks which are vital for the entire chain as well as tasks which do not have an important influence on the system. The results are plausible. They could be however used on smaller DSMs in order to identify especially those tasks which poorly influence the system. Such tasks may be further coupled or ignored.

2.4 Summary of the Chapter

In this chapter the DSM methodology was briefly described and available optimization algorithms were used. On the basis of the Design Structure Matrix other characteristics of the system were identified, by applying other matrix methods. Three types of analyses were performed:

- Partitioning – delivering the proper sequencing of the processes.
- Eigenstructure Analysis – delivering the most important processes.
- Cross Impact Analysis – dividing the processes into five zones of influence, and characterizing their impact on the whole system.

Performing the 3 analysis on a smaller DSM, focused for instance on design or on certification would allow an easier interpretation. The results obtained:

- highlight the most important processes,
- provide the optimized sequencing of the processes,
- underline the coupling between design and certification phases.

The process chain is however an ideal process chain, as described in the TN 1, applicable inside a Completion Center. The next chapters of this Technical Note will further focus on the current ELAN capabilities and will identify the working procedure / processes when the DOA is missing and the Completion Center is not functioning.

3 Conducting Independent Cabin Conversion Design Activities at ELAN

3.1 Engineering Input Information

3.1.1 Systematic of Aircraft Documentation

The aviation industry covers three interdependent domains: the *construction* of the air-vehicles, their *maintenance*, and their *operation*. For achieving the end product, a lot of entities interact during the design process. The aircraft manufacturers often divide the engineering work between different subcontractors.

In order to avoid conflicts during the cooperative work, a standardized platform for the required technical documentation needed to be created. The *Air Transport Association of America* took over the role to create such international standards for aviation technical documentation. Their publications are known as *ATA-Specs*. Some of the most important publications are (**ATA 2009a**):

- *ATA Common Support Data Dictionary* (CSDD) – is a catalog of all data elements, terms, and tags that are used throughout ATA specifications.
- *ATA iSpec 2200 Information Standards for Aviation Maintenance* – is a global aviation industry standard for the content, structure, and electronic exchange of aircraft engineering, maintenance, and flight operations information.
- *ATA iSpec 2200 Extract: ATA Standard Numbering System* – is an extract from ATA iSpec 2200, which provides the industry-wide standard for numbering aircraft systems, often referred to as system or chapter numbers
- *ATA Spec 100: Manufacturers' Technical Data* – it contains format and content guidelines for technical manuals written by aviation manufacturers and suppliers and is used by airlines and other segments of the industry in the maintenance of their respective products

In a wider sense, standards are structured as shown in Table 3.1 (**Scholz 2002**). International and European norms are undertaken at national level. The purpose is to ensure desirable characteristics of products and services such as quality, environmental friendliness, safety, reliability, efficiency and interchangeability, at an economical cost (**ISO 2009**). The *International Organization for Standardization* (ISO) has currently 162 members and cooperates with the *International Electrotechnical Commission* (IEC) and the *International Telecommunication Union* (ITU). The *European Committee for Standardization* (CEN) uses the same principles as ISO, but is limited to

Europe. It cooperates as well with the *Committee for Electrotechnical Standardization* (CENELEC) and the *European Telecommunications Standards Institute* (ETSI).

Table 3.1 Standardization Organizations (**Scholz 2002**)

	General	Electrotechnology	Telecommunication
International	International Organization for Standardization (ISO)	International Electrotechnical Commission (IEC)	International Telecommunication Union (ITU)
Regional (Europa)	European Committee for Standardization (CEN)	European Committee for Electrotechnical Standardization (CENELEC)	European Telecommunications Standards Institute (ETSI)
National (Deutschland)	Deutsches Institut für Normung (DIN)	Verein Deutscher Elektrotechniker (VDE)	—

Standards used in aircraft manufacturing comprise not only of the above mentioned, general norms (ISO, CEN, DIN), but also of special norms, such as the Air Force Navy Standards or the ATA Specifications (see Figure 3.1).

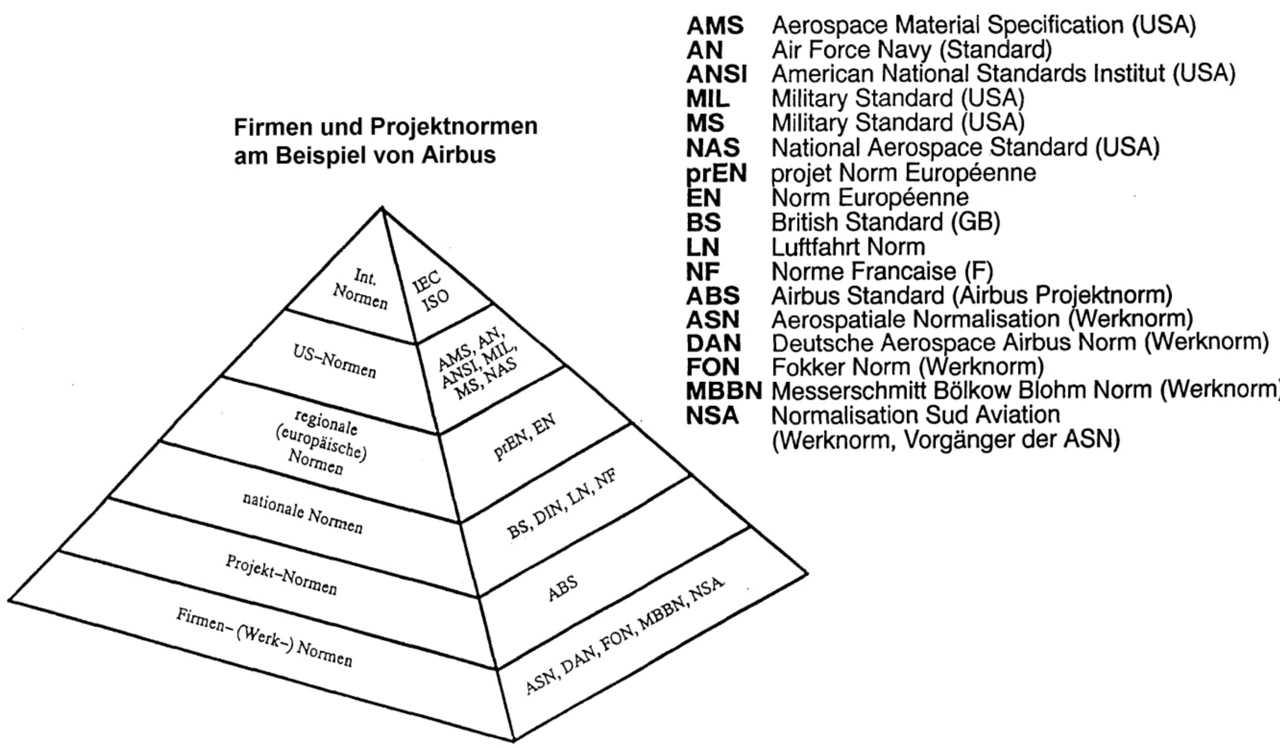


Fig. 3.1 The hierarchy of norms on the example of aircraft development at Airbus (**Scholz 2002**)

Standards are necessary not only in maintaining and operating the aircraft, but in designing and developing it as well. Information exchange between manufacturers, suppliers, engineering offices, maintenance facilities and aircraft operators is currently well structured and used already in the preconception phases. The ATA Chapters are referred to in the purchase agreements between manufacturers and airlines. During the life cycle, the manufacturer is contractually committed to meet the air carrier's data requirements in a manner that conforms to the ATA specification agreed to at the time of the aircraft sale (**ATA iSpec 2200**). These relations are illustrated in Figure 3.2.

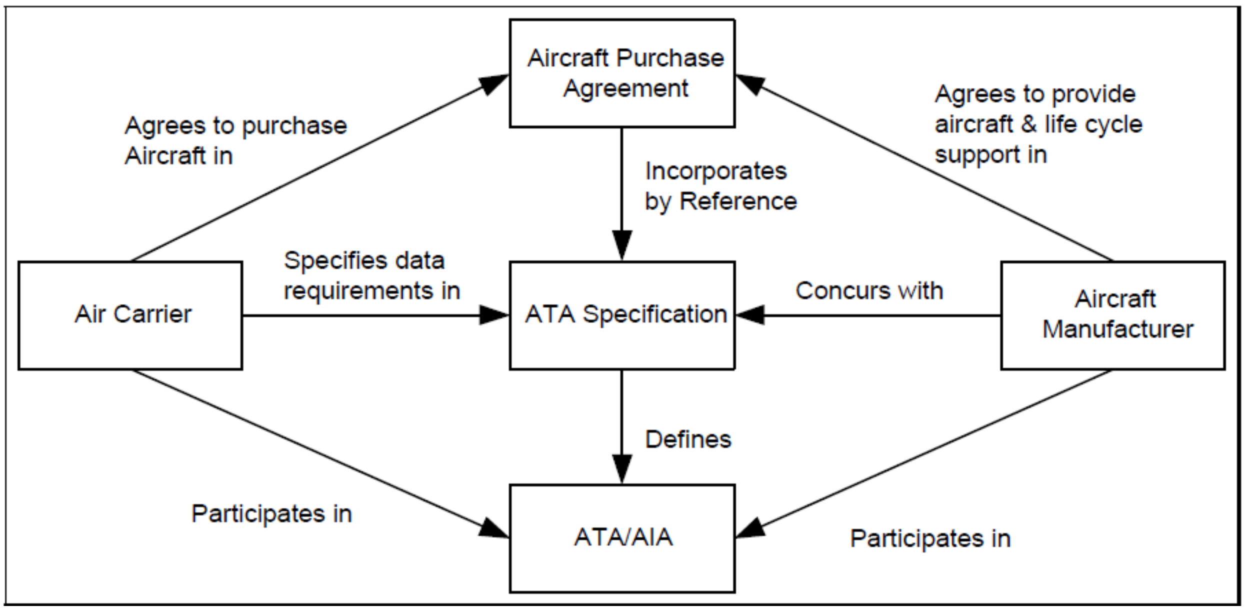


Fig. 3.2 Role of ATA Specifications in defining Contract Data Requirements (**ATA iSpec 2200**)

The ATA, founded in 1936, 'serves as a focal point for industry efforts to standardize practices' (**ATA 2009b**). In creating the specifications (see Figure 3.2), the following groups are involved:

- ATA Technical Information and Communication Committee (TICC)
- TICC Working Groups
- Manufacturers and Air Carriers
- ATA Engineering Maintenance & Material Council (EMMC)
- AIA Commercial Customer Support Council (CCSC)
- ATA Staff

According to ATA Spec 100 the technical publications are to be classified each under the appropriate *equipment identifier*. The equipment identifier consists of three elements of two digits each (see Figure 3.3 and Figure 3.4 and Table 3.2). For example, the code 25-21-41 indicates the *system* 25 – Equipment and Furnishings, *subsystem* 21 – Passenger Compartment Seats and *unit* 41 – Seat Passenger. Table 3.3 lists the chapter numbers and their allocated names.

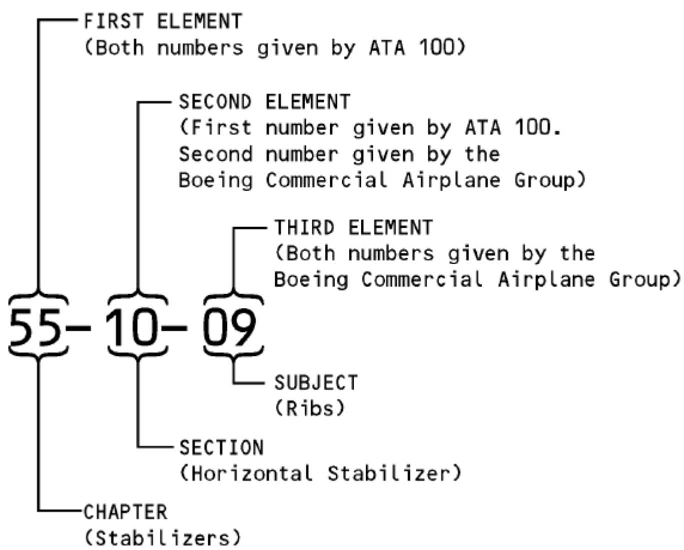


Fig. 3.3 Standard Numbering System (**SRM Boeing 2006**)

SYS/ CHAP	SUB-SYS/ SECTION	TITLE	DEFINITION
11		PLACARDS AND MARKINGS	All procurable placards, labels, etc., shall be included in the Illustrated Parts Catalog. They shall be illustrated, showing the part number, Legend and Location. The Maintenance Manual shall provide the approximate Location (i.e., FWD-UPPER-RH) and illustrate each placard, label, marking, self-illuminating sign, etc., required for safety information, maintenance significant information or by govern ment regulations. Those required by government regulations shall be so identified.
	-00	General	
	-10	Exterior Color Schemes and Markings	This sub-system/section breakdown reserved for airline use.
	-20	Exterior Placards and Markings	Those placards and markings required for ground servicing instructions, inspections, cautions, warnings, etc.
	-30	Interior Placards	Those placards, markings, self-illuminationg signs, etc. required for interior general and emergency infor-mation, instructions, cautions, warnings, etc.

Fig. 3.4 ATA Spec 100: Manufacturers' Technical Data – example of equipment identifier

Table 3.2 Definition of aircraft groups in the ATA numbering system (**ATA iSpec 2200 Extract**)

aircraft group	system/ chapter range	definition
Aircraft General	5 - 12	The complete operational unit. Includes dimensions and areas, lifting and shoring, levelling and weighing, towing and taxiing, parking and mooring, required placards, servicing.
Airframe Systems	20 - 50	All airframe systems except the Power Plant package.
Propeller/Rotor	60 - 67	Complete propeller/rotor system excluding propeller/rotor anti-icing system.
Standard Practices - Engines	70	
Power Plant	71 - 84	The complete power unit which develops thrust either through the exhaust or through a propeller. Excludes items such as generators, cabin superchargers, etc., which are covered under their respective systems.
Other	91	Charts
	97	Wire Reporting
	115	Flight Simulator Systems
	116	Flight Simulator Cuing Systems

Table 3.3 System/chapter number of airframe systems (**ATA iSpec 2200 Extract**)

system/chapter number	name of system
(20)	(standard practices - airframe)
21	air conditioning
22	auto flight
23	communications
24	electrical power
25	equipment / furnishings
26	fire protection
27	flight controls
28	fuel
29	hydraulic power
30	ice & rain protection
31	indicating / recording systems
32	landing gear
33	lights
34	navigation
35	oxygen
36	pneumatic
37	vacuum
38	water / waste
41	water ballast
44	cabin systems

45	central maintenance system (CMS)
46	information systems
49	airborne auxiliary power
50	cargo and accessory compartments

The ATA 100 Spec has not been reviewed since 1999. Instead, the *ATA iSpec 2200 : Information Standards for Aviation Maintenance*, was created in the year 2000 as a synergy between *ATA Spec 100 : Manufacturers' Technical Data* and *ATA Spec 2100 : Digital Data Standards for Aircraft Support*. The context in which this new standard appeared is illustrated in Figure 3.5 and Figure 3.6. This documentation includes, besides the numbering system (see Table 3.2 and Table 3.3), the Document-type definitions (DTDs) and the ATA Data Model and was created with the purpose to introduce a new consolidated specification for the documentation, regardless of delivery medium (**ATA 2009b**). Additionally, the *ATA iSpec 2200 Extract : Definitions of Aircraft Groups, Systems, and Subsystems*, as an extract from ATA iSpec 2200, provides the standard for numbering aircraft systems (**ATA iSpec Extract**).

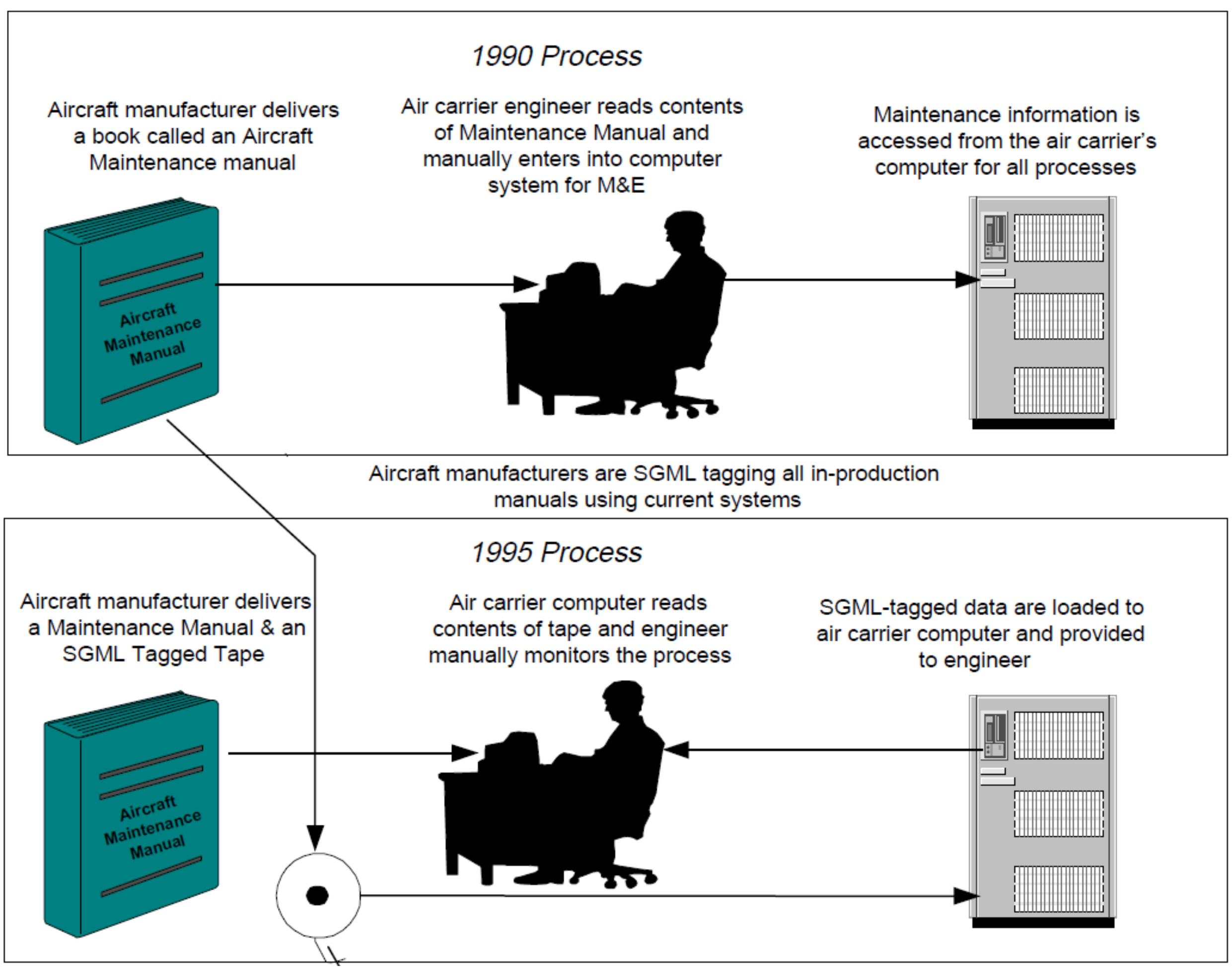


Fig. 3.5 Industry Direction Statement (part I) (**ATA iSpec 2200**)

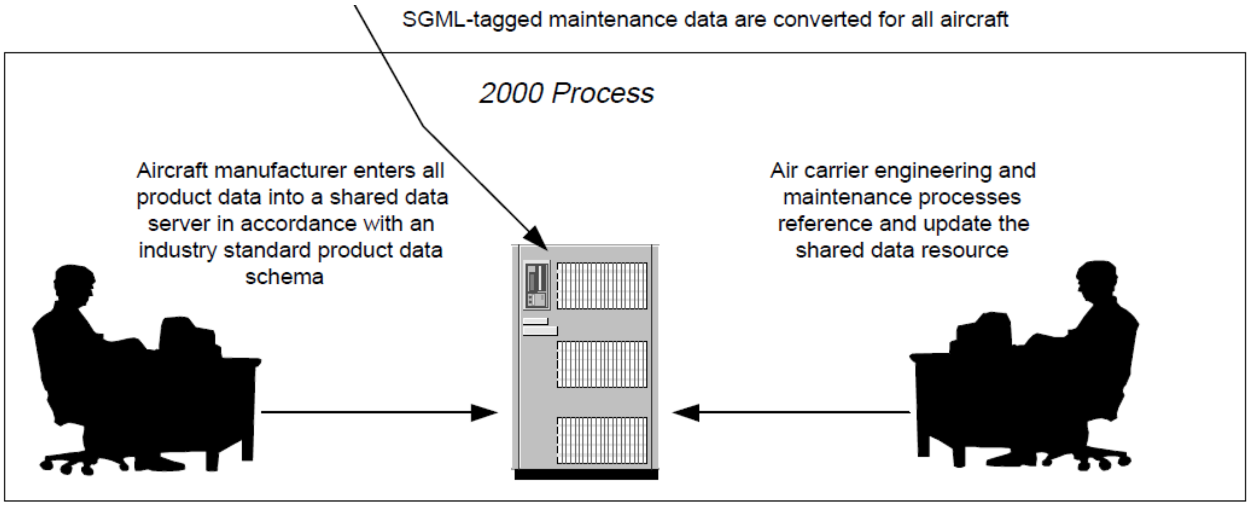


Fig. 3.6 Industry Direction Statement (part II) (**ATA iSpec 2200**)

The ATA iSpec 2200 is structured as shown in Table 3.4.

Table 3.4 The content of ATA iSpec 2200 (**Scholz 2002**)

Chapter of the Spec	**Title of the Chapter**
Preface	General information on the use and update/revision of this specification.
Chapter 1	Introduction to iSpec 2200
Chapter 2	Requirements
Chapter 3	Information Standards
Chapter 4	Models and Schemas
Chapter 5	Media, Protocols and Data Packaging
Chapter 6	Annex 1 (Bibliography)

The aircraft manuals, written after the ATA specifications, are listed in Table 3.5. These manuals are created by the aircraft manufacturers (or suppliers) and are required for operating and maintaining the aeroplanes.

More than 25 manuals, used in one of the fields:

- aircraft maintenance,
- aircraft configuration and definition,
- training of maintenance personnel,
- flight operations,

are written after the ATA specifications.

Table 3.5 Manuals of which configuration is described in the ATA iSpec 2200 (**Scholz 2002**)

Manual	**Abbreviation**
Maintenance Procedures	
Aircraft Maintenance Manual	AMM
Aircraft Recovery Manual	ARM
Component Maintenance Manual	CMM
Consumable Products Manual	CPM
Engine Cleaning Inspection and Repair Manual	CIR
Engine (Shop) Manual	EM
Fault Reporting and Fault Isolation Manual	FRM/FIM
Non Destructive Testing Manual	NDT
Power Plant Buildup Manual	PPBM
Service Bulletin	SB
Structural Repair Manual	SRM
System Schematic Manual	SSM
Weight & Balance Manual	WBM
Configuration Control of Product Definition	
Aircraft Illustrated Parts Catalog	AIPC
Component Maintenance Manual Parts List	CMMPL
Engine Illustrated Parts Catalog	EIPC
Engine Parts Configuration Management Section	EPCM
Power Plant Buildup Manual Illustrated Parts List	PPBMIPL
Tool and Equipment Manual	TEM
Wiring Diagram Manual	WDM
Training	
Systems Description Section	SDS
Flight Operations	
Flight Crew Operations Manual	FCOM
Master Minimum Equipment List	MMEL
Universal Applications	
Component Manual Index	CMI
Publications Index	PI
Service Bulletin Index	SBI
Service Letter	SL

Aircraft Maintenance Manual (AMM)

According to **ATA Spec i2200** the AMM is developed in accordance with the Aircraft Maintenance Task Oriented Support System (AMTOSS) specification, which aims to organize the maintenance in tasks and sub-tasks. The manual can be customized for particular operators or for a group of operators. It comprises of two parts:

- Part I of the AMM contains the Systems Description Section (SDS) data for all of the airframe and powerplant systems
- Part II of the AMM contains the maintenance practices and procedures data

Aircraft Recovery Manual (ARM)
According to **ATA iSpec 2200** the ARM must contain information in sufficient detail to effect recovery in the most expeditious manner while maintaining consideration of recovery personnel safety and prevention of additional damage to the aircraft.

Component Maintenance Manual (CMM)
According to **ATA iSpec 2200**, the procedures contained in this manual, are intended for work on the applicable components in a workshop environment. The manual contains sufficient detail for the return of the component to a serviceable condition.

Consumable Products Manual (CPM)
According to **ATA iSpec 2200**, this manual must include all the consumable materials that may be called for in their and their vendor's manuals and processes, for the overhaul or repair of the prime manufacturer's equipment and components and their vendor's components.

Engine Cleaning Inspection and Repair Manual (CIR)
According to **ATA iSpec 2200**, this manual must contain all applicable cleaning, inspection, and repair data normally included in the Engine Manual, except for any such procedures that apply to assembled modules and engines.

Engine (Shop) Manual (EM)
According to **ATA iSpec 2200**, the aim of this manual is to provide technical data requirements for information needed to maintain the engine and the maximum potential number of parts that could, regardless of design responsibility, remain with the engine when it is removed from the aircraft.

Fault Reporting and Fault Isolation Manual (FRM/FIM)
According to ATA iSpec 2200, the FRM must provide technical data for flight crews to easily identify and communicate details of aircraft faults to maintenance personnel. In the same time, the FIM must provide the technical data required by the maintenance crew to isolate the cause of the fault and to determine the corrective action. The FIM is for the maintenance crew, while the Fault Reporting Manual (FRM) (which contains information required to report the faults in the systems and equipment installed on the aircraft) is for the flight and cabin crew.

Non Destructive Testing Manual (NDT)
According to **ATA iSpec 2200**, this manual must contain the Standard Practices and explanations of each testing procedure. Procedures shall be defined including effectivity, tooling / equipment, preparation, equipment calibration, inspection procedure, evaluation and acceptance / rejection standards.

Power Plant Buildup Manual (PPBM)

According to **ATA iSpec 2200**, this manual must be produced jointly by the airframe and engine manufacturers with responsibility residing with the airframe manufacturer.

Service Bulletin (SB)

According to **ATA iSpec 2200**, the SB manufacturer must provide it in the media of the customer's choice (as it is being created individually for each operator). SB's need to be issued to cover each subject and shall describe changes that fall into the following categories:

- Modifications to the aircraft, engine or accessory including embedded software.
- Modifications, which affect performance, improve reliability, increase safety of operation, provide improved economy or facilitate maintenance or operation.
- Substitution of one part with another superseding part only when it is not completely interchangeable both functionally and physically, or when the change is considered to be sufficiently urgent or critical that special scheduling or record of accomplishment will be required.
- Substitution of one embedded software program by another which change equipment function and the part number of the programmed memory device, requiring a record of accomplishment.
- Special inspections/checks required to maintain the aircraft, engine, or accessories in safe operating condition.
- One-time inspections/checks to detect a flaw or manufacturing error.
- Special inspections/checks required to be performed until a corrective action can be taken. (e.g. an inspection to detect cracks in a radius until the radius can be ground out.) The modification information may be issued as a revision to the same Service Bulletin that transmits the inspection instructions.
- Special functional checks of an urgent nature required to detect an incipient failure, such as pressure checks, functional checks, etc.
- Reduction of existing life limits or establishment of first time life limits for components.
- Conversions from one engine model to another.
- Changes affecting the interchangeability or intermixability of parts.

Structural Repair Manual (SRM)

According to **ATA iSpec 2200**, the SRM must define both damage that has no significant effect on the strength or life of the structure and that which does. For significant damage it shall provide data for repairs which will restore the structure to the condition required to fulfill its design function. Repair data shall make maximum use of standard materials, fasteners, and processes in preference to the manufacturer's own standards.

Weight & Balance Manual (WBM)
According to **ATA iSpec 2200**, the WBM must contain all the weight and balance material required by government regulations for a commercial aircraft and sufficient supplementary information to allow personnel concerned to intelligently perform the duties of their position.

Aircraft Illustrated Parts Catalog (AIPC)
According to **ATA iSpec 2200**, the AIPC must contain all those individual line-replaceable units such as light bulbs, sockets, lenses, caps, seals, bearings, screens, screws, filters, electrical connectors, circuit cards, relays, pulleys, fittings, brackets, external lines. Additionally the AIPC includes all components and/or parts where maintenance practices allow replacement of the components rather than replacement of the next higher assembly.

Engine Illustrated Parts Catalog (EIPC)
According to **ATA iSpec 2200**, the EIPC is intended for use in the identification and requisition of replaceable engine parts and units. It must contain all those individual parts, such as caps, seals, bearings, screens, screws, rivets, clips, covers, filters, electrical connectors, circuit cards, relays, sleeves, ties, pulleys, fittings, brackets, external lines and wires, any and only those components and / or parts where optimum maintenance practices dictate replacement of these components or parts rather than replacement of the major assemblies.

3.1.2 Available Drawings in Aircraft Documentation

As mentioned in the previous paragraph, each aircraft is delivered to the airline together with a series of manuals (as shown in Table 3.5).

Usually the technical documentation is used for maintenance, repair and operation activities. When an airline whishes to modify or update the configuration of the aircraft cabin, the information contained in these manuals becomes important also for the engineering work behind the redesign activity. However, the information contained in the manuals is not accurate enough in order to conduct the conversion of the cabin without additional engineering input. In most cases, the original drawings are required.

This subchapter aims to filter the data contained in those relevant aircraft manuals received by an airline and to conclude over which particular manual/manuals can be used, at least partially, for the engineering input information phase. Table 3.6 shows which manuals are more likely to be useful.

Table 3.6 The usefulness of the aircraft documentation for cabin redesign activities

Manual	Usefulness
Maintenance Procedures	
AMM	X
ARM	
CMM	X
CPM	
CIR	
EM	
FIM	X
NDT	
PPBM	
SB	X
SRM	X
SSM	X
WBM	
Configuration Control of Product Definition	
AIPC	X
CMMIPL	
EIPC	
EPCM	
PPBMIPL	
TEM	X
WDM	X
Training	
SDS	X
Flight Operations	
FCOM	
MMEL	
Universal Applications	
CMI	
PI	
SBI	
SL	

Aircraft Maintenance Manual (AMM)

When looking on an AMM (here the AMM for A319/320/321 reviewed in August 1999 was used, **AMM Airbus 1999**), one can see that the AMM was build according to the ATA specifications and that (example drawings in Appendix B):

- It contains information required to service, repair, replace, adjust, inspect and check equipment and systems of the aircraft, normally performed on the ramp or in the maintenance hangar
- It contains information about inspections and maintenance of aircraft structure
- It contains the necessary data to cover scheduled maintenance procedures prescribed by the MPD and MMEL and CDL
- The information is divided into two main categories:

- Description and Operation → providing an explanation of systems for function, operation, control and component location
- Maintenance Procedure comprising of:
  - general Maintenance Practice (MP) Procedures – such as aircraft jacking, application of electrical, pneumatic, hydraulic power
  - Servicing (S) – procedures for covering replenishment (e.g. hydraulic fluid) or procedures for covering filters, magnetic plug, lamp replacement etc
  - Removal/Installation – providing all data for removing, installing or replacing component and Deactivation/Reactivation – describing the procedures to be performed to allow flight operations with a system or a part of a system failed according to MMEL and CDL requirements
  - Adjustment/Test (A/T) – Operational, Functional, System test
  - Inspection/Check (I/C) – general, with and without component removal
  - Cleaning/Painting (C/P) – procedures which require special precautions (parts contaminated by hydraulic fluid)
  - Approved Repairs (AR) – approved repair procedures with the exception of those covered by CMMM/CMMV or by the SRM/NSRM

Illustrated Parts Catalogue (IPC)

In order to understand the purpose of an IPC, the AIPC of Boeing 737 600/700/800/900 (**AIPC Boeing 2007**) was used. It was found out that (example drawings in Appendix B from **AIPC Boeing 2007** and **AIPC Airbus 1999**):

- Is intended only for use in identifying, provisioning, requisitioning, storing and issuing line replaceable aircraft parts and units and in identifying maintenance significant parts.
- The IPC is a companion of the AMM and includes all parts for which maintenance practices has been provided.
- Boeing uses an indenture system for each illustrated part, which shows the relationship of one part to another, or to the system of which it is a part of. This system is explained in the Front Matter of the manual.
- All pages which are customized to a specific customer carry an airline code located on the bottom of each page.
- Each figure contains both illustrations and part lists pages.
- The Part Numbers are developed by Boeing for the following part categories and purposes: 1.) Boeing proprietary parts, 2.) specification numbers for non-proprietary parts, 3.) Boeing standard parts, 4.) reference purposes only. They are explained as well in the Front Matter.

Structural Repair Manual (SRM)
In order to understand the purpose of a SRM, the SRM of Boeing 737 600/700/800/900 (**SRM Boeing 2006**) was used. It was found out that (example drawings in Appendix B):

- The manual gives general airplane data, usual procedures, and repair. It refers to ATA Chapters 51 to 57.
- It includes material identification, allowable damage, and repair data for the airplane structure.
- It provides dimensions.
- It is useful when the conversion involves interferences with the aircraft structure.

System Schematic Manual (SSM)
In order to understand the purpose of a SSM, the SSM of Boeing 737 600/700/800/900 (**SSM Boeing 2007**) was used. It was found out that (example drawings in Appendix B):

- Is a collection of diagrams which define the airplane systems.
- It was prepared to serve as a source of information to assist in understanding system function and to facilitate fault isolation to the Line Replaceable Unit (LRU) level.
- The data contained in this manual are customized for each airline.

Wiring Diagram Manual (WDM)
In order to understand the purpose of a WDM, the WDM of Boeing 737 600/700/800/900 (**WDM Boeing 2006**) was used. It was found out that (example drawings in Appendix B):

- The WDM is a collection of diagrams, drawings, and lists which define the wiring and hookup of associated equipment installed on the airplanes.
- It may also contain data and information provided by the customer.
- The WDM document number is unique to the customer whose name appears on the title page.
- All Wiring Diagrams are shown, unless otherwise specified, with the airplane on the ground, after normal flight, with the shutdown checklist complete (power off).

Illustrated Tool and Equipment Manual (ITEM)
In order to understand the purpose of an ITEM, the ITEM of Boeing 737 600/700/800/900 (**ITEM Boeing 2007**) was used. It was found out that (example drawings in Appendix B):

- Provides descriptive information illustrations and explanations for use of aircraft-designed tools, ground handling and test equipment recommended by the aircraft manufacturer to facilitate airplane maintenance, component maintenance and servicing.
- A tool and equipment classification is distributed over the ATA Chapters.
- The tools and equipment included in this manual are used as airplane maintenance tools or component maintenance tools.

Each manual lists the operators for which it was created or adapted. Boeing uses three reference lines which provide an exact position within the airplane to aide in locating the equipment (see Figure 3.7):

- The Station Line (STA) – edge view of vertical reference plane which divides the body, wing, nacelle etc., into sections.
- The Waterline (WL) – edge view of longitudinal horizontal reference plane.
- Buttock Line (BL) – edge view of longitudinal vertical reference plane.

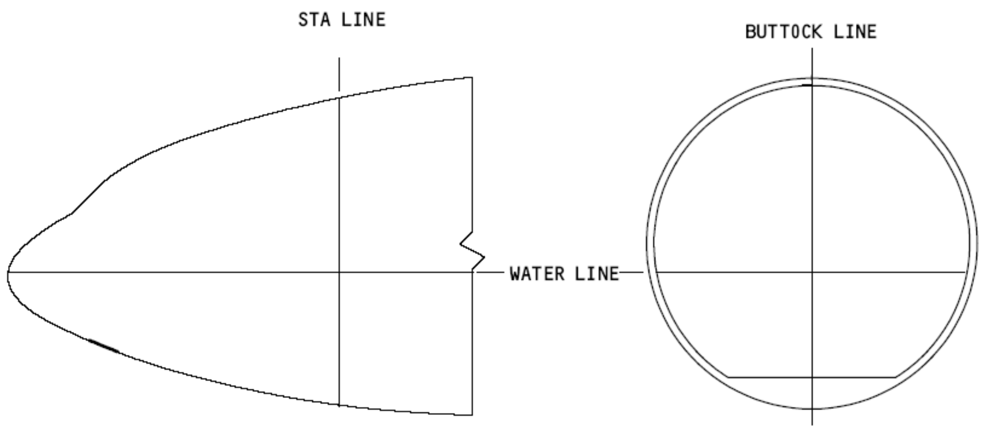


Fig. 3.7 Reference lines of Boeing used in the manuals (**SSM Boeing 2007**)

Table 3.7 summarizes the conclusions with respect to the utility of these technical documents.

Table 3.7 List of useful technical documents and their characteristics

Technical Document	Form	Engineering Input Information	Usefulness
AMM	Digital image data	Dimensionless 2D Drawings	Informative
AIPC	Digital image data	Dimensionless 2D Drawings	Informative
SRM	Digital image data	2D Drawings with dimensions (not all)	More than Informative
SSM	Digital image data	Dimensionless 2D Drawings	More than informative
WDM	Digital image data	Dimensionless 2D Drawings	More than informative
ITEM	Digital image data	Dimensionless 2D Drawings	Informative

3.1.3 Alternatives to Unavailable Drawings

This subchapter analyzes several possible sources of information for conducting the cabin redesign activity, under the hypothesis of Airbus independency. The practical utility of these proposals is evaluated also in Chapter 4, based on the Condor Berlin Study Case.

1.) Access to the aircraft

One of the possibilities to get the necessary input information is by having direct access to the aircraft which is about to be converted. It may also be enough to have access to similar models.

Usually the airplane cabins are being upgraded or converted during a maintenance check. In this case the airline can facilitate the direct access to the airplane. If the maintenance check is shorter than the design preparation phase, the access period may not be enough for the engineers. Also, the airlines expect the upgrade package to be ready without keeping the aircraft too much on the hold position. In this case, another possibility to have direct access to the aircraft is to seek the agreement with companies providing services in the area of aircraft disposal and recycling.

The Aircraft Fleet Recycling Association is an association dedicated to pursuing and promoting environmental best practice, regulatory excellence and sustainable developments in aircraft disassembly, as well as the salvaging and recycling of aircraft parts and materials (**AFRA 2009**). Among the members of this association are Boeing, Rolls Royce, Air Salvage International or Volvo Aero.

Agreements can also be set between ELAN and other Completion Centers, either with the purpose to use their documentation or in order to have direct access to aircraft. In this case a win-win situation must be identified.

Having access to aircraft provides the engineers with:

- an overall understanding of the pre-mod cabin layout,
- the possibility to measure and inspect different parts involved in the conversion,
- the possibility to take scaled pictures.

Depending on the size of the conversion, some of the zones may be inaccessible (e.g. changing the EXIT signs and EXITS lights may require the adaptation from DC to AC; in order to understand how the new bulbs can be connected, the lining or ceiling would need to be removed, in order for the engineer to inspect the wiring networks and the available electrical paths; this, however, may not be part of the conversion scenario). In this case, additional input information must be searched.

Measuring inside the aircraft

Once the access to the aircraft is ensured, the next challenge is to obtain correct measures for each of the items involved in the conversion. An optimal way to solve this problem is a correlated approach between:

- the use of the predefined measuring points (German: Datum Masse) as reference points; these coordinates are specified in the *Frame Specs* (**Müller 2010**).

- the use of LASER based measuring equipment.

Appendix C shows an exemplarily layout extracted from the Frame Specs. Figure 3.9 shows how such a point is marked inside the aircraft (courtesy of **Müller 2010**).

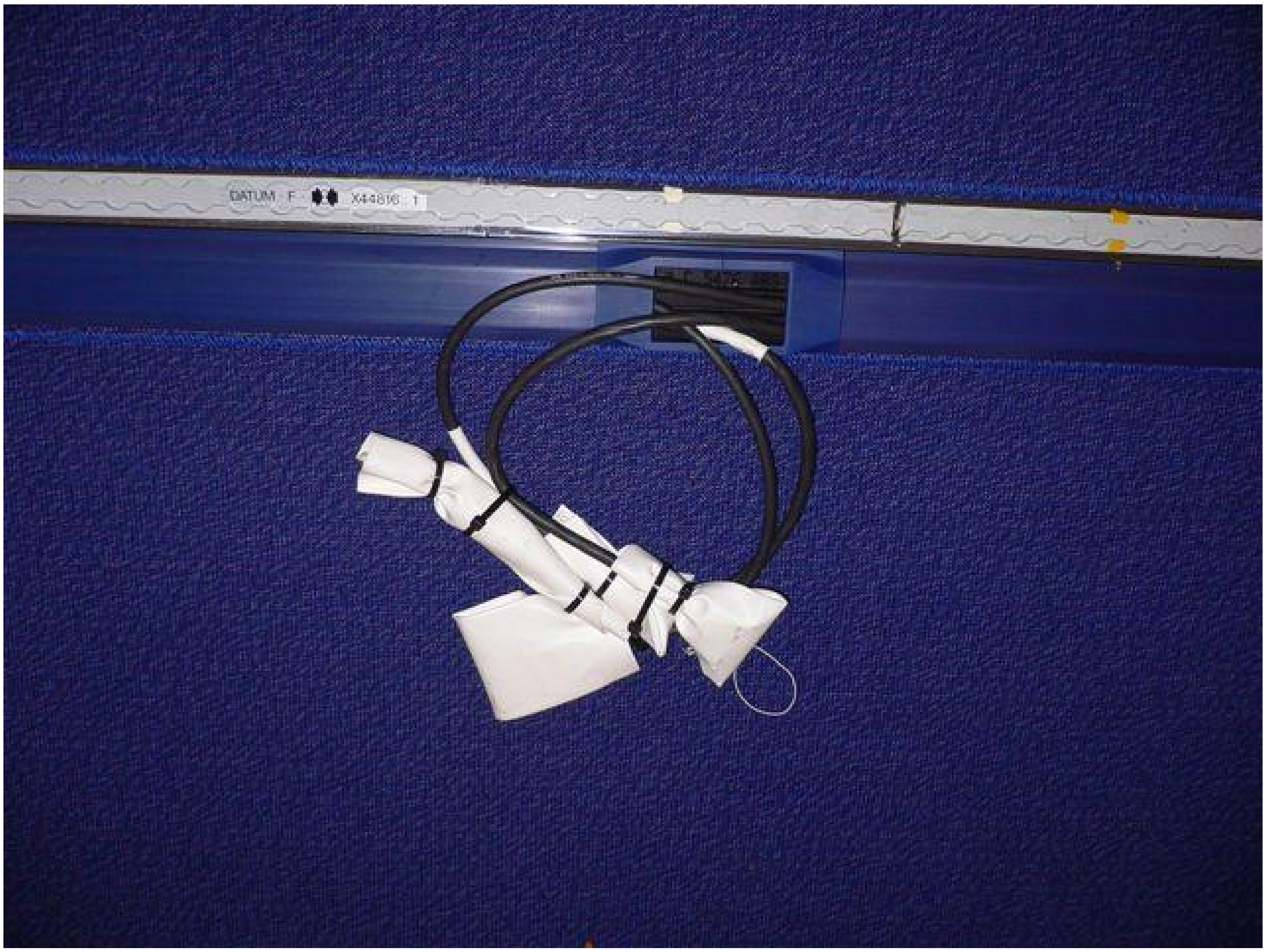


Fig. 3.8 Example of a reference point (courtesy of **Müller 2010**)

There are several types of LASER based measuring equipment. One of the most common measuring principles is as follows: the device sends a light impulse and measures the time needed to receive the reflection of the light impulse back from the object. Having the speed of light, the distance can then be calculated. Such devices have an accuracy of ± 1.5 mm. The price ranges between 90 € and 120 €, and can be used by a single person (**Bosch 2010**). For a better accuracy, other principles may also be used: 1.) the phase deviation between the source of the light wave and its reflection is also distance dependent; 2.) the laser beam is projected onto the object and further reflected on a lens; the lens images the laser point onto a sensor (a charged-coupled device or a photodiode); an offset of the objects causes an offset of the image; this principle is called triangulation (see Figure 3.10) (**Wikipedia 2010**). Table 3.8 summarizes the main characteristics of such devices:

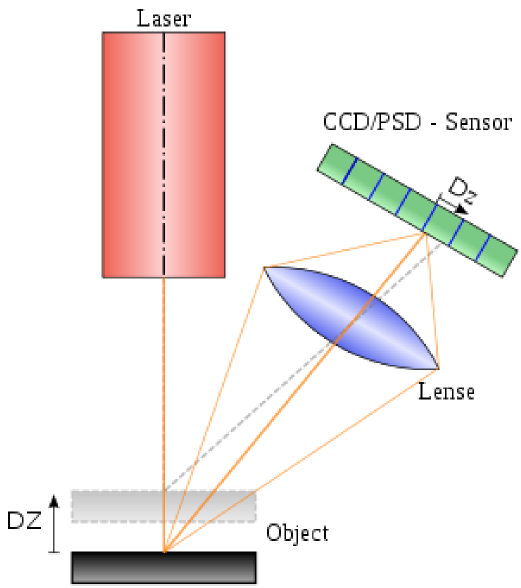


Fig. 3.9 Principle of laser triangulation (**Wikipedia 2010**)

Table 3.8 Laser based measuring equipment

Principle	**Accuracy**	**Observations**
Simple signal reflection	± 1.5 mm	Very small price, very robust and simple to use
Phase deviation	Very high	Higher price
Sensor utilization (triangulation)	Very high	Surface dependant, small price, robust

Combining the use of these devices with scaled photos and simple scaled sketches represents, in our opinion, a reliable source of data. The inspection engineers could apply the following work breakdown:

- previous familiarization with the affected cabin area, including available reference points,
- previous creation of the cabin area schematics,
- previous preparation of a reference scale,
- utilization of a high precision measuring device (LASER) for determining the distances,
- utilization of digital photos taken together with the visible reference scale,

For irregular surfaces devices that use the triangulation principles are suitable, but more expensive. An additional alternative is the use of 3D scanners. Currently this type of scanners can provide enough accuracy and allow the measured data to be transferred in CAD tools. A deeper research with this respect will be conducted in the frame of Technical Note 4.

2.) Input information from airlines

As discussed in the previous paragraph, the airlines possess a series of aircraft manuals, which are useful in understanding the general implications, but do not deliver precise data.

The airlines also possess the history of the respective aircraft changes in the form of SB's, which provide important information.

The airlines also receive valuable information from the equipment or components manufacturers (different than the aircraft manufacturer), e.g. the hatrack bins and doors (which are currently produced by Fisher for Airbus SA), or the monitors from the IFE system.

The most valuable and crucial information that an airline can provide is the aircraft itself, available for inspection and measurements.

3.) Data from the components manufacturers

When it comes to installing different new devices or items (e.g. monitors as part of IFE, literature pockets, or even seats), part of the information comes from the manufacturer of the respective items. He possesses drawings and installation instructions, but he needs as well additional information from the aircraft manufacturer (connection possibilities for the monitor, monuments layout for installing literature pockets, or seat rails layout for the seat installation). ELAN may obtain form the components manufacturers not only item related information, but also aircraft related information.

4.) New designs under DOA

If ELAN possesses a DOA, it can perform – under the DOA privileges – changes to the type design (see TN 1). Depending on the complexity of the conversion and on the wishes of the customer airline, where input information is no longer available and the original dimensions of the Airbus components cannot be measured, ELAN can offer a new design to the customer. An example of such a situation is the sidewall lining. It would be more difficult to reproduce the design, than to design a new lining, according to the wishes of the customer. ELAN has the experience to perform the task, but currently lacks the Design Organization Approval.

5.) Other sources

5.1) Inverse engineering

Inverse engineering is a method used by the Future Projects engineers at Airbus, in order to redesign the concurrent airplanes (from Boeing). Based only on the available public information sources, they need to understand how the original design was made and recalculate the flight performances. However, this method is not accurate enough when it comes to the aircraft interior parameters. Another disadvantage is that a lot of time input is required in order to achieve feasible results. The same method is used by the so called Advanced Scanner and 3D Photocopier: the characteristics of a product that already exists (or part of them) are being transformed through the computer into a virtual product.

5.2) Old documentation

Original old aircraft documentation can only be bought from aircraft manufacturers which declared bankruptcy. A well known example is the Fairchild Dornier. This would however be useful only for the Dornier aircrafts which would currently require a refreshment program.

5.3) Pacelab Cabin

The program is already known to ELAN. The advantage of this program is that it contains a database of aircraft contours which can be exported to CATIA. In this way the time necessary to redraw the contours, especially when exact information about dimensions is lacking, is spared. The program is also useful to create preliminary cabin layouts in the preliminary phase of negotiation with the customer. If ELAN becomes Airbus independent, the Offer phase grows in importance, especially due to the tight relationship required with the airline.

6.) Summary and Conclusion

The decisive factor in getting the engineering documentation is represented by the airline itself. After looking into the technical documentation provided to the airline by the aircraft manufacturer, it can be concluded that these manuals are helpful but not enough. If ELAN would possess a DOA, the information contained by the manuals would be very helpful in the initial phase of the conversion project (i.e. the Offer phase, as well as Concept Phase) as well as in making the change classification and contacting EASA for starting the certification procedures. The certification procedures become vital if the upgrade scenario is not a standard one (already certified by the aircraft manufacturer). Also, the manuals help engineers to familiarize with the complexity of their task. More helpful among the manuals are the SRM, SSM, and WDM. In the end, however, the engineers need to know the exact configuration of the aircraft, with respect to the items involved in the conversion. The data contained in the manuals needs to be supplemented by the data gathered during the aircraft inspection.

In the end there are two tangible possibilities to get the necessary drawings and part lists:

- From the airline and its partners (component manufacturers)
- From the manufacturer and/or its partners (component manufacturers)

The aircraft manufacturer would not give away the valuable data, unless an agreement is set or a win-win situation is found (unlikely). The airlines may not have enough information available. Third party suppliers (component manufacturers) may provide additional information.

The conclusion to be drawn is that a close cooperation with the airline along with a certain flexibility from its side is required. It would be suitable to identify a series of conversion scenarios which are feasible – in both with and without DOA cases.

3.2 Engineering Output Information

3.2.1 Service Bulletin

The ATA definition, provided in paragraph 3.1.1, shows the instances in which an SB must be issued. Shortly, the SB's represent the form in which the engineering work is further transmitted to the aircraft operator, which has the responsibility to implement the instructions comprised within.

The SB's are created individually for each operator. When looking on an SB example for an A340 aircraft (**SB ATA 21 2007**), the following can be concluded towards the content and form:

- The SB starts with a summary comprising the involved ATA Chapters, the title, the type of change, reason of change, a general evaluation, material price information, (for each kit for ach configuration), effectivity, nature of the work (aircraft, engine, propeller), manpower, informative drawings.
- It continues with the SB itself, by first indicating the modification (Mod Number – typical for Airbus system) for which it was written. The following topics are covered by an Airbus SB:
    - Planning information, referring to:
        - Effectivity: MSN, Operator, Material effectivity.
        - Concurrent requirements.
        - Reason: history (e.g.: 'The airline required…'), objective/action (e.g.: 'The SB describes the work necessary to…'), advantages, operational/maintenance consequences.
        - Description (e.g.: 'Task 214146-831-848-001: Modification: (1) Install the rivet brackets at FR 64 and FR 65, RH, (2)…').
        - Compliance: classification, accomplishment timescale.
        - Approval ('Approved under EASA Part 21').
        - Manpower (without including the time to prepare, plan and inspect the work).
        - Weight and Balance (calculated from MEW – Manufacturer Empty Weight, written in WBM – Weight and Balance Manual).
        - Electrical Load Data: (1) DC Load Changes, (2) AC Load Changes.

        - References (which manuals are used, and which chapter).
        - Publication affected (which manuals are affected: e.g: AMM, IPC, ASM, TEM).
        - Interchangeability/Mixability: the interchangeability codes are defined in ATA Common Support Data Dictionary.
        - Spares.
    - Material Information
        - Material price and availability: (1) Procurement addresses (e.g. the kit is supplied by Airbus Upgrade Services based on a Customer Purchase Order); (2) Price and Availability (e.g.: the sales terms are agreed in accordance with RFC).
        - Industry Support Information (in connection with price and availability).
        - List of components: kit (items from the kit with the corresponding part no, quantity, key word or title).
        - List of Materials - Operator Supplied: (1) Consumable Materials, (2) Components, (3) Equipment (e.g. brush, cotton cloth).
        - Parts to be re-identified by Operator (item, new part no, old part no).
        - Tooling.
    - Accomplishment Instructions: task title, warnings (red), cautions (yellow), task associated data (manpower).
        - General – for each subtask, e.g.: (1) standard practices: manpower resources, material necessary to do the job, references, afterwards the actions that the worker needs to do are listed, (2) documentation.
        - Preparation – for each subtask, e.g.: (1) external preparation: manpower resources, references, actions that the worker needs to do, (2) internal preparation: manpower resources, references, actions that the worker needs to do.
        - Procedure – for each subtask: work zones and access panels, manpower resources, material necessary to do the job, references (not only manuals, but figures of the respective SB), actions that the worker needs to do.
        - Test – for each subtask: manpower resources, references (tasks in AMM).
        - Close up – for each subtask: e.g.: (1) Internal Close Up: manpower resources, references (tasks in AMM), (2) External Close Up: manpower resources, references (tasks in AMM).
- The SB ends with:
    - List of Figures
    - Appendices: e.g.: manpower Gantt Chart

- SB Reporting Sheet, comprising of: title, Mod No, operator comments. The sheet states if the operators manuals need to be either revised (intermediate revision) or modified (Modification Operational Impact). Also, the operator needs to fill in YES or NO if the SB has been embodied or not and justification. This sheet must be returned to Airbus and approved, in order to be incorporated in the maintenance and operation documentation.
- SB Quality Perception Form: ranking from 1 to 4 with respect to quality rating of the SB, of the Accomplishment Instructions, of the Illustrations, if it's easy to understand; the operator is then asked to choose areas where difficulties have been met and to comment them with respect to planning, material, instructions.

An example is shown in Table 3.8.

Table 3.9 Example of SB – title, short description and subtask (**SB ATA 21 2007)**

Title	Air Conditioning – Distribution – Install Heated Air Outlets in Cabin (A340)
Short Description	The customer requested the installation of an air-outlet heating system which is installed in the ceiling air outlets of the air conditioning system in the area of AFT pax/crew doors. This SB describes the work necessary to install new brackets and supports, new electrical harnesses, the Versatile Heating Control Unit (VHCU) and the Versatile Heating Data Unit (VHDU) and the air outlet heaters in the ceiling between FR 73A and FR 75A. It also describes the modification of the circuit breaker panel 5006VE in the AFTZ Cargo Compartment. The accomplishment of this SB enables the operator to increase the air temperature locally at the air outlets of the air conditioning system
Subtasks	– Get access – Install riveted brackets – Install bolted brackets – Remove door frame lining – Install attachment brackets – Install VHCU and VHDU – Install electrical harnesses – Modify Circuit breaker panel 5006VE – Modify air outlets between FR 71 and FR 75 – Modify air outlets at the AFT pax/crew door – Route electrical harness at air outlets – Install door frame lining – Test – Close Up

3.2.2 Deliverables based on Supplemental Type Certificate

The STC's are issued by EASA only under DOA (or AP to DOA). The issued STC represents the certification approval of the respective change. An STC model, created by EASA, is presented in Appendix D.

The content of a deliverable must cover, in essence, the same topics as an SB. Based on the form of an STC, a deliverable should specify:

- the title of the document and the aircraft involved,
- the design change specifications comprising of installation instructions and drawings,
- the requirements and the limitations,
- the operational characteristics,
- the necessary materials,
- the parts lists and kit lists,
- warnings and cautions for the workers.

The form of the deliverable is discussed with the customer airline during the Offer phase.

3.3 Internal Working Procedure

Both current internal work procedure as well as the work procedure under the Airbus independency hypothesis was identified based on the Condor Berlin study case (see also Chapter 4). The difference between the two is the *source of the engineering input information*.

The current procedure of handling Airbus requests was already described in TN1; it is also referred to in Chapter 4. The procedure is however briefly described in Figure 3.8.

The possible future procedure for fulfilling the task under the 'Airbus independency' conditions is summarized in Figure 3.9. This procedure is based on the following steps:

1) Determine missing information.
2) Check the available possibilities of obtaining the missing information:
    i) if ELAN can obtain the data on its own (through one of the available variants: measuring, self designing under DOA),
    ii) if the component manufacturer can supply the data or related data (drawings).
3) Once the information is available, continue the standard (current) internal procedure.

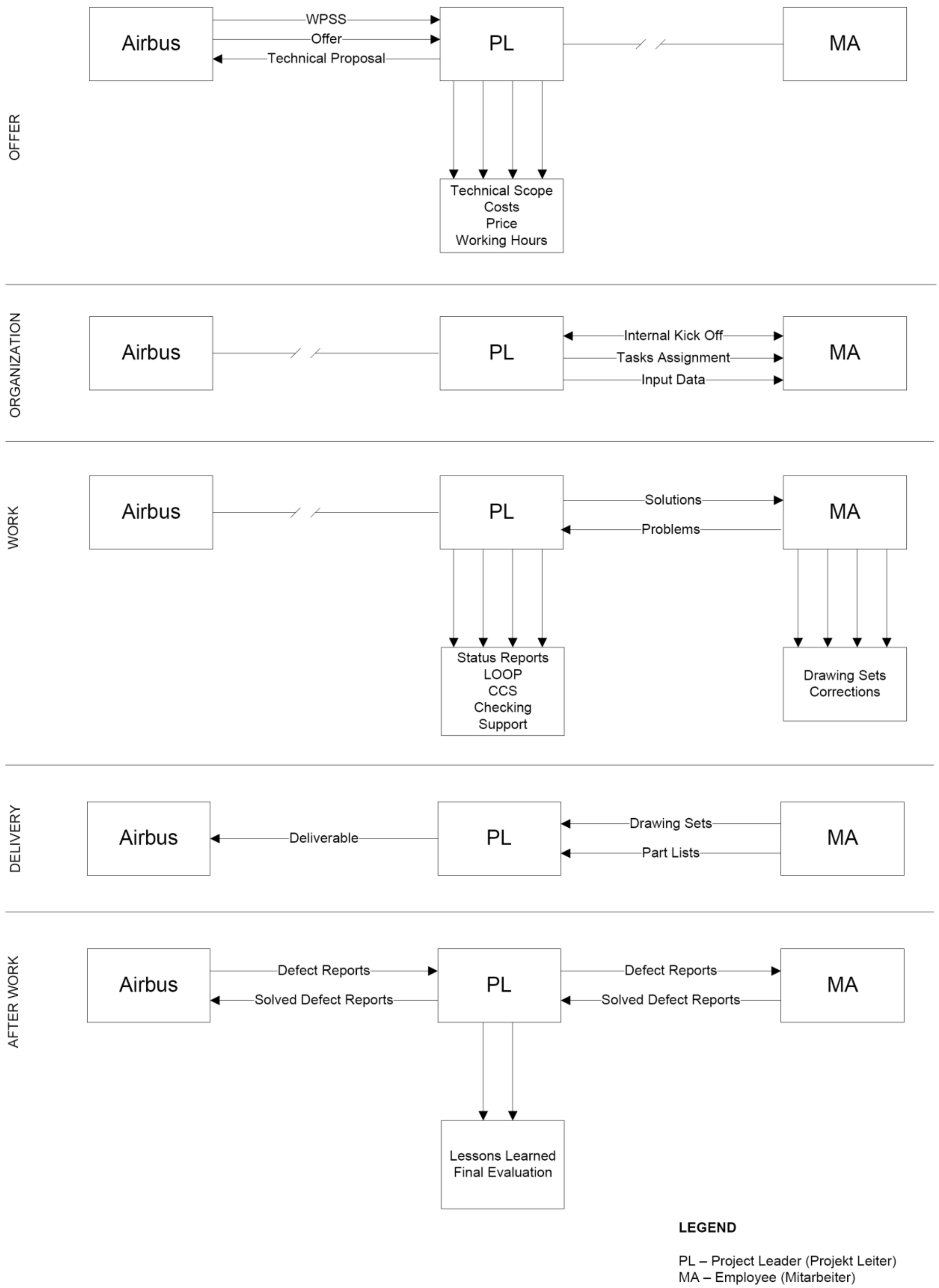


Fig. 3.10 Internal working procedure at ELAN with Airbus

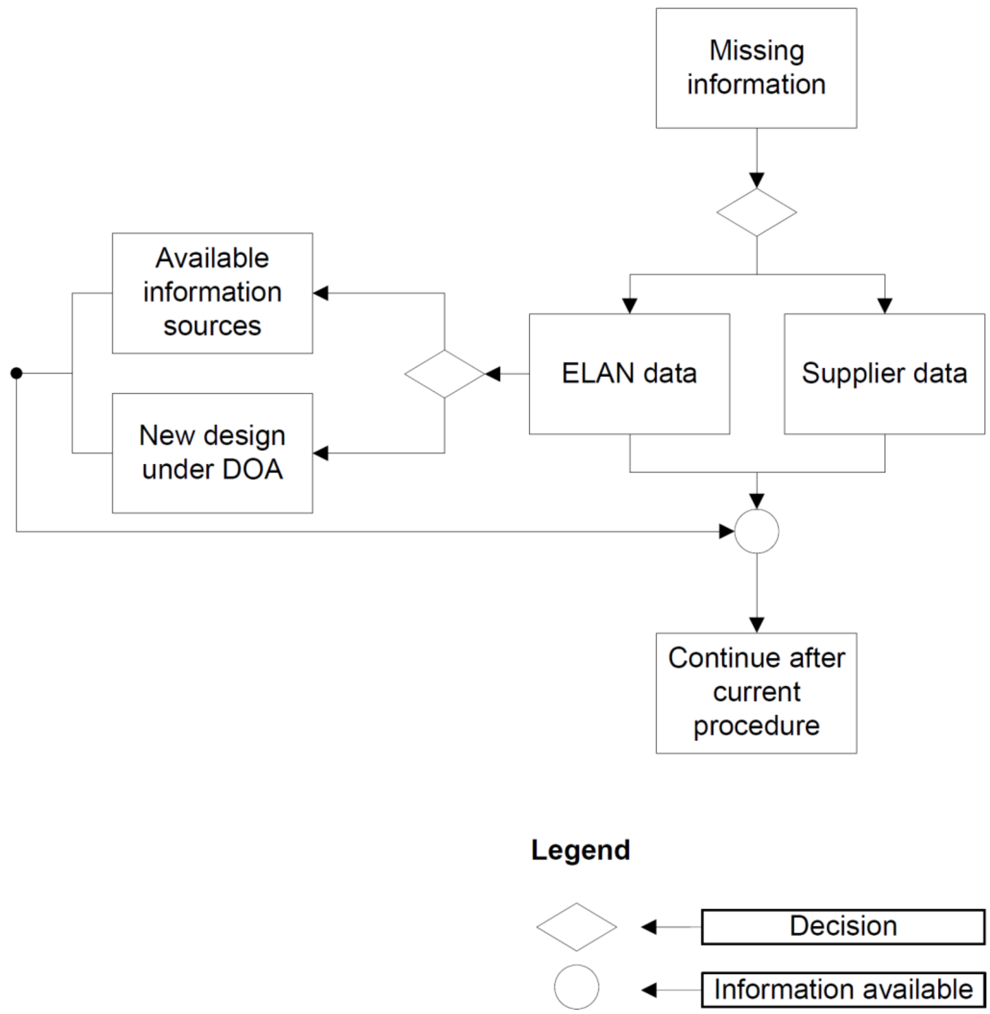


Fig. 3.11 Internal working procedure at ELAN without Airbus

3.4 Summary of the Chapter

This chapter starts with a systematic presentation of the available[2] aircraft documentation. Several norms and standards are used during the aircraft development. The ATA specifications are always referred to when creating technical documentation. Currently the aircraft manufacturers enter all product data into a shared data server in accordance with an industry standard product data schema. In the same time the air carrier engineering and maintenance processes reference and update the shared data resource.

[2] The word 'available' refers to the aircraft related information provided free of charge to the operators by the aircraft manufacturers

More than 25 manuals are used either in aircraft maintenance, aircraft configuration and definition or in training of maintenance personnel. Some of these manuals (like SRM, WDM or SSM) are useful for getting input information for some conversion scenarios. However the engineers cannot rely only on the manuals and their experience. Usually the information is rather informative.

The chapter continues with listing alternatives to unavailable drawings. Some reliable information sources, besides the manuals, are: aircraft inspection and direct measuring (vital in the absence of additional data sources), information from third party suppliers and component manufacturers (who may provide data not only about their product, but also about the environment in the aircraft where it is installed). A third feasible alternative to unavailable data is to create new designs under DOA. If not enough data is available for reproducing some of the items involved in the conversion (such as the sidewall lining or the ceiling), DOA allows the engineers to deliver a new certified design, by applying for STC’s for a major changes. The problem in this case is to produce (under POA) or to find a producer for the respective parts.

The form of the deliverables is usually the SB. The airline has the responsibility to install the respective SB on the aircraft. Other deliverable forms can be established together with the airline customer.

The last paragraph summarizes the internal work procedure at ELAN when the information is not coming from Airbus. The only difference between the current Airbus-dependant work procedure and the future Airbus-independent work procedure is the data gathering phase, required to perform the cabin conversion / upgrade. The problem encountered is the unpredictable duration of this phase. Once ELAN gathers experience with this respect, the duration will decrease.

4 Case Study: A320 Cabin Conversion for Condor Berlin

4.1 Description of the Cabin Conversion

The Cabin Conversion branch at ELAN currently works as a subcontractor for Airbus. Airbus imposes the form and the way the deliverables are created and controlled (in documents such as GREDS – General Requirements for Engineering Design Suppliers).

A Study Case has been chosen based on the example of a cabin conversion developed by ELAN for Condor Berlin, through Airbus. The cabin modification work package basically consisted of the installation of the Enhanced Cabin, aimed to provide a better appearance and improved comfort for passengers. The following subtasks were included:

- the installation of the enhanced CIDS;
- the installation of changes with respect to cabin interior:
    - ceiling panel,
    - overhead stowage compartment including boxes, doors and grip rails,
    - seat row numbering,
    - cove light panel,
    - side wall lining;
- the installation of changes with respect to the IFE system

4.1.1 The View of Airbus

The division at Airbus responsible for Upgrade Cabin Operations has the abbreviation **SEUC**. The organizational Chart of this division is shown in Figure 4.1.

The SEUCE department carries the organizational responsibility and has 13 employees. The SEUCL is responsible for the long range aircraft and has 38 employees. The SEUCS is responsible for single aisle with 22 employees. The SEUCD undertakes the upgrades for A380 and A350 with 11 employees. The SEUCB is the division responsible of creating the service bulletins with 11 employees. The SEUCM is responsible for the kits management with 16 employees. The SEUCV is responsible for the vendor engineering specification with 16 employees. Another division is called SCUZ and refers to the Mobile Alabama, USA site.

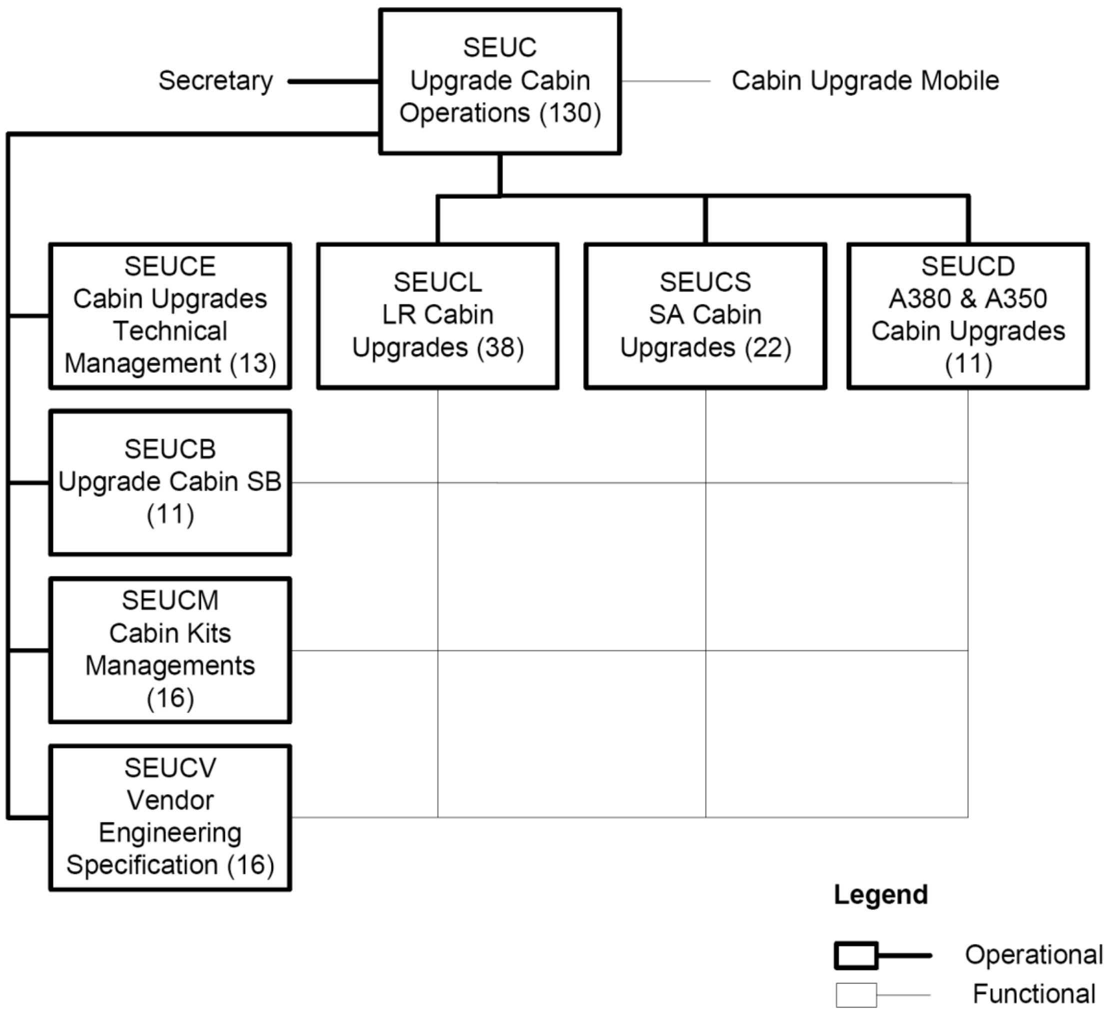


Fig. 4.1 Organizational Structure of the Upgrade Services Department at Airbus

Airbus receives the request from the customer airline and proceeds to providing the appropriate technical solution, by subcontracting one of the several companies, having the capability to perform the task. The selection process starts with the document called 'Work package subcontracting specification (WPSS)' based on which the subcontractor writes an *offer* (called technical proposal). The offer, written as well after Airbus requirements, may be rejected or approved. The acceptance criteria, for Airbus, are usually related to costs, but sometimes other reasons come first (political reasons).

The engineering work delivered by the subcontractors, becomes part of the internal 'Airbus-way' of handling cabin conversions. The *Airbus procedure* with respect to design modifications related to cabin (undertaken by SEUC) is summarized by the following main documents (in this order):

- The customer makes a request which is formalized through what is called **RFC** (**Request for Change**).
- The RFC generates corresponding **MP**'s (**Modification Proposal**), which are documents containing all the technical changes implied by the customer request.
- The **MOD** (**Modification**) is the document containing the technical support for the change to be conducted, as well as the corresponding approvals; it may be composed out of several MP's

The documents are tagged with a specific code number which shows for which type of aircraft is the modification valid. Based on these documents the SB's are created, which represent, along with the kit of parts, the deliverable that goes to the customer. ELAN delivers the engineering work contained in the MP's, MOD's and SB's for Airbus.

After selecting the subcontractor, Airbus must deliver the necessary input information (mentioned already in the WPSS). Airbus asks for weekly reports from the subcontractor, showing that the milestones are being respected, and carries the responsibility for *certifying* the design. At the end of the project, Airbus includes the information provided by the subcontractor in the *SB* that is to be received from the client.

The WPSS together with an Offer *describe the work package* that the subcontractor needs to conduct. The Condor study case was divided in three parts, each with a corresponding offer – one for the CIDS, one for the IFE and one for the cabin interior. The WPSS (**WPSS 2009**) includes a **general milestone plan** which specifies the processes inside Airbus. Another *individual milestone plan* shall be delivered to the subcontractor, based on which the subcontractor can build its own milestone plan, which will ensure meeting the deadlines. It also specifies the general acceptance and **quality criteria of the deliverables**. This document also provides information with respect to **hardware and software access** required by the subcontractor in order to perform the work. Usually the subcontractor works in its own quarters and uses its own hardware and software; however, this is done according to the Airbus standards. Airbus specific software tools are:

- CKM (predecessor: CADABAS)
- TAKSY
- DVO Bowser
- ZAMIZ
- ICC Tools

The WPSS specifies details with respect to the responsible **contact persons** at Airbus and the location of the work. Another specification comprised in this document refers to **the interval and the way of the reviews** and reports which need to be sent by the subcontractor to the purchaser (i.e. Airbus). The reports of the subcontractor (i.e. ELAN) must provide information with respect to:

- deliverables linked to the milestone plan and acceptance criteria,
- technical and quality issues,
- changes,
- risk management,
- open issues, blocking points and actions with action holder.

Airbus has access to the progress of the WP performed by the subcontractor and can control its capability to achieve the objectives. The subcontractor has its own quality system, however in accordance to Airbus criteria written in AP 1500 (GREDS – General Requirements for Engineering Design Suppliers).

The WPSS also specifies which data will be provided to the subcontractor in order to conduct the work package. The data input for the Condor work package (abbreviation: CIB) must be made available on time, for each milestone. During the **preparation phase**, the following input information is made available:

- Airbus Technical Offer (three offers for the Condor case),
- Pre/Post-Cabin Layout Configuration,
- Before/After drawing report example,
- Mechanical Retrofit Drawing example,
- Electrical Retrofit Drawing example,
- Reference KIT long lead item list,
- Flammability Report Order Sheet example,
- SEUC Drawing Guide,
- Defect Report example,
- GREDS Project Review guidelines,
- GREDS Project Review template,
- MP number.

During the working period information is additionally provided as required.

The milestones provided by Airbus along with the required deliverables are described in Table 4.1. ELAN's work begins at milestone M06, having as input the results of the ITCM (Initial technical Coordination Meeting) discussed at M02. It is noticeable that the Long Lead Time Preliminary List of Components (LLT P-Loc) must be delivered already in the initial work phase and later updated. This list comprises of those parts with long delivery times, which need to be ordered much earlier than normal.

The drawings are divided into electrical and mechanical drawings and they need to be delivered to Airbus before M09 – Drawing Freeze. Airbus includes the drawings received from the subcontractors into the MAS (Modification Approval Sheet), which is the document that describes and certifies the change.

Table 4.1 Individual milestone plan provided by Airbus in the WPSS for CIB work package

Milestone		**Due date**	**Deliverable**		**Form of deliverable**
M00	RMO acceptance telex – for information only	10.02.2009	–	–	–
M01	Start of S/C work	02.03.2009 but not before P/O	–	–	–
M02	ITCM	11/12.02.2009	–	–	–
M03	CDF	10.03.2009	–	–	–
M04	PDR	n/a	–	–	–
M05	Internal kick-off meeting	19.02.2009	–	–	–
M06	S/C kick-off meeting	Cw10	**At M06**:	Updated before/after drawing **report** according to M02 inputs	EXCEL file
			1cw prior M07:	Set of **LLT P-LOC**s	–
M07	LLT P-LOCs delivery	ATA25: 19.03, ATA23: 13.05.2009			
M08	CDR	n/a			
			4 cw prior M09:	Electrical **drawing** set	CCD Dwg
			4 cw prior M09:	Mechanical **drawing** set	CCD Dwg
			2 cw prior M09:	Top overview **drawing**	CCD Dwg
			4 cw prior M09:	Final Set of **P-LOC**s	–
			1 cw prior M09:	Order Sheet – draft flammability report order sheet	EXCEL file
M09	Drawing freeze	24.06.2009			
M10	MAS	03.08.2009			
M11	Working party start	November 2009	**Between M11 and M12:**	**Drawing** – deliverable adaptation according working party defect reports	CCD Dwg and PDF file
M12	Working party end	January 2010	–	–	–

During the Working Party phase ELAN delivers final versions of the drawings, according to the incoming defect reports. One of the difficulties encountered by the subcontractors is the lack of input information, or the delays in receiving the input information from Airbus. Often changes in the customer request occur and the post-drawings need to be modified.

The three Technical Offers created by Airbus and received by the subcontractor (ELAN) generally describe the customer request, with respect to the following aspects:

- duration or lead time,
- pre modification configuration,
- the involved aircrafts (after MSN),
- general description of the technical solution, for each ATA Chapter, comprising of:
    - items to be removed,
    - items to be installed,
    - items to be adapted,
    - items to be modified.
- the corresponding SB which is to be created and delivered to the customer,
- the MOD documents, and the corresponding MP's which are to be validated,
- the list of BFE,
- the list of SFE.

The three parts of the work package, formalized in the corresponding three offers are described in Table 4.2.

Table 4.2 The description of the three Airbus-Offers for CIB's

Offer 1: Install new IFE

Pre Mod Status: The aircraft are equipped with a Matsushita IFE system with Airshow 420, PRAM in the E-Bay and a landscape camera.

Objective: The previously installed IFE system shall be modified in order to contain a new digital server unit/system controller (SC-A) with connection to the landscape camera and Airshow system. The Airshow system shall be upgraded to the Airshow 4200.

ATA 23: Communications

Removal of:

- PRAM-Player in the E-Bay
- Old VCC mounting shroud incl. IFE hardware in the OHSC
- Airshow 420 unit
- 18x LCD monitor in PSU channel
- 2x LCD monitor wall mounted

Installation of:

- System provisions for PRAM in IFE, video, audio incl. internal wiring for 80 VU & 2000 VU
- Wiring provisions between 1st LH Hatrack, 2000 VU and 80 VU
- 1 new tray & SC-A in 80 VU
- 1 mounting shroud and crew panel in hatrack spacer (C21 LH)
- 1 Airshow 4200 unit in 80VU
- 18x 10" LCD monitor in PSU channel
- 2x 9~~ L~~CD monitor wall mounted

Adaptation of:

- Hatrack spacer C21 LH. (Covered by EHC-retrofit)
- 2000VU: New C/B for 115V power supply)
- Wire harnesses between 80VU, 200VU and VCC
- 80VU / 2000VU + wiring for power distribution.
- 80VU to new standard

Offer 2: Install new enhanced CIDS

Pre Mod Status: pre-modification configuration as known to AIRBUS

Objective: removal of the classic CIDS and the installation of the enhanced CIDS. Additionally to the already available CIDS functions the Smoke Detection Control Unit (SDCU) and the Vacuum System Controller and their respective functions are integrated in the new CIDS directors.

ATA 25: Equipment and Furnishings

Removal of:

- FAP cover for classic CIDS

Installation of:

- FAP cover for enhanced CIDS

Modification of:

- entrance ceiling area due to new IBU's
- hatracks due to new IBU's
- lavatories with modified ballast units (per VSB)

ATA 92:

Removal of:

- DEU A's incl. brackets
- DEU B's incl. brackets
- CIDS directors
- FAP
- CAM
- AIP
- AAP
- PTP

-Passenger service information units (PSIU)
- Air outlets
- Lighted placard 11LF due to permanant No smoking configuration

Smoke:
- Smoke Detection Unit (SDCU)
- Wire harnesses (Cargo ventilation /FWC1,2/CFDIU/CIDS Directore interface, 2 data busses)
- CB's
- Equipment mount
- Smoke detectors in lavatories and in cargo compartment

Vacuum system:
- vacuum system controller (VSC) inl. Tray and brackets
- wire harness between VSC and LGCIU
- wire harness between VSC and CFDIU
- wire harness between VSC and CIDS (FAP interface)
- wire harness between VSC and Flush control unit (FCU)
- wire harness between VSC and Vacuum generator
- wire harness between VSC and liquid level sensor/ transmitter
- wire harness between water service panel and FAP
- wire harness between VSC and waste panel
- wire harness between VSC and altitude pressure switch
- CB's

Lighting:
- Illumination ballast unit (IBU's)
- Emergency power supply units (EPSU)
- Exit light lens

Installation of:
- new and modified bracket arrangement
- new and modified wire harnesses
- new DEU A's incl. Brackets
- new DEU B's incl brackets
- new DEU connection boxes
- new termination plugs
- new data buss harnesses
- 2 new CIDS directors
- new touch -screen FAP
- OBRM integrated in FAP
- New CAM
- New AIP
- New AAP
- New PSIU incl. No PED/ Fasten seat belt signs
- New air outlets
- Lighted placard 11LF with the wording EXIT instead of No SMOKING

Smoke:
- Additional wires between DEU B and smoke detection sensors in the lavatory
- Additional wires between CIDS - director and cargo compartment
- Additional wires between CIDS - director and cargo ventilation interface
- New Smoke detectors in lavatories and in cargo compartment

Vacuum system:
- Additional wires between DEU B and the water/ waste system interface
- Additional wires between CIDS - director and the water/ waste system components

Lighting:
- Illumination ballast unit (IBU's)
- Emergency power supply units (EPSU)
- Exit light lens

Modification of:
- essential power wiring for DEU A's

- 2000 VU due to relocation of stand alone PISA from inside to outside and installation of additional C/B's
- 2001 VU due to relocation of stand alone PISA from inside to outside and installation of additional C/B's
- Pin Programming air conditioning zone controller
- SDAC Pin Programming due to permanent no smoking configuration

Offer 3: Install new Enhanced Cabin

Pre Mod Status: pre-modification configuration as known to AIRBUS

Objective: installation of the new, so called ~~"~~Enhanced Cabin". The changes concerns the following cabin interior:
-Ceiling Panel
-Overhead stowage compartment incl. boxes, doors and grip rails
-Seat row numbering
-Cove light panel
-Side wall lining

ATA 25: Equipment and Furnishings

Removal of:

- All Side Wall Panels
- Partitions fwd of seat row 1
- Door Frame.Lining Door 1 (Transition Panels)
- All Cove Light Panels
- Spacer Compl.
- All End Panels
- All Ceiling Panels
- Alternativ Spacer
- All Hatrack Boxes
- Spacer Bin
- All Hatrack Doors
- All Grip Rails
- All Cover Profiles
- Partition Panel
- Ceiling F14-F21
- Filler
- Info-Panel 3700VU
- Ceiling F65-F68
- Filler
- Info-Panel 3701VU
- Ancillary Parts
- All Placards Seats
- Placards Cabin
- Placards for Emergency Equipment
- Brackets for Emergency Equipment
- CAM
- NTF
- Insulation of door frame lining

Installation of:

- New Side Wall Panels with window funnels
- New Partitons fwd of seat row 1
- Door Frame.Lining Door 1 (Transition Panels)
- All Cove Light Panels
- Spacer Compl.
- New End Panels
- New Ceiling Panels
- Alternativ Spacer
- New Hatrack Boxes
- Spacer Bin
- Security mirrors in all hatrack boxes
- New Hatrack Doors
- New Grip Rails
- New Cover Profiles
- Ceiling F14-F21
- New Filler
- New Info-Panel 3700VU
- Ceiling F65-F68
- New Filler
- New Info-Panel 3701VU
- New Partitions in OHSC
- All Placards Seats
- Placards Cabin
- Seat Row Numbering incl. Indication in grip rail
- Placards for Emergency Equipment
- CAM
- NTF
- Insulation of door frame lining
- Floor mounted EFPMS

Adaptation of:

- Pelmet of Lavatory D and E
- Primary insulation C38 / C39 and C64 / C65 l/h and r/h
- Upper air outlets: Prolongation of the air duct hoses
- 2000VU and 2001VU: New LED CAS reading light
- Re-use Emergency Equipment
- Re-use Brackets for Emergency Equipment
- Re-use Ancillary Parts

ATA 53:

Removal of:	**Installation of:**
-Structural brackets for OHSC	-Structural brackets with new rivets for OHSC
ATA 92:	
Removal of:	**Installation of:**
- All Exit and Emergency Light - Exit Sign - Lens Assy - Wiring to the DEUs	- New Exit and Emergency Light - Exit Sign - Lens Assy - New wiring to the DEUs

4.1.2 The View of ELAN

Based on the WPSS and the Offer received from Airbus, ELAN creates and sends a **Technical Proposal**. The technical proposal receives a number and a title and is written in accordance with GREDS. Based on the milestones presented in the WPSS (M06 to M M12), ELAN proposes the delivery plan, corresponding to the new milestones Z01 to Z 08 (see Table 4.2). If the offer is accepted, the plan is followed according to the ELAN *internal procedure*, which will be further illustrated based on the CIB study case.

The proposal written by ELAN covers the following topics:

- compliance with the specifications covered in WPSS,
- payment plan,
- ELAN experience background,
- management of the project:
    - project leaders,
    - work breakdown structure,
    - organizational breakdown,
    - resources,
    - skill matrix,
    - trainings,
    - workplaces and hardware,
- project Master Schedule,
- milestones,
- risk management,
- technical facts and assumptions used as input for creating the technical proposal (comprised in appendix).

When analyzing the Airbus milestones written in the reference document CIB0804_after_kick-off_20090220.pdf (**WPSS 2009**), which was received by ELAN as input information along with the WPSS, the role of the subcontractor ELAN can be identified throughout the Airbus processes (see Figure 4.2). A total number of 500 hours are allocated by Airbus for the process called *SU Engineering Design/Drawing and Preliminary List of Components and Long Lead Items*, which is entirely performed by ELAN. In practice, for the CIB project, ELAN needed to work more than double, achieving a number of more than 1200 work hours. The drawings delivered are included in the Airbus documents and eventually in the SB that goes to the customer. Specifically for the CIB case, Appendix E shows the Gantt chart of the entire CIB conversion – with both Airbus and ELAN input.

Along with the technical proposal, before the contract is agreed upon, ELAN usually sends Post Mod layouts, under a separate convention with Airbus. This is rather valid for LR and WB aircraft. For the CIB case preliminary layouts have not been sent. Instead, each retrofit task, described in the appendix of the Technical Proposal/Offer is accompanied by sample drawings.

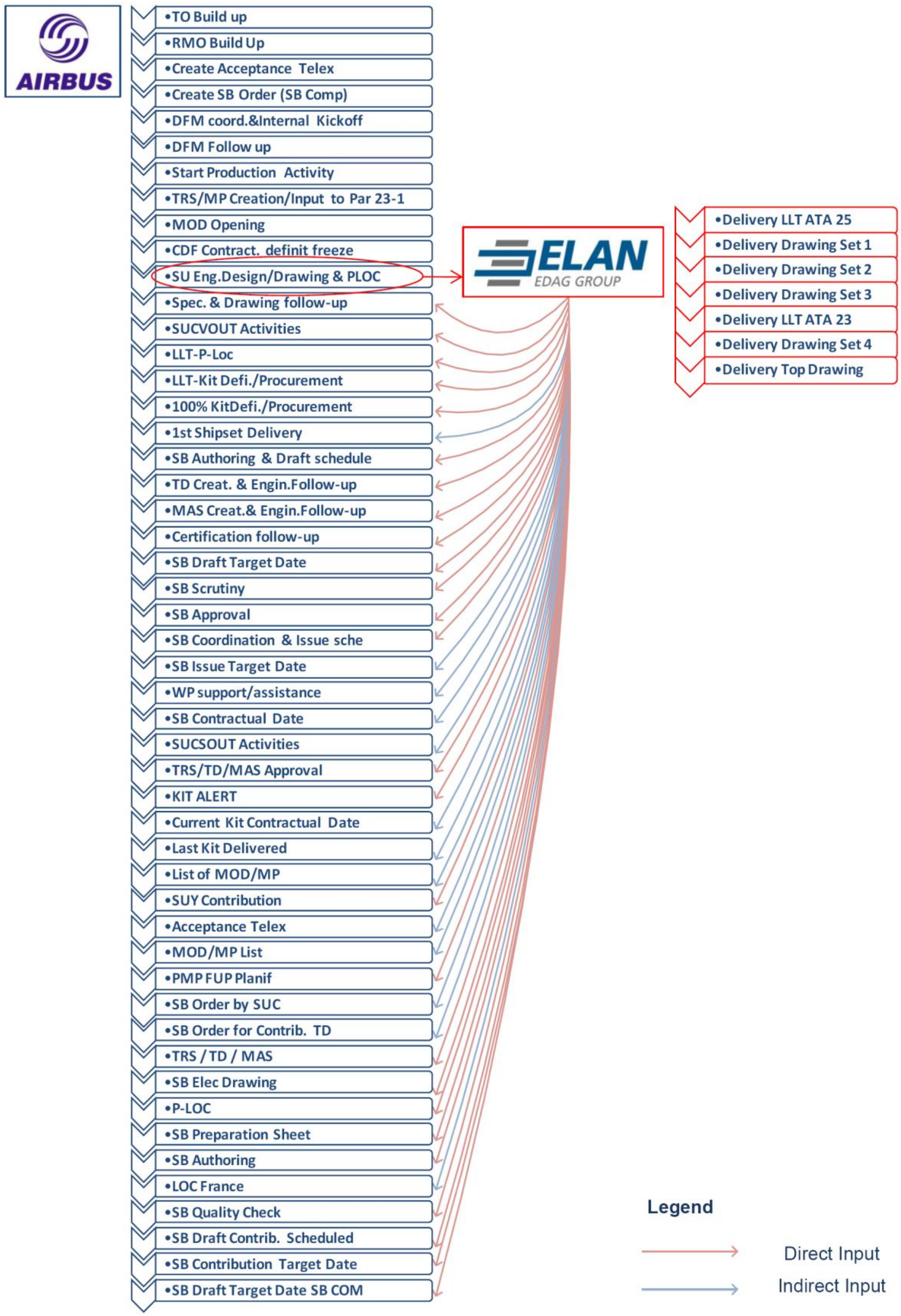


Fig. 4.2 Airbus Process Chain for CIB and ELAN Deliverables (based on **WPSS 2009**)

Table 4.3 Delivery milestones plan of ELAN for CIB work package

Milestone	Due Date	Deliverable
Z00	06.03.2009	**Kick Off Meeting**
Z01	12.03.2009	**LLT ATA 25**
Z02	31.03.2009	**Drawing Set 1**: Partition installation Seat installation Hatrack box and Hatrack door EFPMS Sidewall lining Griprails InstallationEquipment 80VU CIDS equipment inst. and CIDS cable routing, each 25%
Z03	21.04.2009	**Drawing Set 2**: NTF Endpanels Emergency Exit Jointstrip Seat Track cover Doorframe lining Cove light panels Ancillery parts Door frame 4 – insulation VCC-inst. Monitor-inst. CIDS equipment inst. and CIDS cable routing, each 25%
Z04	06.05.2009	**Drawing Set 3**: PSU PSU new air outlets Ceiling Curtain rail Ceiling F14-F21 FAP-cover Hatrack connection parts Ceiling F65-F68 2000VU mod. to 115VC Adaption of available VCC inst. Inst. of Wiring for 2000VU, 80VU - LHS Hatrack CIDS equipment inst. and CIDS cable routing, each 25%
Z05	06.05.2009	**LLT ATA 23**
Z06	27.05.2009	**Drawing Set 4**: Emerg. Equipment Emerg. Equipment brackets Cabin placards P-Loc status3 Sys. prov. For PRAM in IFE, video, audio incl. routing Wiring prov. between 1st LH-Hatrack,2000VU and 80VU CIDS equipment inst. and CIDS cable routing. each 25%
Z07	10.06.2009	**Drawing Set**: Top drawing
Recap		**Recap Meeting after Drawing Completion**
Z08		**Working Party Support for S/C drawing set**
Recap		**Recap Meeting after Working Party**

4.2 Work Preparation Phase

Once the Technical Proposal is accepted, ELAN applies its *internal procedure* for conducting the engineering work. The work assignments are different for the *Project Leader* then for the rest of the *personnel*.

The project leader (PL) is the one who responds to the Airbus offer by creating the Technical Proposal. This involves further responsibilities:
- estimative calculation of working hours,
- estimative calculation of costs,
- determination of the WP price.

After the *offer* stage, the PL has *organizational* responsibilities:
- setting the internal meeting,
- assigning responsibilities to the personnel.

During the *working* stage, the PL is the one:
- creating and delivering reports to Airbus (as set in the WPSS),
- performing the design verification (the so called checks),
- setting meetings as required by the personnel, to discuss and overcome problems,
- creating the Change Control Sheets (CCS) if it's necessary,
- creating and updating the List of Open Points (LOOP).

During the *after work* phase, the PL at ELAN is:
- providing the WP Support,
- making required drawing corrections,
- gathering *recap* data and summarizes Lessons Learned.

In practice the PL workload is quite high. Besides the tasks mentioned above, the PL contributes himself in creating the drawing sets.

The tasks of the engineering personnel can be summarized as follows:
- They take part in the internal meeting, where they receive their tasks.
- Along with their tasks, they also receive the specific input data: the Pre Mod layouts delivered by Airbus.
- They create the drawing sets, in accordance with their tasks, which may suffer changes along the project, as the Airbus inputs modify.

- They perform corrections, in cooperation with the PL whenever the case is, after the drawing set is finished.

This task enumeration is valid for both *mechanical* and *electrical* engineers.

The work preparation phase is, as underlined before, the responsibility of the PL, and starts with the internal meeting and the distribution of the assignments. Figures 4.3 and 4.4 summarize the distribution of tasks for the PL and for the rest of the personnel. Figures 4.3 and 4.4 also illustrate the ELAN *internal current procedure* for conducting refurbishing projects *together with Airbus*.

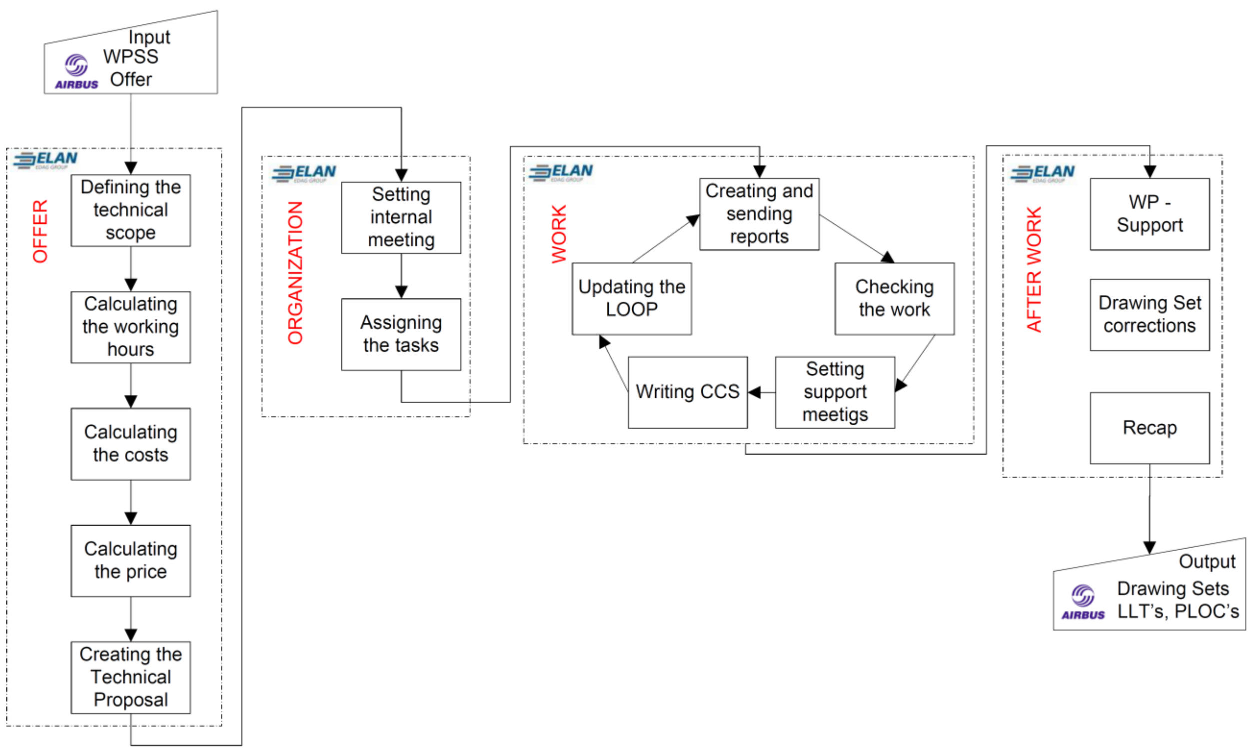


Fig. 4.3 PL responsibilities at ELAN

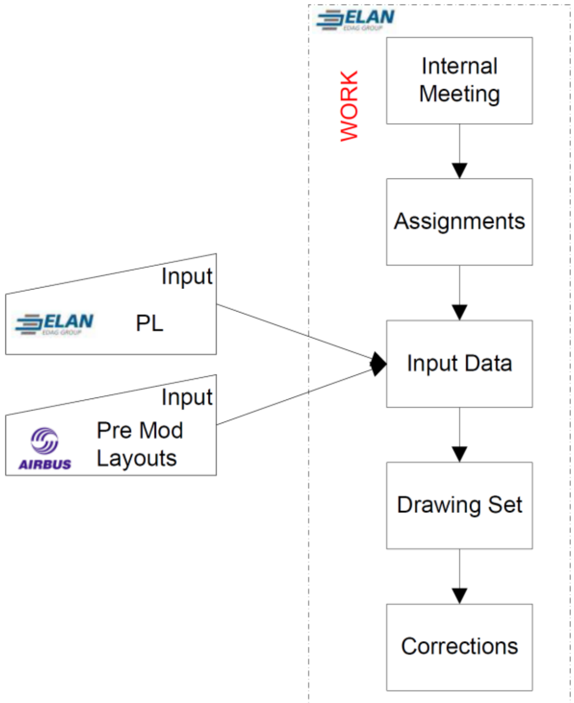


Fig. 4.4 Design engineers responsibilities at ELAN

4.3 Design Phase

The aim of analyzing the CIB project is to identify the answers for the following questions:

- What can ELAN cover from a technical point of view *with* Airbus?
- What can ELAN cover from a technical point of view *without* Airbus?
- What can ELAN cover from a technical point of view *with* DOA?
- What can ELAN cover from a technical point of view *without* DOA?
- Which is the internal procedure (German: *Vorgehensweise*) in the ‘with’ case?
- Which is the internal procedure (German: *Vorgehensweise*) in the ‘without’ case?

The design phase comprises of the work for achieving the deliverables (shown in Figure 4.2, Table 4.3). In order to answer the above questions, the CIB has been divided into a number of *subtasks*, for which several problems have been investigated, while differentiating between tasks belonging to *mechanical* engineers and tasks belonging to *electrical* engineers. Design engineers in both fields gave answers on these essential topics (**Becker 2009**, **Mihalke 2009**):

- necessary input data,
- alternatives to unavailable input data,

- procedure for fulfilling the task (Figure 3.8).

Mechanical refurbishing tasks

The results for the mechanical engineering tasks in the CIB project are summarized in Table 4.4. The data was gathered with the help of **Becker 2009**.

Table 4.4 Results of the interviews with engineers dealing with Enhanced Cabin (EC) for the CIB project with respect to required input data, difficulties encountered when the data would be missing, alternatives to unavailable data and feasibility of the task

EC	Input data	Difficulties	Alternatives	Feasibility
Seat Installation	**F**uselage contour. **M**onuments: location, dimensions. **S**eats: documents from seat manufacturer (dimensions). **S**eat rails: location, type.	**G**etting data from seat and monuments manufacturer. **D**etermining the dimensions and position of the monuments, without the original layout: e.g. location of the reference point.	**D**irect measurements. **A**dditional data from seat manufacturer. **P**hotographs (with dimensions). **D**ata from monuments manufacturers.	**+ +**
Seat track cover	**M**onuments: location, dimensions. **S**eats layout. **I**nformation about the seat track covers.	**T**here are three types of seat track covers used by Airbus; if there is no other manufacturer, these parts must be ordered from Airbus; a new design involves having DOA.	**D**irect measurements. **P**hotographs (with dimensions). **D**ata from monuments manufacturers. **D**ata from seat track cover manufacturer (if there is one different than Airbus).	**– +**
EFPMS	**M**onuments: location, dimensions. **S**eats layout. **S**eat rail position. **P**ath Marking manufacturer info (e.g. Lufthansa produces non-electrical EFPMS).	**F**or electrical EFPMS the complexity of this task is greater, as electrical connection possibilities must be investigated. **G**etting the correct dimensions and positions.	**D**irect measurements. **P**hotographs (with dimensions).	**+ –**

Sidewall panel Sidewall emergency exit Cove light panel	**F**uselage contour. **L**ining contour. **L**ocation and dimensions of seats and monuments. **I**nformation about brackets.	**I**t is impossible to reproduce the same type of lining without the original drawings. **A** new design, in accordance with the airline requirements can only be achieved under DOA.	**B**uying the parts from Diehl (small chance of happening). **S**elf measuring. **S**elf (new) designing – only under DOA.	**– –**
Ceiling	**F**uselage contour (does not depend on the position of the monuments). **I**nformation about brackets. **I**nformation about electrical connection possibilities (e.g. EXIT sign).	**I**t is impossible to reproduce the same type of ceiling without the original drawings. **A** new design, in accordance with the airline requirements can only be achieved under DOA.	**B**uying the parts from Diehl (small chance of happening). **S**elf measuring. **S**elf (new) designing – only under DOA.	**– –**
Door frame lining	**F**uselage contour. **L**ining contour. **L**ocation and dimensions of seats and monuments. **I**nformation about brackets.	**I**t is impossible to reproduce the same type of ceiling without the original drawings. **A** new design, in accordance with the airline requirements can only be achieved under DOA.	**B**uying the parts from Diehl (small chance of happening). **S**elf measuring. **S**elf (new) designing – only under DOA.	**– –**
Hatrack bin	**M**onuments: dimensions, location. **S**eats: dimensions, position. **F**uselage contour. **F**uselage frames.	**T**here are only special connection points where the hatracks can be mounted on the fuselage frames – this would require Airbus drawings, but ELAN can handle this based on its experience.	**I**nformation can be made available by the hatrack bin manufacturer – for SA: Fischer. **U**sually a retrofit project implies the replacement or adaptation of one of the hatracks. ELAN could design in this case alone through direct measuring.	**+ –**

Hatrack door, grip rails, covers	**M**onuments: dimensions and location. **D**ata from hatrack doors manufacturer. **D**ata about the hatrack bins.	**T**he current hatracks, rails and doors come from Diehl (doughter of Airbus – small chance of getting information). The new hatracks and hatrack related parts are produced by Fischer.	**D**irect measuring. **P**hotographs (with dimensions).	**+ –**
Hatrack connection parts	**M**onuments: position and dimensions. **S**eats layout. **F**uselage structure layout – the position of the frames.	**T**he hatracks are connected to the structure, therefore information must be made available for the area belonging to the fuselage frames; the location of these frames must be known.	**H**atrack manufacturer may provide information about the fuselage frames. **A**ircraft inspection. **D**irect measuring.	**+ –**
Curtain and curtain rail	**M**onuments: position and dimensions. **S**eats layout.	**I**f there are already connection holes in the monuments, their position must be known.	**A**ircraft inspection. **D**irect measuring. **P**hotographs (with dimensions).	**+ +**
Emergency equipment, Emergency brackets	**E**R layout from the Airline. **T**he quantity and location according to the legislation. **D**ata about the dimensions of the ER equipment from the manufacturer. **T**he hatrack layout and dimensions. **T**he flight attendant seat layout and type.	**T**he ER equipment must be secured through brackets within the hatrack, under the seat of the flight attendants, or within other monuments (e.g. dog house); the layout of these monuments along with the dimensions of the equipment must be known. **A**irbus produces part of the ER equipment.	**A**ircraft inspection. **D**irect measuring. **I**nformation from the ER equipment manufacturer.	**+ –**

Ancillary parts	**T**hey refer to: baby basinets, literature pockets, or magazine racks. **M**onuments layout: position and dimensions. **S**eats layout **D**ata from the ancillary parts manufacturer: dimensions.	**G**etting the monuments and seats layout.	**A**ircraft inspection. **D**irect measuring. **P**hotographs (with dimensions).	**+ +**
Placards cabin, seat row numbering, ER, doors	**E**R layout. **M**onuments: position and dimensions. **I**nner layout of the monuments. **N**umber of seats.	**T**he placards are produced by Airbus; either the airline or ELAN must choose from the Airbus catalogue, and buy them accordingly.	**A**ircraft inspection. **D**irect measuring. **F**or new monuments, the inner layout can be obtained from the monuments manufacturer.	**+ +**
NTF (Non Textile Floor)	**F**uselage contour. **M**onuments layout. **L**ocation of floor connectors for monuments. **F**light attendants seat layout and seat type (connected on the floor or not).	**T**he NTF is required in the area near the doors and monuments and under the galley (the lavatory has its own NTF) **G**etting the exact cabin layout in this area, as well as the exact galley specification.	**A**ircraft inspection. **D**irect measuring. **I**nformation from galley manufacturer.	**+ –**
Joint strip	**P**osition of the curtains. **F**loor layout and floor type.	**T**he joint strips connect the NTF and the textile covering. The floor is part of the primary structure, therefore information about the floor can only be obtained from the aircraft manufacturer. **I**f the floor is from CFK, one cannot make holes in it, and it must be ordered from aircraft manufacturer	**I**f the floor is not from CFK, aircraft inspection my be enough to find out if there are available holes; if not, such a design modification must be certified under DOA.	**+ –**

PSU	**S**eats layout and seats type. **M**onuments layout. **H**atracks layout. **D**ata for each device contained in the PSU and related legislation.	**T**he PSU requires work from both mechanical and electrical engineers; data must be available with respect to the electrical connection which goes through the hatrack and beyond. **A**irbus is the one producing the covering parts between 2 PSU's	**A**ircraft inspection. **D**irect measuring. **P**hotographs (with dimensions).	**+ –**

Legend **+ +** the task can currently be conducted at ELAN

+ – the task could not currently be conducted at ELAN due to the difficulties encountered and the lack of information

– – the task could currently be conducted under certain circumstances, but it would be difficult to implement, and certain unknown aspects make the duration of the engineering work unpredictable

The conclusions after analyzing the Condor study case with respect to design problems in the **mechanical** part of the refurbishing, represented by the implementation of the Enhanced Cabin concept, are summarized further down. The entire analysis has been performed under the Airbus independency hypothesis.

- A feasible alternative is always inspecting the aircraft, measuring and making photographs. Observations / difficulties with this concern:
    - The first condition in this case is to have the aircraft available enough time for the inspection.
    - It may be the case that the aircraft is not available for inspection – in this case a solution must be found together with the airline, depending on the complexity of the refurbishing – they may have an aircraft with a similar layout standing on ground.
    - This is rather the Lufthansa Technik way – they have aircraft available.
    - If the airlines are not willing to set an aircraft inspection date, another possibility is to seek the agreement either with completion centers like Lufthansa Technik, or with aircraft disposal companies.
    - When measurements in front and in the rear of the fuselage are required, a systematic method (like in FEM) must be applied and enough measuring points must be selected, in order to get to the required measuring tolerance.
    - A problem in measuring is defining the 'point zero', which must be constant along the entire project; the flexibility exist to choose a different point for each case/aircraft.

- The cabin layout – position and dimensions of seats, monuments and hatracks along with the fuselage contour is almost for all refurbishing scenarios required. When measuring all the dimensions and rebuilding this layout, the question arises: how exact are the measurements, how big the tolerances should be. The answer may come only from practice, and experience will play a major role.
- Depending on the type of the refurbishing/upgrade/modification, specific information is required. Usually several small tasks within the same project are related and require the same type of information: e.g. when a hatrack bin requires a modification, this must be done according to the seats and monuments layout; once these layouts are known, they may be used for instance also for the carpet installation. Therefore, the same information (seats, monuments layout) may be used several times – the effort for gathering it must be efficiently managed, in accordance with (as far as possible) its plural utility.
- The long term advantage of this approach – rebuilding the designs based on aircraft inspection – is that an own ELAN database will be formed and used as a knowledge base.
- Several items are either very difficult or impossible to measure – e.g. lateral covering (lining). The alternative is to measure only basic dimensions and to redesign the hole lining again, in accordance with the airline wishes. A small lining modification would not be possible, but to redesign it and to produce a new concept is possible. ELAN engineers have enough experience to handle the design, however, this is achievable <u>only under DOA</u>.
- DOA gives enough flexibility to ELAN to cover, theoretically, the missing parts of measuring and inspecting, by creating new designs. This involves certification activities (granted in any case by a DO approval). Another issue is the production of these new designs. ELAN <u>may consider getting a POA</u> (Production Organization Approval) as well.

<u>Electrical refurbishing tasks</u>

The tasks involving electrical engineering are challenged by the complexity of the wiring network of an aircraft, particularly due to the fact that these networks may vary from one aircraft to another of its kind. Basically the input information, always required when it comes to refurbishing electrical devices, is (**Michalke 2009a**):

- A general understanding of the electrical wiring of the entire aircraft/the system involved in the refurbishing, by means of Principle Diagrams (PD).
- Additionally basic information provided by Wiring Diagrams (WD), which contain the description of the circuits as well as their identification placards.
- Connection diagrams, in order to understand the functioning of the system.

When it comes to installing new electrical devices, a very good source of information is the manufacturer of the respective device, who provides information with respect to the electrical connections, necessary source of power, and may also have additional information about the wiring network of the respective system in the aircraft.

Very useful in understanding the overall functioning of the electrical systems are the Wiring Diagram Manual (WDM) and the System Schematic Manual (SSM).
Table 4.5 summarizes, for the CIB case, the items which needed electrical engineering processing, the input information required for each item, as well as the conclusion towards the feasibility of the respective item modification. The data was gathered with the aid of **Michalke 2009a** and **Michalke 2009b**.

Table 4.5 Results of the interviews with engineers dealing with IFE and new enhanced CIDS for the CIB project with respect to required input data, difficulties encountered when the data would be missing, alternatives to unavailable data and feasibility (do-ability) of the task

IFE	Input data	Alternatives	Feasibility
Monitor Installation	**S**SM **W**D **C**onnection diagrams **P**art numbers **M**anufacturer data (drawings) **W**iring bundle **S**eats layout **M**onuments layout	**A**ircraft inspection **D**irect Measuring **D**ata from Manufacturer **O**wn research (e.g. aircraft documentation)	**+ +**
VCC Equipment	**L**ocation of the VCC (from Airline) **D**imensions of the VCC (from manufacturer) **C**onnection diagrams (from manufacturer) **P**art numbers **M**anufacturer data (drawings) **R**elated regulations	**A**ircraft inspection **D**irect Measuring **O**wn research (e.g. aircraft documentation)	**+ +**
E-Rack 80VU	**S**SM **W**D **C**onnection diagrams **D**imensions and location	**A**ircraft inspection **D**irect Measuring **O**wn research	**+ –**
Circuit breaker panels 2000VU	**P**D **W**D **C**onnection diagrams **D**imensions and location	**A**ircraft inspection **D**irect Measuring **O**wn research	**+ –**
New enhanced CIDS	Input data	Alternatives	Feasibility

Cable routing	Original cable routing SSM WD List of harnesses Hook-up List	Aircraft inspection Direct Measuring Own research and experience	**+ –** **– –** Depends on the size of the change
Equipment installation & Bracket installations	SSM WD Equipment related data (from manufacturer) Bracket related data (from manufacturer)	Aircraft inspection Direct Measuring Own research and experience Data from equipment manufacturer	**+ –**
DEU			**+ +**
FAP, AAP, AIP installation			**+ +**
Smoke detection			**+ +**
Ballast Units			**+ +**
EPSU			**+ +**
Exit light lens			**+ +**
Pin programming			**– –**
C/B			**– –**

Legend
- **+ +** the task can currently be conducted at ELAN
- **+ –** the task could not currently be conducted at ELAN due to the difficulties encountered and the lack of information
- **– –** the task could currently be conducted under certain circumstances, but it would be difficult to implement, and certain unknown aspects make the duration of the engineering work unpredictable

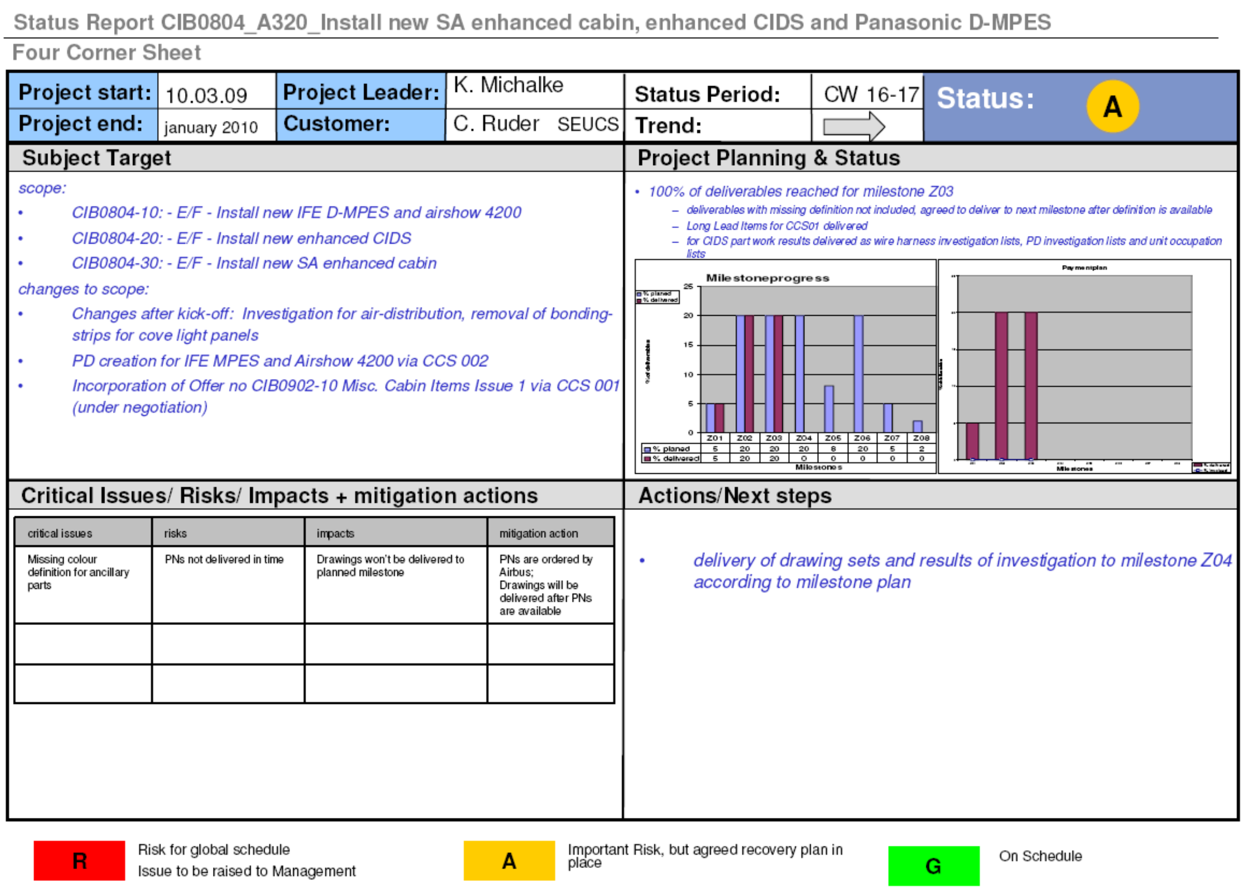
Difficulties:

- A long inspection time would be required for understanding the system, the connection possibilities, as well as the implications of each change.
- Most of the equipments are produced by Airbus or Airbus partners and Airbus information is required
- If a new equipment is installed (especially for CIDS, e.g. a new smoke detector), it must be verified that the respective equipment can function inside the system, as part of a whole.
- The complexity of an 'Airbus independent' task (with electrical implications) is rather unpredictable, as unexpected problems may occur during the conversion processing, which otherwise might have been easily solved with Airbus input. A prediction of the duration for the CIB case (or any other) under these circumstances is difficult to make. This would be unacceptable in practice, however ELAN would grow in experience and the duration would decrease in time.

4.4 Design Analysis and Verification

In the WPSS Airbus states how often the status reports should be handled in. The CIB specification required a biweekly report and a weekly technical review, besides the internal ELAN review.

As stated in the previous paragraph, the project leader (PL) is the one responsible for checking the design, in close cooperation with the design engineers. Figure 4.5 shows an example of status report for the CIB project, which is sent to Airbus biweekly. Figure 4.6 shows an internal detailed status, made according to the internal Quality Management.



Status Report CIB0804_A320_Install new SA enhanced cabin, enhanced CIDS and Panasonic D-MPES

Four Corner Sheet

Project start:	10.03.09	**Project Leader:**	K. Michalke	**Status Period:**	CW 16-17	**Status:** A
Project end:	january 2010	**Customer:**	C. Ruder SEUCS	**Trend:**		

Subject Target

scope:

- *CIB0804-10: - E/F - Install new IFE D-MPES and airshow 4200*
- *CIB0804-20: - E/F - Install new enhanced CIDS*
- *CIB0804-30: - E/F - Install new SA enhanced cabin*

changes to scope:

- *Changes after kick-off: Investigation for air-distribution, removal of bonding-strips for cove light panels*
- *PD creation for IFE MPES and Airshow 4200 via CCS 002*
- *Incorporation of Offer no CIB0902-10 Misc. Cabin Items Issue 1 via CCS 001 (under negotiation)*

Project Planning & Status

- *100% of deliverables reached for milestone Z03*
  - *deliverables with missing definition not included, agreed to deliver to next milestone after definition is available*
  - *Long Lead Items for CCS01 delivered*
  - *for CIDS part work results delivered as wire harness investigation lists, PD investigation lists and unit occupation lists*

	Z01	Z02	Z03	Z04	Z05	Z06	Z07	Z08
% planed	5	20	20	20	8	20	5	2
% delivered	5	20	20	0	0	0	0	0

Critical Issues/ Risks/ Impacts + mitigation actions

critical issues	risks	impacts	mitigation action
Missing colour definition for ancillary parts	PNs not delivered in time	Drawings won't be delivered to planned milestone	PNs are ordered by Airbus; Drawings will be delivered after PNs are available

Actions/Next steps

- *delivery of drawing sets and results of investigation to milestone Z04 according to milestone plan*

R	Risk for global schedule Issue to be raised to Management	
A	Important Risk, but agreed recovery plan in place	
G	On Schedule	

Fig. 4.5 Example of a status report for the CIB project delivered to Airbus for the CW 16-17

The status report shown in Figure 4.5 (also called 4 Corner Sheet) can receive three status marks, represented by three colors with a corresponding meaning:

- green – on schedule,
- yellow – important risk but agreed recovery plan in place,
- red – risk for global schedule issue to be raised to management.

The 4 Corner Sheet contains:

- the subject target – the scope or changes to the scope (corner 1),
- the critical issues, risks, impacts and mitigation action (corner 2),
- the project planning and status – the milestone progress and the payment plan (corner 3),
- the actions and next steps (corner 4).

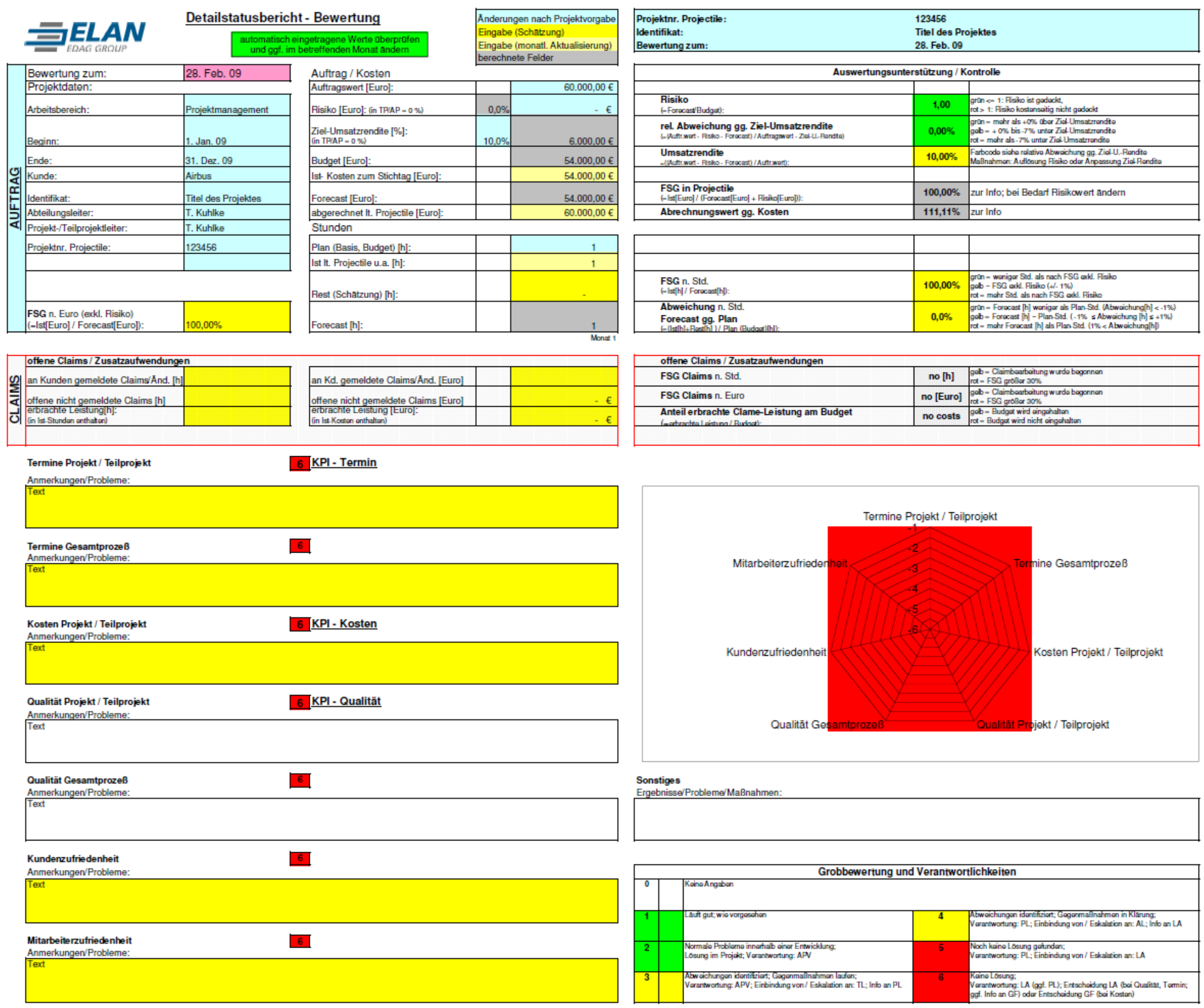


Fig. 4.6 Example of a blank detailed status report (EXCEL template)

Basically, each project – from the quality point of view – respects the following project plan:

- Project Scope
- Deliverables List / Inputs & Outputs
- WBS (Work Breakdown Structure)
- OBS (Organizational Break Down)

- Time Schedule
- Resource Plan
- Changes to Scope / Change Management
- Risk Analysis and Mitigation Plan
- Quality Requirements and Metrics
- Communications Plan
- Status Report
- KPI on deliverables

Figure 4.6 shows the detailed status and the internal project evaluation. This type of evaluation uses the same color code, but with a more detailed ranking (see Table 4.6).

Table 4.6 Evaluation system of the detailed status used by ELAN

Coarse Evaluation and responsibility			
0	No information		
1	Working as planned	**4**	Deviations identified; counter actions under clarification; Responsibility: PL Involvement of / escalation to: AL; Info from LA
2	Normal problems within the development; solving within the responsibility of the APV	**5**	No solution yet found; Responsibility: PL; Involvement of / escalation to: LA
3	Deviations identified; counter actions under progress; Responsibility: APV ; Involvement of / escalation to: TL; Info from the PL	**6**	No solution; Responsibility: LA (if applicable PL); Decision: LA at quality term; if applicable, Info from GF) or decision GF(with respect to costs)

4.5 Handover Phase

Each Z milestone defined in the technical proposal defines the set of deliverables and the corresponding deadline. Responsible for delivering the Drawing Sets on time is always the Project Leader (PL). ELAN uses its own tool, called *Airpax*, for transferring the data package. The sender can choose the Airbus receptor out of a list, as well as the type of data (CCD, Catia V4, V5, etc), the type of aircraft involved. He afterwards selects the data package by dragging it and dropping it into a specific window. The program compresses the data, and sends it to Airbus. In parallel the PL 'signs' for the respective transfer in the TAKSY tool.

Once the transfer is over, ELAN may receive defect reports. The PL takes the responsibility for solving them.

4.6 Summary of the Chapter

Based on the study case of Condor Berlin (CIB), Chapter 3 describes the current ELAN procedure for dealing with cabin conversions, in relation with the Airbus process chain. It also analyses the procedure – separately for mechanical and electrical tasks – when the input information is not available.

The CIB consisted of three parts: 1.) installation of new IFE, 2.) installation of new enhanced CIDS and 3.) installation of new enhanced cabin.

The Airbus view (expressed in Section 4.1.1) shows how the subcontracted work reflects on the entire Airbus process chain. The basic Airbus requirements are written in the WPSS. The ELAN reaction to WPSS (Section 4.1.2) is concretized through the technical proposal (or offer), which defines the project milestone plan.

Paragraph 5.2 describes the work preparation phase, underlines the responsibilities of the project leader and the rest of the personnel and describes and illustrates the current internal procedure.

Further on, each task of the CIB project (separately for mechanical and electrical) is evaluated under the Airbus independency hypothesis, with respect to: 1.) necessary input information, 2.) difficulties encountered, 3.) alternatives to overcome the difficulties, 4.) feasibility of the task (is it achievable or not). Two major conclusions can be extracted:

- Simple upgrade scenarios can be achieved without Airbus input, with the available information from airlines.
- Complete and complex conversions are achievable if ELAN develops new designs itself – the only way to do that is by applying for STC's through DOA.

The internal quality control procedures currently used by ELAN (Section 4.4) are created in accordance with Airbus criteria (expressed in documents like GREDS). However these criteria are also the criteria of EASA or EN 9100.

5 Virtual Case Study: B737 Cabin Conversion

This chapter treats a virtual conversion scenario for a Boeing 737. It is intended to identify the proper source of information to be used in practice when not all the information from the aircraft manufacturer is available.

5.1 Description of the Virtual Conversion

The conversion scenario consists of the removal of the first 5 seat rows, each with 6 seats abreast of a one class Boeing aircraft and installation of 3 business class seats rows, each with 4 seats abreast. This involves the following changes of the cabin items:

- Installation of:
  - 12 Business class seats,
  - 1 Class divider,
  - 1 Curtains,
  - Seat to seat cabling,
  - IFE,
  - 4 Monitors,
- Adaptation of:
  - emergency floor path marking
  - seat placards,
  - carpet,
  - seat track cover,
  - hatracks,
  - PSU

This conversion scenario is rather simple. More complex scenarios involve tasks like installation of a monument, or modification of the lining. The tasks required by this case study are enumerated below:

- Removal of 5 rows of economy class seats
- Installation of 3 rows of business class, 4 seats abreast
- Installation of a class divider that incorporates 4 monitors
- Installation of monitors on the class divider
- Installation of curtain rails between the B/C and Y/C, attached to the overhead bins
- Installation of curtain and curtain fasteners

- Installation of new seat track covers
- Installation of new seat placards
- Installation of new EFPM
- Installation of new carpet
- Adaptation of the overhead bins
- Adaptation of seat-to-seat cabling
- Adaptation of IFE system into one available overhead bin
- Adaptation of the PSU

Figure 5.1 shows the before and after modification layout.

5.2 Necessary and Available Engineering Input Information

For each required task, the necessary input information needs to be identified and made available. Table 5.1 summarizes the required input information for performing the tasks and the corresponding sources for obtaining it.

Two additional sources of information which deserve to be mentioned, especially when considering aircraft types, other than Airbus are:

1.) **Other design and production organizations** which have already the capability to provide the missing pieces of information. Such a company is **HeathTecna**, located in the USA. It provides the engineering, certification, installation and manufacturing for overhead bins, bin extensions, partitions, panels and linings, lavatories, galleys, IFE modules, closets and stowages, bars and serveries. Similar companies can be found especially in the USA, which host almost 65% of the completion centers (**Heath 2010**).

2.) **New technologies and trends in cabin design**. Some examples are (**Reuter 2010**):
   - Integrated power management
   - Contactless seat power
   - Low and no power signs and displays
   - Power over Ethernet (LAN networking)
   - Movable PSU (through rails)

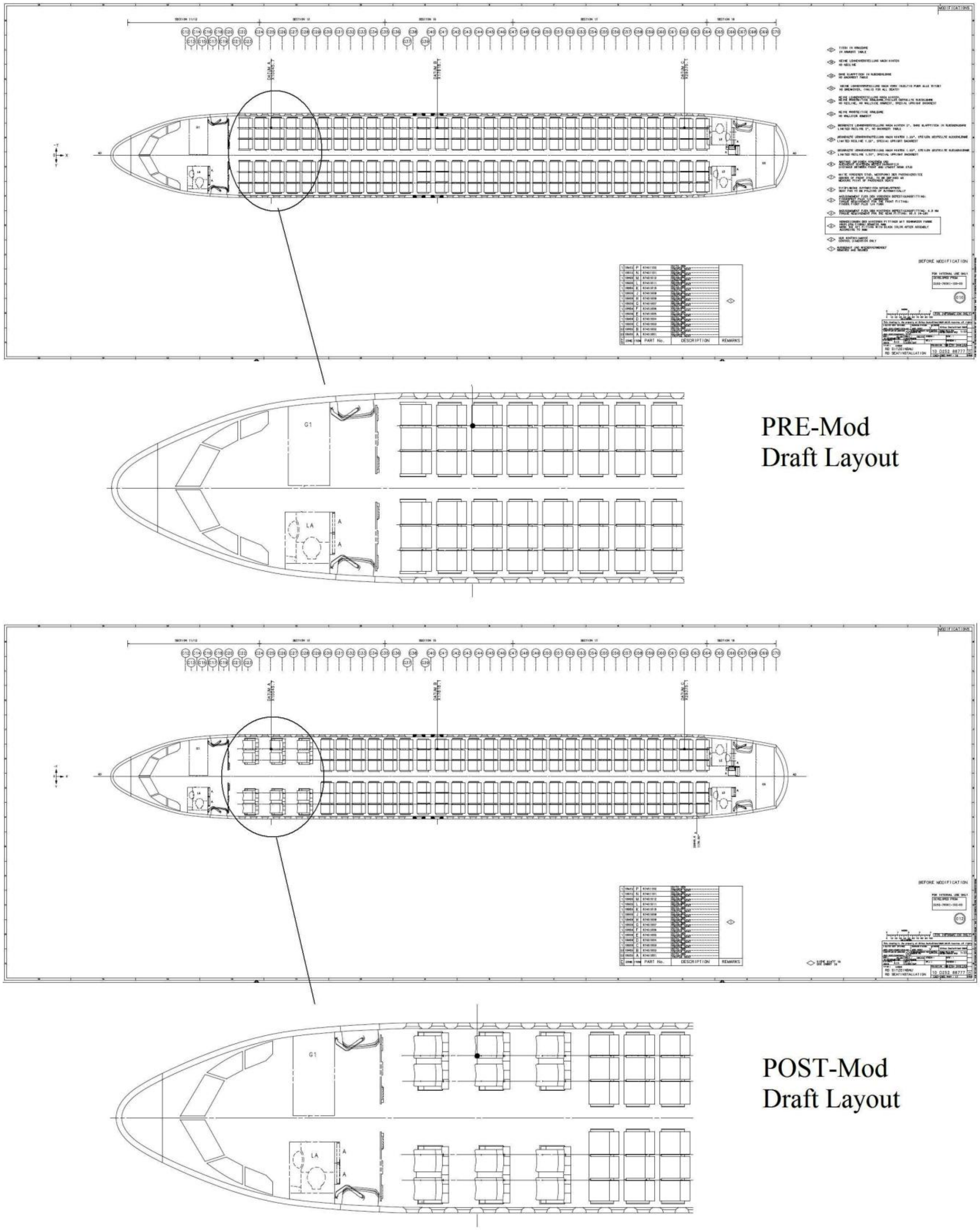


Fig. 5.1 Before and after modification layout for the conversion study case of Boeing 737 (shown here - for reasons of generating results quickly - with an Airbus A320 contour)

Table 5.1 Input information required and sources for obtaining it

Item	Information required	Source of information	Information from aircraft manual / ATA chapter	Source of material and observations
Observations	General information required: • fuselage inner dimensions • position of the monuments • position of the seat and seat rails → the current cabin layout with dimensions	Main source of information considered: Aircraft inspection	Informative drawings, useful before the aircraft inspection can be found in the flight manuals.	This column provides information about different parts manufacturers.
B/C seats	Seat drawings and dimensions Seat description (e.g. monitors included or not) Seat rail location and type Monuments layout	Seat manufacturer Aircraft inspection	–	**Recaro** BC seats include video, audio RJ45 and PC Power installation. Additionally they may include electronically operated backrest, leg-rest, leg-rest extension and manual footpad. http://www.recaro-as.com/
Seat rail	Seat rail location Seat rail type	Aircraft inspection Aircraft manual	SRM ATA 53-30-52 Provides the part drawings with main dimensions	Manufacturing: Boeing Other manufacturers: **Interturbine Aviation Logistics GmbH** produces semi-finished seat tracks according to SRM URL:http://www.itlogistics.de/wDeutsch/itt/Semi_Finished_Seat_Tracks.php
Seat track cover	Seat layout Seat rail location	Seat track cover manufacturer Seat manufacturer	–	**ALLWEST Plastics** has the tooling and engineering drawings to produce over 700 different aircraft parts made to the specs of Boeing, Douglas, DeHavilland, Bombardier, and others. URL: http://www.allwestplastics.com/
Class	Dimensions and layout	Class divider	–	**Sell GmbH**

divider	Components to be integrated (monitors) Mounting possibilities	manufacturer		Produces class dividers and partitions suitable for the integration of other cabin interior components such as LCD monitors, baby bassinets, folding tables, literature pockets, timetable holders, etc. and can also be delivered with doghouses and/or bustles. URL: http://www.sell-interiors.com/airbus-boeing-interiors/class-dividers-partitions.html
Curtain	Mounting - on curtain rails Curtain fastener Hatrack layout (distance between hatracks, respectively hatrack fasteners	Aircraft inspection Aircraft manual	AIPC ATA 25-24-50	**Group Aertec** Lieu dit La Sucrerie, RN 17 95380 VILLERON, France Tel: +33 1 34 47 15 00 Fax: +33 1 34 47 15 80 URL: www.groupe-aertec.com
Curtain rail	Mounting possibilities (on hatracks → hatrack layout)	Aircraft inspection Aircraft manual	AIPC ATA 25-24-50	**Group Aertec** provides curtain rails as well, including electrical curtain rails.
Seat to seat cabling	Connection possibilities, required power, if there is a MCU (Master Control Unit) which controls the power	Aircraft Inspection Aircraft manual Seat manufacturer	AIPC ATA 25-27-31 Describes the cable and raceway	Manufacturing: Boeing A deeper aircraft insight is required. Technology trends: contactless seat power **(Reuter 2010)**
IFE	Available position Hatracks layout Connection possibilities Connection with the cabin communication system or flight attendant panels	Aircraft inspection IFE manufacturer (chosen by airline)	–	**Panasonic Avionics Corporation** URL: http://www.mascorp.com/Products/Products.aspx **Heath Tecna** – besides IFE head units, it can provide VCC or Direct View System capture device URL: http://www.heath-eu.com/
Monitor	Connection possibilities Mounting information and mounting possibilities (ref. to class divider manufacturer)	Aircraft inspection Monitor manufacturer (chosen by airline) Class divider manufacturer	–	The class divider manufacturer, the IFE manufacturer and the monitor manufacturer must cooperate in order for the installation requirements to be fulfilled. A decisive role is played by the customer airline, which in the end chooses the providers. Generally the IFE manufacturers provide monitors as well.
Emergency	Information about the	Airline / aircraft	AIPC	**Lufthansa Technik**

floor path marking	current system (electrical or photo luminescent)	inspection EFPM manufacturer Aircraft manual	ATA 33-51-05 for electrical emergency lights ATA 25-27-15-23H for photo-luminescent emergency lights For electrical path marking AIPC gives reference to the WDM	Provides a non-electric, unlimited life-time, certified marking system consisting of photo-luminescent material. URL: http://www.lufthansa-technik.com/applications/portal/lhtportal/lhtportal.portal?_nfpb=true&_page Label=Template5_6&requestednode=248&webcacheURL=WG/Services---Offers/Component-Services/_1Products---Services/80-Guideline/guideline.xml
Seat placards	–	Airline requirements aircraft inspection Placards manufacturer	AIPC ATA 11-32-04	**Biggles Labelling Limited** Harlow Business Park Essex, CM19 5QF United Kingdom Tel: +44 1279 432800 Fax: +44 1279 432802 control@biggleslabelling.co.uk URL: www.biggleslabelling.co.uk **Aero Decals** 1914 Canova Street S.E Palm Bay, FL. 32909 Telephone: (321) 768-2114 Fax: (321) 768-1783 aerodecal@aol.com URL: www.aerodecals.com **Aircraft Engarvers** 151 north Granby Road Granby, CT 06035 USA URL: www.engravers.net/ **Avion Graphics** 27192 Burbank Foothill Ranch, CA 92610 Phone: (949) 472-0438 Fax: (949) 768-3794

				URL: http://aviongraphics.com/ pete@aviongraphics.com
Carpet	Dimensions and type of current carpet Seat dimensions Seat rail position	Aircraft inspection Airline reuirements Seat manufacturer	AIPC ATA 25-27-15	**Ser-Mat-Corp** 3104 S. Andrews Ave Ft Lauderdale, FL 33316 Phone: 800-783-3104 Fax: 954-525-1410 mmmoran@sermatcorp.com URL: http://www.sermatcorp.com/ supr.htm **Marion Aircraft** 20312 Hermana Circle Lake Forest CA 92630, USA Tel: +1 949 837 1006 Tel: +1 800 321 1041 Fax: +1 949 837 2222 URL: www.marionaircraft.com
Overhead bin	Position Dimensions Content – ER layout	Aircraft inspection Hatrack and Hatrack components manufacturer	–	**Heath Tecna** URL: http://www.heath-eu.com/ **FACC AG** (preferred supplier for Boeing in 1997) URL:http://www.facc.at/en/interiors/index.asp?dat=commercial_aircraft_products
PSU	Seat layout Information about all PSU devices. PSU of B737 contains all the devices (reading lights, gasper air outlet, speaker, O2 masks) in one box. There is one speaker for each second row.	Aircraft Inspection PSU manufacturer	AIPC ATA 25-23-61	**FACC AG** URL:http://www.facc.at/en/interiors/index.asp?dat=passenger_service_units

5.3 Discussion of the Virtual Case Study

It was assumed that the minimum available source of information is the aircraft available for inspection. Most of the difficulties (such as seat-to-seat cabling) can be overcome by having access to the aircraft.

The second valuable source of information is represented by different parts manufacturers, such as seat manufacturer or class dividers manufacturers.

Additional information can be extracted from the aircraft manuals. Useful drawings are gathered in the AIPC, such as wire bundles or raceways (of the seat-to-seat cabling). An example of an interesting case is the PSU. Unlike Airbus aircraft, the Boeing aircraft have included all the devices in a single unit: Oxygen supply, 4 Oxygen masks, one speaker for each second row, 3 air outlets, 3 reading lights, ‘fasten seat belts’ and ‘no smoking’ signs, along with the adjustable fill in panels (see Figure 5.2). Another important information provided by this manual is the part list for each assembly. However, a familiarization with the Boeing conventions (e.g. numbering system) is previously required.

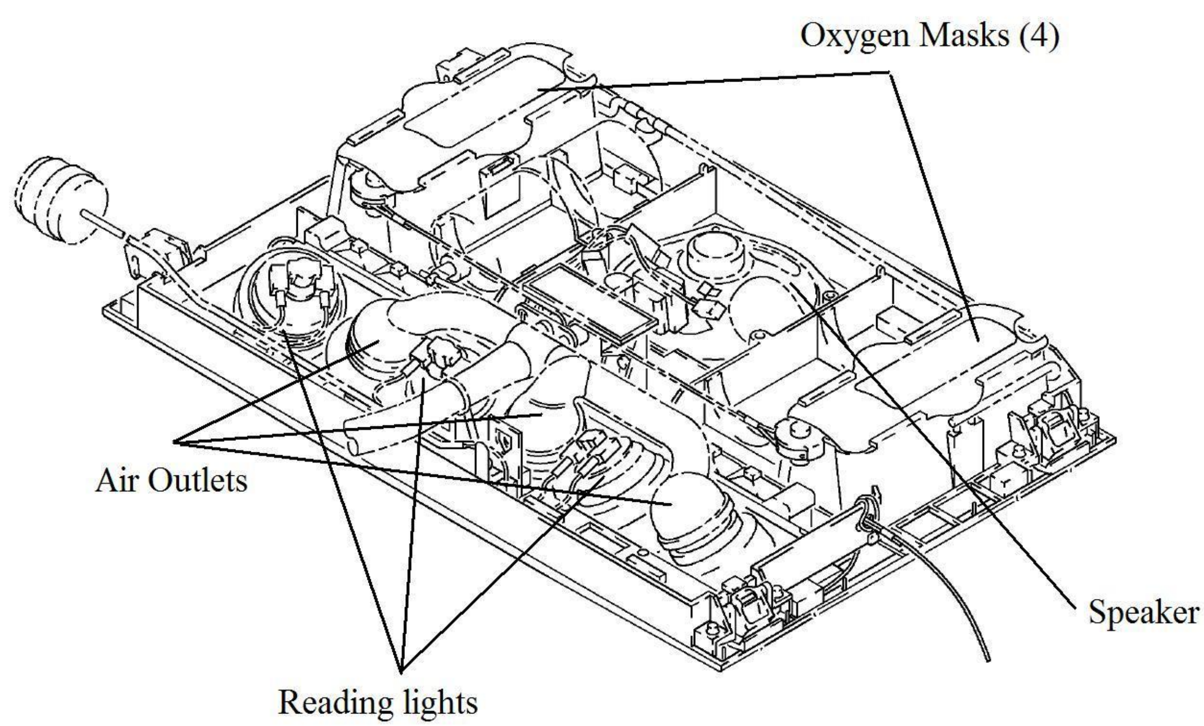


Fig. 5.2 Passenger Service Unit (PSU) for B737 600/700/800/900 (**AIPC Boeing 2007**)

Certain parts are classified after ATA different than Airbus. The ATA standards provide the general frame, but when it comes to details, the aircraft manufacturer has a certain degree of flexibility.

However, small cabin conversions can be conducted with the current resources. Due to the fact that the study case is a virtual one, duration estimations are not possible.

Currently ELAN is pursuing the cooperation with other design organizations, such as V-Plane. Another useful direction is to seek the agreement with airlines. Airlines can name and provide with better accuracy the sources of information at their disposal. The win-win situation can be the following: airlines get cheaper conversions in exchange of information (documents, drawings and available aircraft); ELAN gains experience and know how, outside the box called Airbus, in exchange of lower prices.

A better cooperation with the aircraft operators leads to a better understanding of their needs. Market fluctuations become predictable and surprise situations are avoided. All these factors, combined with the right personnel – trend oriented and well prepared, can ensure the successful delivery of size increasing independent conversions.

To summarize, the current alternatives for increasing the know-how are:

- Seeking collaborative partners among airlines, suppliers or design and production organizations
- Getting access to aircraft destined to be removed from service, recycled or deposited, by contacting aircraft disposal companies.
- Hiring experts or former employees of design organizations/engineering offices that dealt with conversions of other aircraft types than Airbus.

After investigating this scenario, it can be concluded that the current internal procedure of ELAN together with the current resources, illustrated in Chapters 4 and 5, is suitable for non-Airbus customers as long as the requirements fall under what can be classified as simple refurbishing/upgrade request.

5.4 Summary of the Chapter

This chapter dealt with the analysis of a conversion case study for Boeing 737. The challenge consisted of gathering all the required input information. The hypothesis was considered that the aircraft is available for inspection. For this simple scenario, most of the difficulties encountered, can be solved by having access to the aircraft. Additional data can be obtained from the part manufacturers and aircraft manuals. It is concluded that simple scenarios, which do not require detailed information about un-measurable parts, can be conducted after the current internal procedure.

The chapter also proposes applicable solutions to overcome the lack of information and know how.

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Appendix A

The Design Structure Matrix for the Process Chain for Cabin Conversion

Below two matrices are presented:

1.) The original DSM showing the relations between the processes expressed through the values 1 or 0.
2.) The partitioned DSM resulted after running the portioning algorithm on the original matrix.

Name	
Receive request	1
Assign Offer Leader*	2
Analyze request	3
Contact customer and set first meeting	4
On the first meeting: initiate discussions and negotiations	5
Write CRTS (Customer Request Technical Sheet) in which:	6
Preliminary describe the technical implications (based on first meeting)	7
Make estimations (based on experience) regarding design effort, time, costs(based on first meeting)	8
Conceive preliminary solutions (for discussing it with the customer)(based on first meeting)	9
Create preliminary representation of the solutions found (with tools which fit the (based on first meeting)	10
Make feasibility studies(based on first meeting)	11
Analyse estimated results(based on first meeting)	12
Identify required resources (based on first meeting)	13
Estimate profit (based on first meeting)	14
Decide if go ahead: if yes, then:	15
Get signed agreement within a second meeting	16
Write DTS (Detailed Technical Sheet)	17
Estimate the size of the work package	18
Identify involved technical fields	19
Identify certification basis	20
Identify certification implications	21
Set preliminary certification requirements	22
Identify resources for performing the work	23
Make estimations regarding design effort, time, costs	24
Identify suitable project leader and personnel	25
Confront DTS with CR	26
Make adjustments	27
Send results further down (concept) in order for the work to be initiated	28
Analyze customer requirements (conception team)	29
Perform aircraft inspection	30
Write document describing diagnosis	31
Identify the technical fields involved in the design process*	32
Initiate team organization for- and division of responsibilities between	33
Engineering Avionics & Equipment	34
Certification (OoA) Avionics & Equipment	35
Quality Assurance Avionics & Equipment	36
Engineering Environmental Systems	37
Certification (OoA) Environmental Systems	38
Quality Assurance Environmental Systems	39
Engineering Electrical Systems	40
Certification (OoA) Electrical Systems	41
Quality Assurance Electrical Systems	42
Engineering Cabin Interior	43
Certification (OoA) Cabin Interior	44
Quality Assurance Cabin Interior	45
Engineering Monuments and other Equipment	46
Certification (OoA) Monuments and other Equipment	47
Quality Assurance Monuments and other Equipment	48
Engineering Emergency & Safety Equipment	49
Certification (OoA) Emergency & Safety Equipment	50
Quality Assurance Emergency & Safety Equipment	51
Plan the design & engineering process (by the Engineering and Design Office)	52
Assign teams for each technical field	53
Assign tools to work with	54
Choose QM strategy (! Before defining processes)	55
Concieve the process (what) chain of the work flow	56
Conceive the procedures (how) to be followed	57
Make optimization studies	58
Plan the certification process (by Office of Airworthiness)	59
Contact EASA and TC Holder	60
Identify certification basis*	61
Analyze certification requirements	62
Transform Certification Requirements into technical rules	63
Identify means of testing and showing of compliance (MOC's)	64
Set classification procedures for minor and major chnages according to EASA	65
Send application for STC to EASA	66
Send application for major changes to EASA	67
Identify responsible persons for approving minor changes	68
Identify responsible persons for creating the documentation to be sent to EASA	69
Verify the consistency of the certification basis	70
Identify required resources and tools	71
Decide if it's necessary to involve subcontractors	72
Conceive preliminary models	73
Consult/report to customer	74
Verify the fulfilling of customer requirements	75
Validate concept (regarding all aspects: work flow, work procedures, design…)	76
Define the QM strategy and follow it when detailing the processes	77
Organize work flow (who & what does)/Create Work Breakdown Structure	78
Define tasks	79
Identify types of documents and document flow to be produced by Design Engineers:Engineering Orders	80
Identify types of documents and document flow to be produced by Airworthiness Engineers:Documents	81
Identify parallel processes and prescribe the parallel process performing	82
Schedule work	83
Define work procedures (how to do it) for Certification	84
Define work procedures (how to do it) for Monitoring	85
Define work procedures (how to do it) for Design	86
Define work procedures (how to do it) for Quality Assurance	87
Define work procedures (how to do it) for Relation with subcontractors	88
Define the design concept	89
Perform design studies for each technical field	90
Identify interferences between technical fields	91
Identify possible conflicts between technical fields	92
Identify the feasible choice	93
Validate design concept	94
Prepare Certification	95
Define Test and Verification Methods, according to the MOC's and specific	96
Create compliance check lists	97
Recieve and understand design assignments from responsible person (Chief of Design)	98
Analyze and understand constraints specific to the design: Certification constraints	99
Analyze and understand constraints specific to the design: Customer constraints	##
Optimize tool selection (already indicated in concept phase, but also in definition phase)	##
Perform design, including:	##
Perfom simulations	##
Perform 2D and 3D respresentations	##
Perform design analysis and verification (Design Verification Engineer-DVE)	##
Analyze the electrical and mechanical loads	##
Analyze interference with structure	##
Define tolerances	##
Perfom assembly analysis	##
Identify clashes	##
In case of clashes, propose feaseble solutions	##
Choose and apply final solution	##
Perform design analysis and verification (Compliance Verification Engineer-CVE)	##
Confrunt results of the DVE with the prescriptions from MOC's	##
Report uncompliance back to the DVE	##
Choose and apply final solution (after receiving feedback from CVE)	##
Produce part lists	##
Produce coresponding documentation (as described in the definition phase)	##
Send documentation to get approval (to the OoA)	##
Receive documentation to be approved (by OoA)	##
Perform test and compliance verification procedures according to MOC	##
Create coresponding approval reports	##
Send coresponding documentation (e.g. test results) to EASA (for major chnages)	##
Approve minor changes under the DO priveleges	##
Receive STC	##
Recieve approval for major chnages	##
Prepare instructions for Continued Airworthiness	##
Collect technical documentation and approval documents	##
Collect assembly instructions	##
Prepare the documentation in the form required by the customer	##
Deliver results	##
Asign assistance team available upon customer request	##
Register Lessons Learned	##
Archive all data	##
Perform final cost evaluation	##
Get functioning feedback from every engineering department	##
Analyze overall functioning of the DO	##
Detect points of improvement	##
Propose optimized solutions	##
Create functioning reoprts	##
Send reports to management	##
Receive feedback from management	##
Prepare updated procedures, as it is required, after reciveing instructions	##

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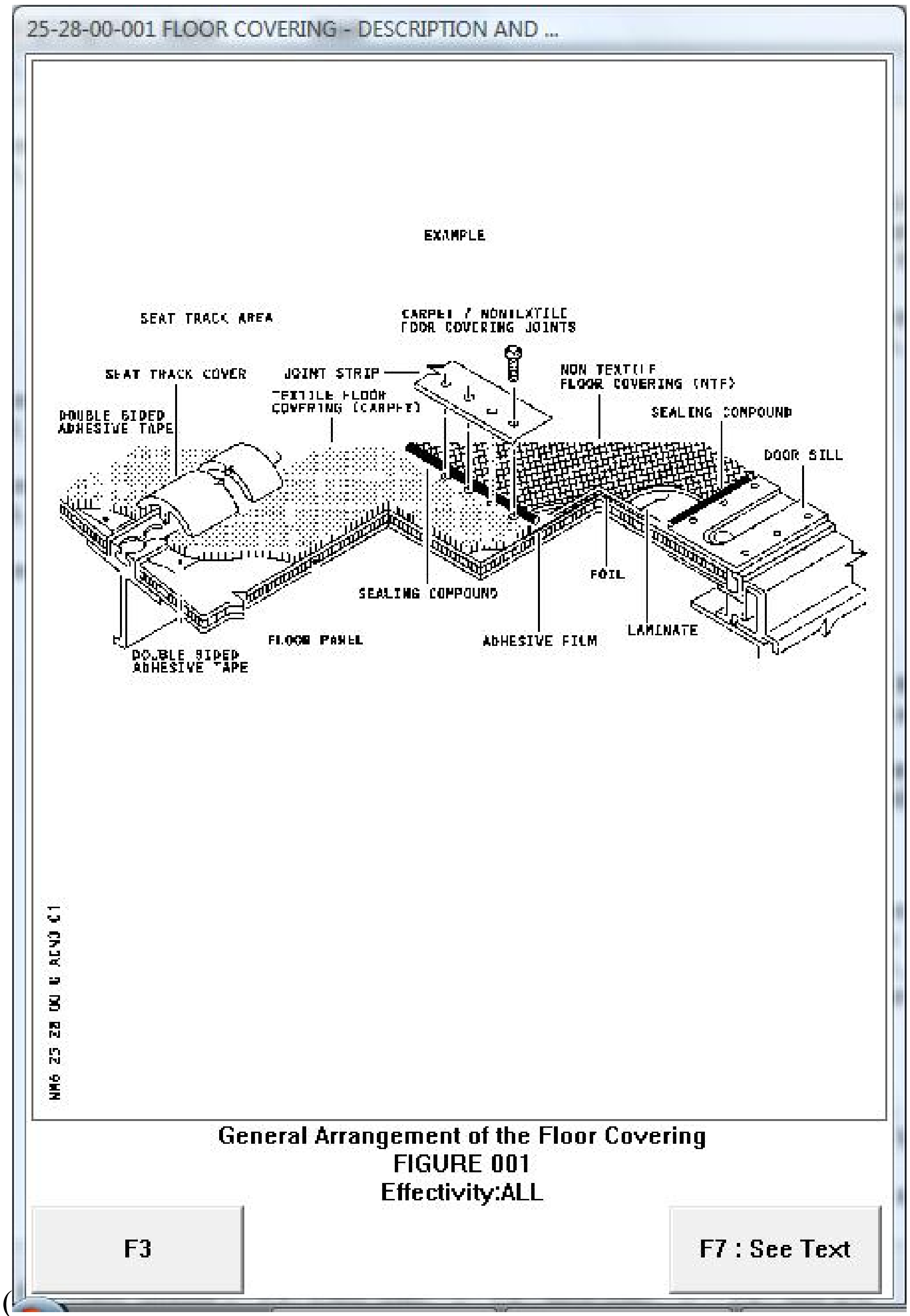
Define tasks	79
Identify types of documents and documen	80
Identify types of documents and documen	81
Identify parallel processes and prescribe	82
Schedule work	83
Define work procedures (how to do it) for	84
Define work procedures (how to do it) for	86
Define work procedures (how to do it) for	87
Define work procedures (how to do it) for	88
Define the design concept	89
Perform design studies for each technical	90
Identify interferences between technical fi	91
Identify possible conflicts between technic	92
Identify the feasible choice	93
Validate design concept	94
Prepare Certification	95
Define work procedures (how to do it) for	85
Define Test and Verification Methods, acc	96
Recieve and understand design assignm	98
Create compliance check lists	97
Analyze and understand constraints spec	99
Analyze and understand constraints spec	100
Optimize tool selection (already indicated	101
Perform design, including:	102
Perfom simulations	103
Perform 2D and 3D respresentations	104
Analyze the electrical and mechanical loa	106
Analyze interference with structure	107
Report uncompliance back to the DVE	115
Define tolerances	108
Perfom assembly analysis	109
Identify clashes	110
In case of clashes, propose feaseble solu	111
Choose and apply final solution	112
Perform design analysis and verification (	105
Confrunt results of the DVE with the pres	114
Perform design analysis and verification (	113
Choose and apply final solution (after rec	116
Produce part lists	117
Produce coresponding documentation (as	118
Send documentation to get approval (to th	119
Receive documentation to be approved (b	120
Perform test and compliance verification	121
Create coresponding approval reports	122
Send coresponding documentation (e.g. t	123
Approve minor changes under the DO pri	124
Receive STC	125
Recieve approval for major chnages	126
Prepare instructions for Continued Airwor	127
Collect technical documentation and appr	128
Collect assembly instructions	129
Prepare the documentation in the form re	130
Deliver results	131
Asign assistance team available upon cus	132
Register Lessons Learned	133
Archive all data	134
Perform final cost evaluation	135
Get functioning feedback from every engi	136
Analyze overall functioning of the DO	137
Detect points of improvement	138
Propose optimized solutions	139
Create functioning reoprts	140
Send reports to management	141
Receive feedback from management	142
Prepare updated procedures, as it is requ	143

Appendix B

Aircraft Manuals Extracts

B.1 Aircraft Maintenance Manual (AMM)



(

Fig. B.1 Example drawing for ATA 25-28-00-001 extracted from **AMM Airbus 1999**

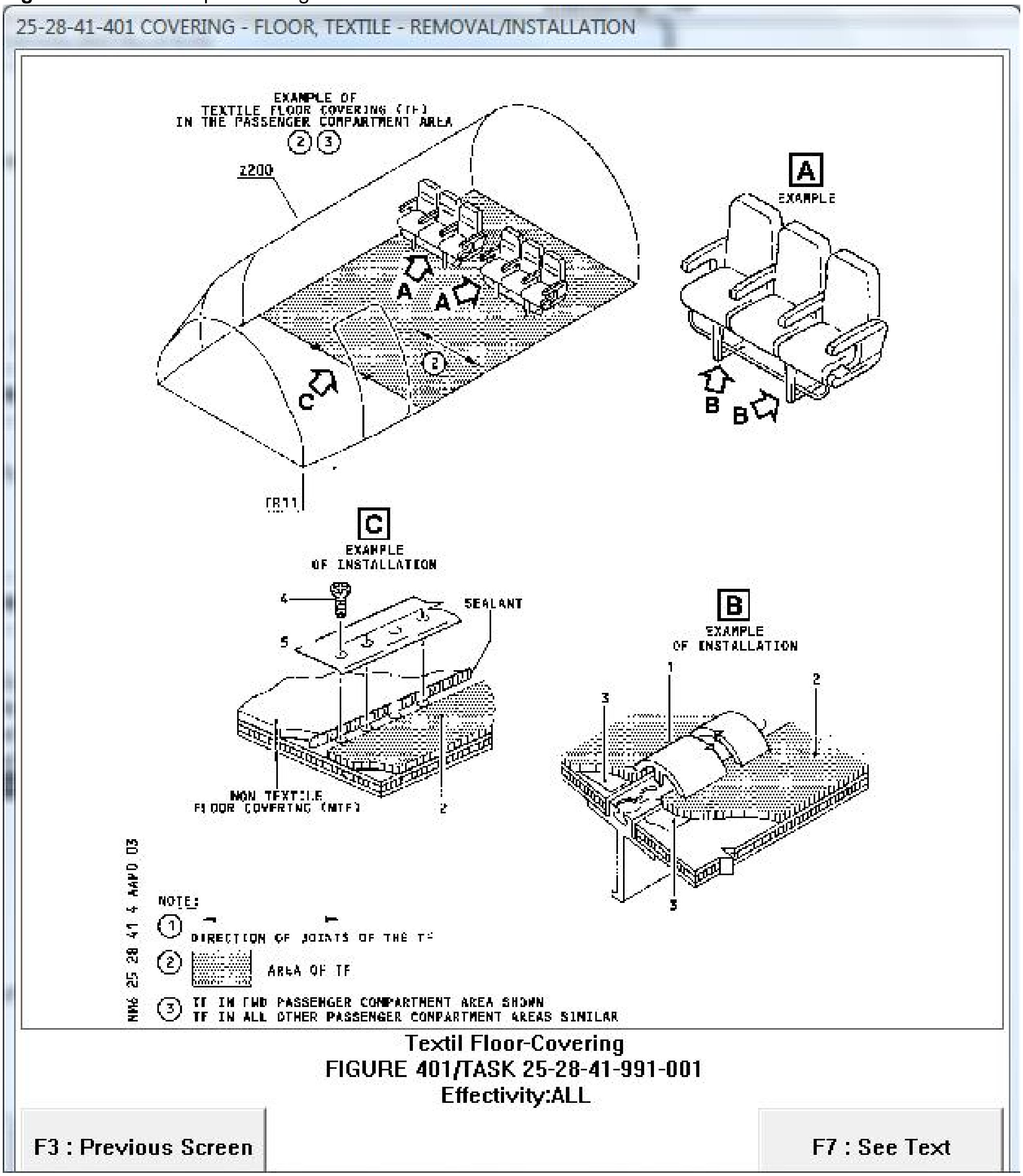


Fig. B.2 Example drawing for ATA 25-28-41-401extracted from **AMM Airbus 1999**

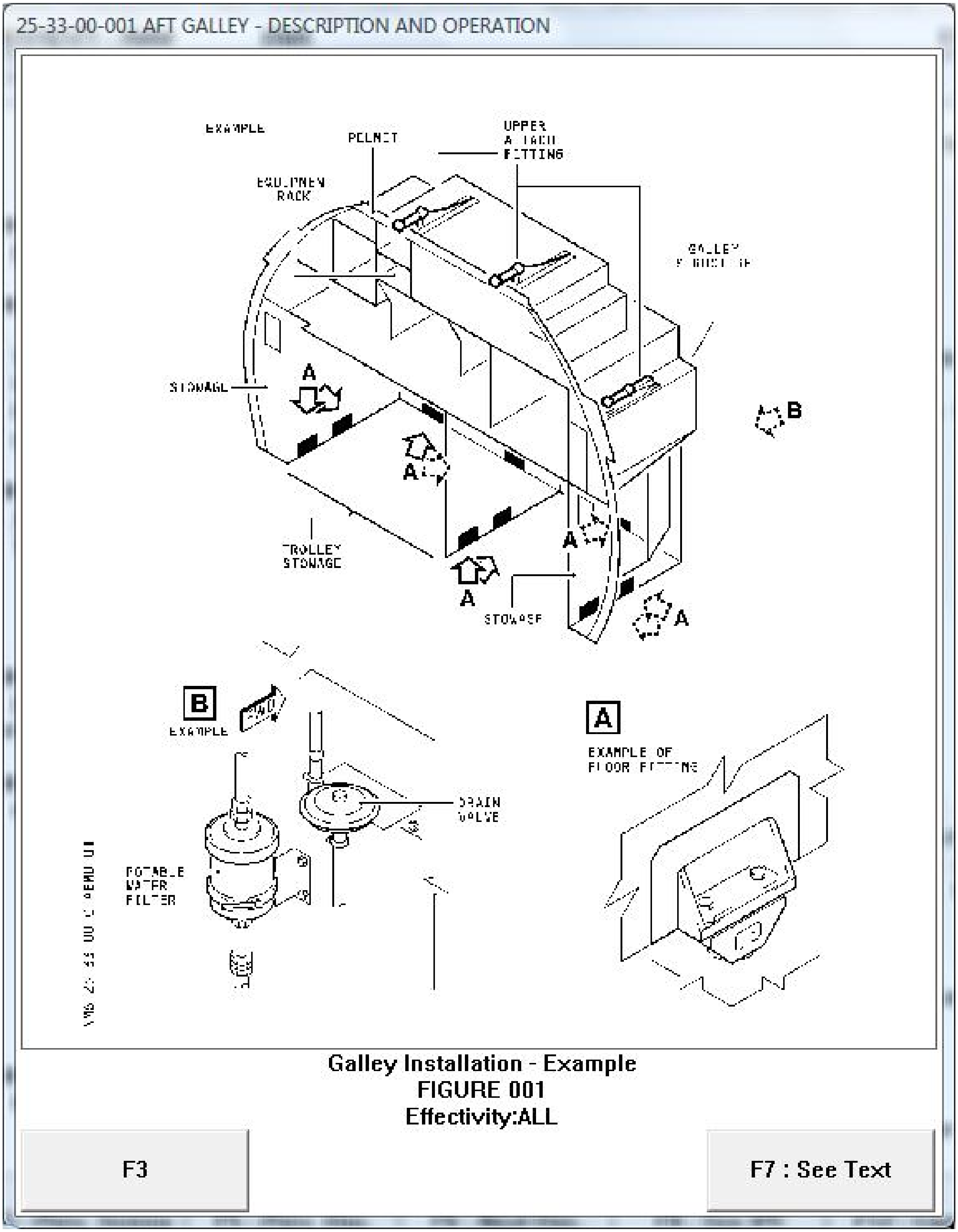


Fig. B.3 Example drawing for ATA 23-33-00-001 extracted from **AMM Airbus 1999**

B.2 Illustrated Parts Catalogue (IPC)

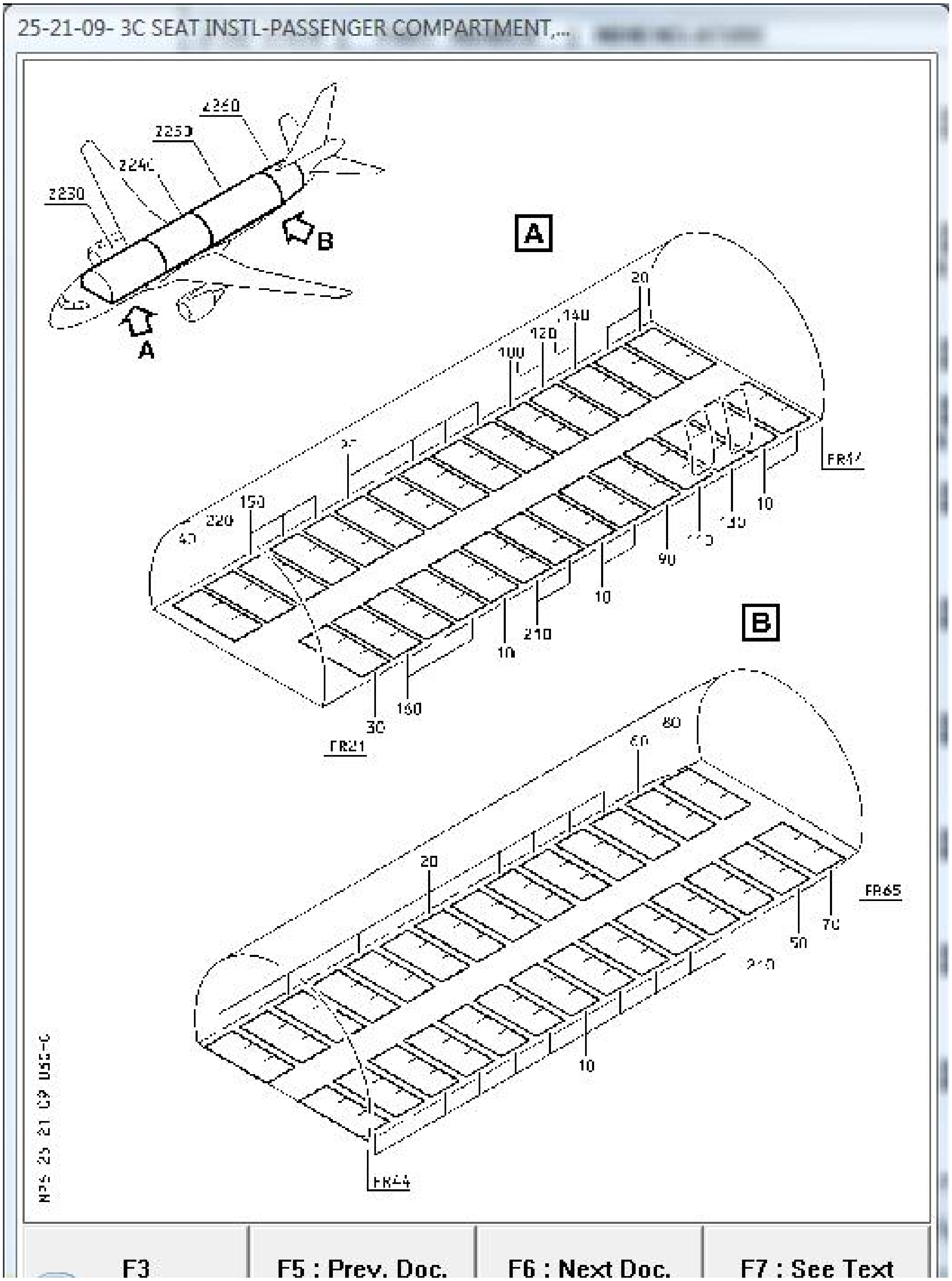


Fig. B.4 Example drawing for ATA 25-21-09-3C extracted from **AIPC Airbus 1999**

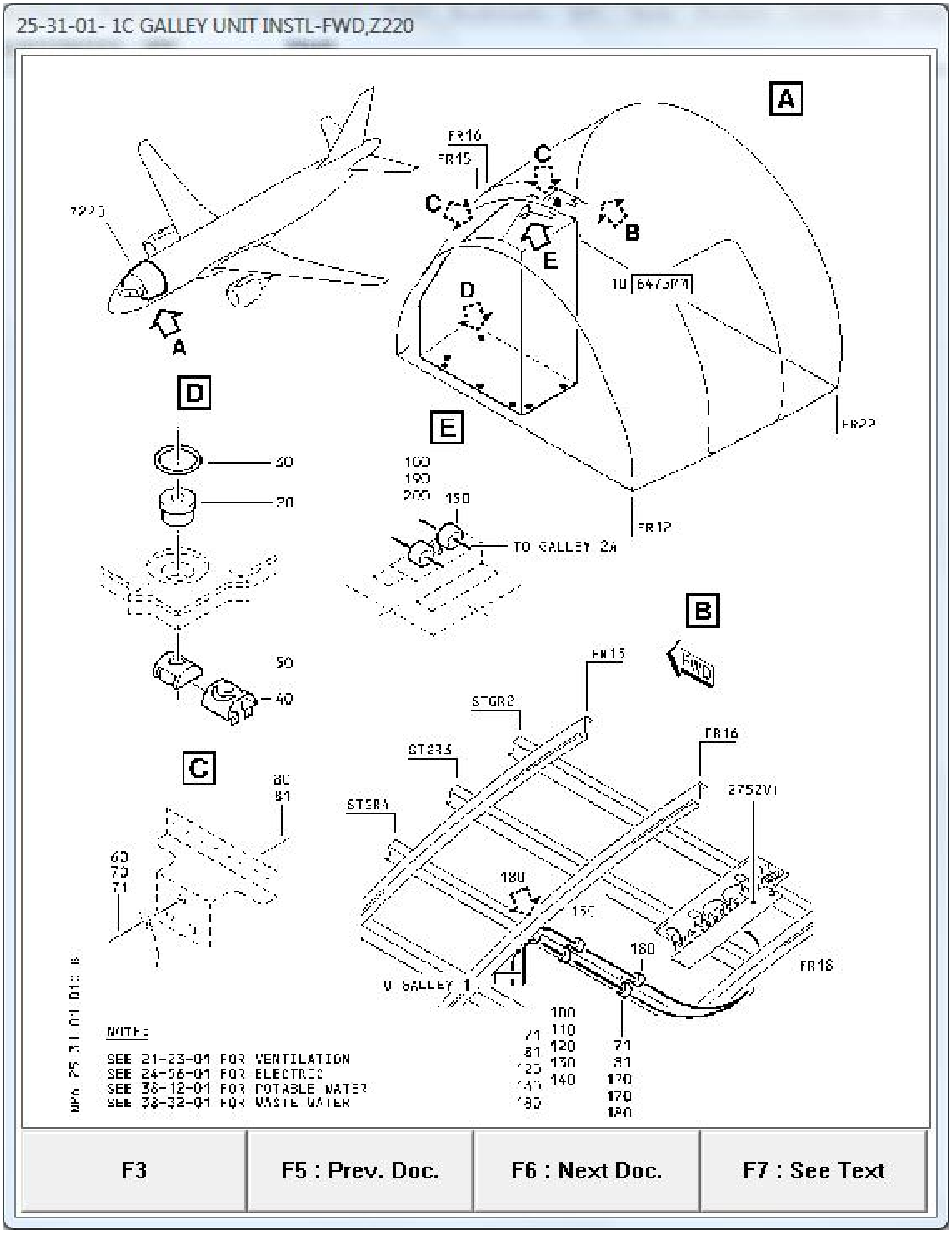


Fig. B.5 Example drawing for ATA 25-31-01-1C extracted from **AIPC Airbus 1999**

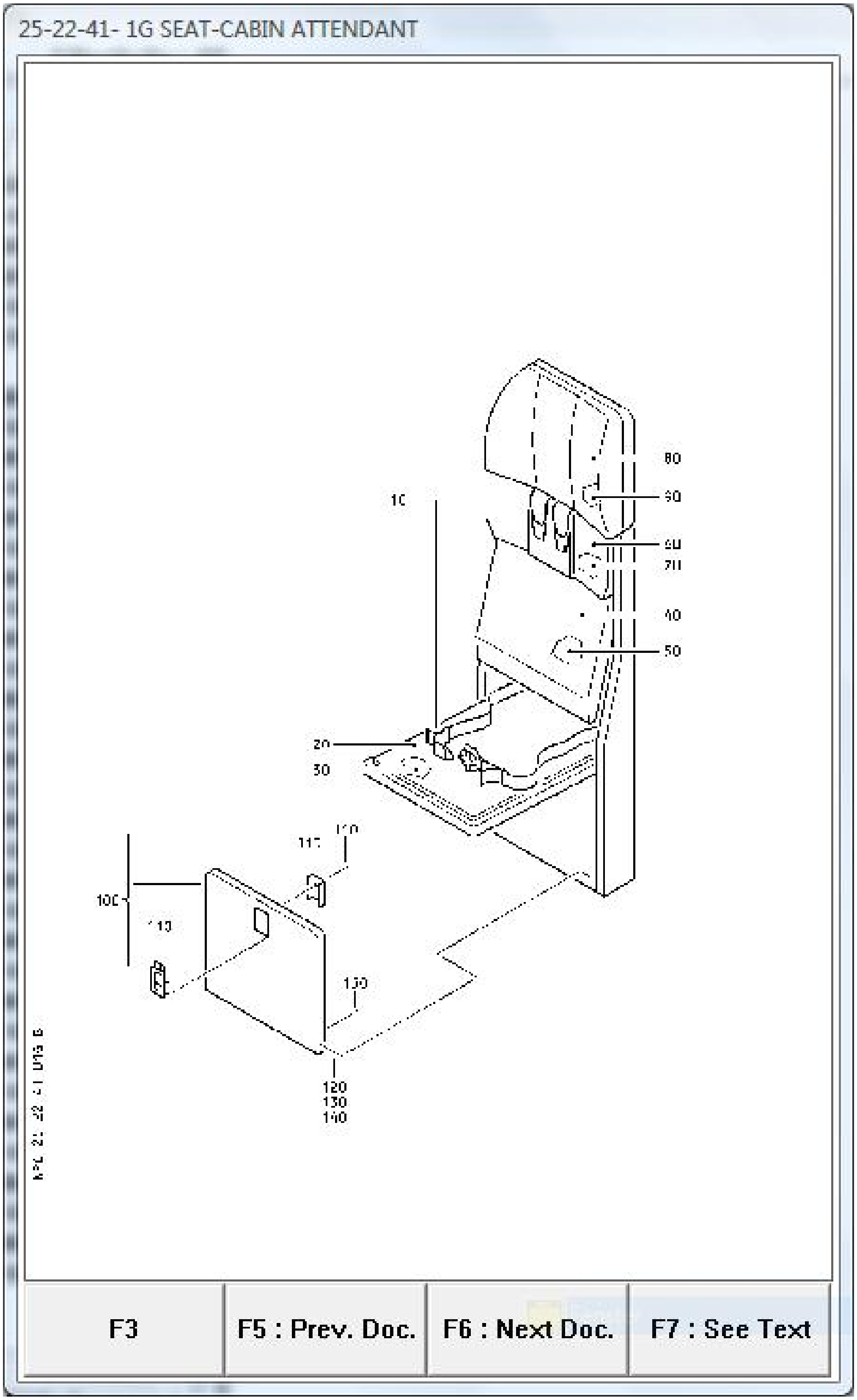
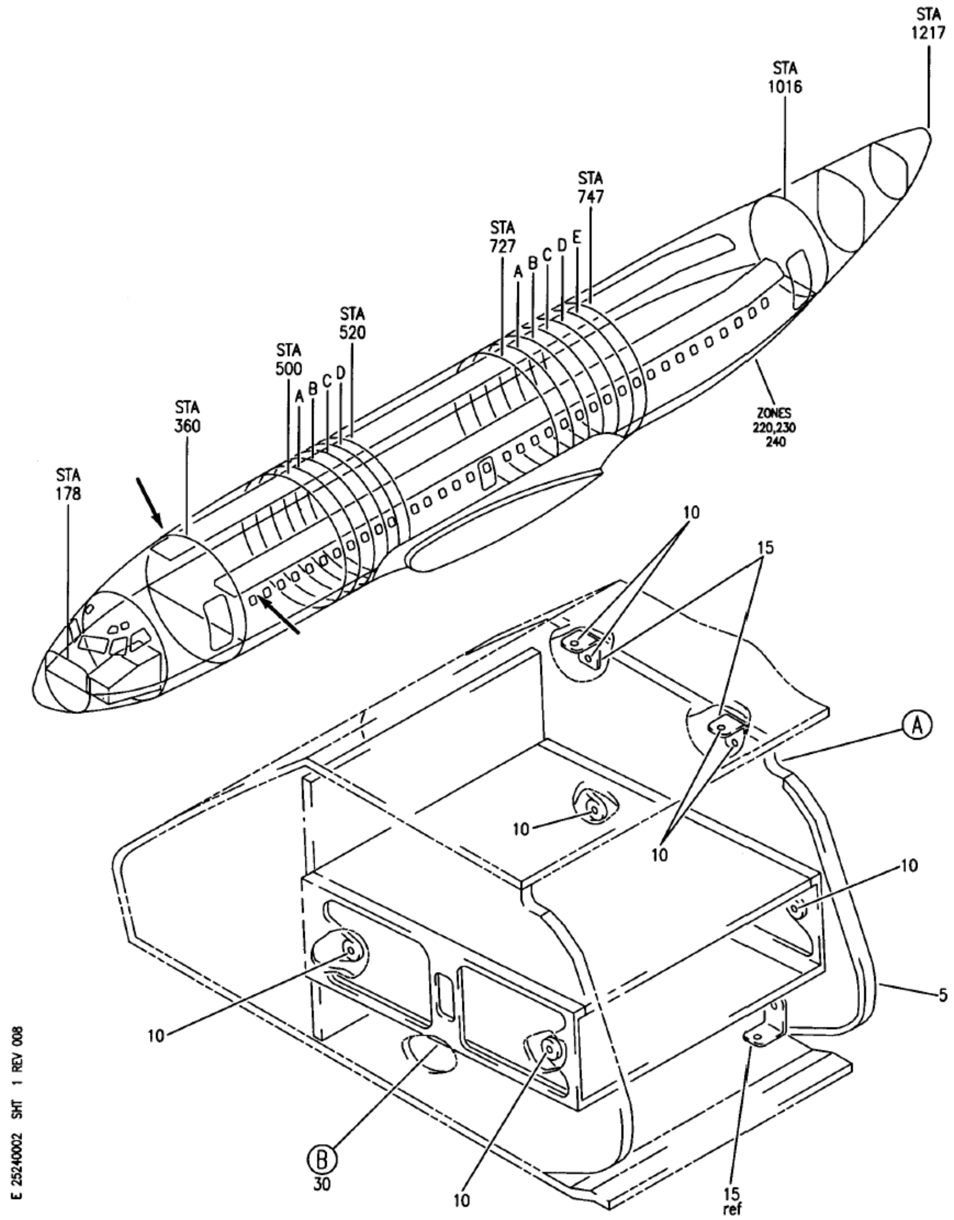


Fig. B.6 Example drawing for ATA 25-22-41-1G extracted from **AIPC Airbus 1999**

BOEING
737-600/700/800/900
PARTS CATALOG (MAINTENANCE)



RACK ASSY-OVHD STOWAGE COMPT MAGAZINE
FIGURE 2 (SHEET 1)

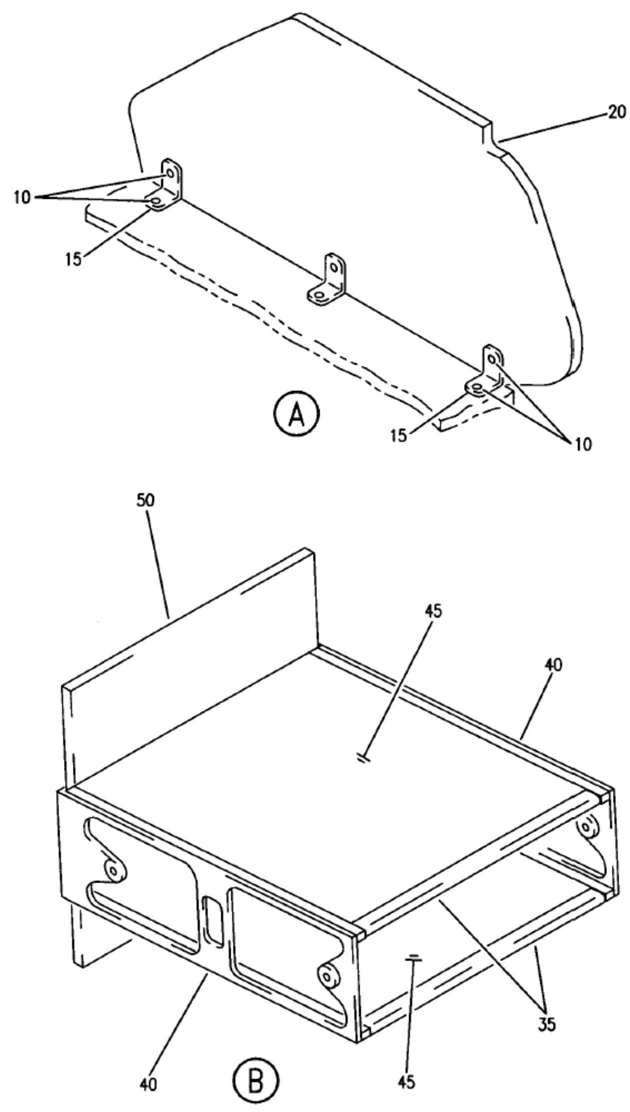
TCI
OCT 10/06

25-24-00-02

25-24-00-02
PAGE 0

Fig. B.7 Example drawing for ATA 25-24-00-02 extracted from **AIPC Boeing 2007 –** page 0

BOEING
737-600/700/800/900
PARTS CATALOG (MAINTENANCE)



E 25240002 SHT 2 REV 008

RACK ASSY-OVHD STOWAGE COMPT MAGAZINE
FIGURE 2 (SHEET 2)

TCI
OCT 10/06

25-24-00-02

25-24-00-02
PAGE 0A

Fig. B.8 Example drawing for ATA 25-24-00-02 extracted from **AIPC Boeing 2007 –** page 0A

BOEING
737-600/700/800/900
PARTS CATALOG (MAINTENANCE)

FIG ITEM	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	EFFECT FROM TO	UNITS PER ASSY
2				
		RACK ASSY-OVHD STOWAGE COMPT MAGAZINE	001006 201205 250250 301313	
- 1	412A1910-23SP	RACK ASSY-OVHD STOWAGE COMPT MAGAZINE FOR NHA SEE: 25-24-30-25E 25-24-30-25F 25-24-30-27	002006 201205 301302	RF
- 1	412A1910-23A	RACK ASSY-OVHD STOWAGE COMPT MAGAZINE FOR NHA SEE: 25-24-30-25E 25-24-30-25F 25-24-30-27	001001 250250 303313	RF
5	412A1250-91A	.TRIM-EDGE	001006 201205 250250 301313	1
10	BACS12FA3K5	.SCREW-	001006 201205 250250 301313	14
15	412A1220-61A	.CLIP-	001006 201205 250250 301313	5
20	412A1213-46A	.PANEL ASSY-DIVIDER	001006 201205 250250 301313	1
- 25	SL2334-3A1	..INSERT- SUPPLIER CODE: V97393	001006 201205 250250 301313	11
30	412A1910-3A	.RACK ASSY-	001006 201205 250250 301313	1
35	412A1450-17A	..TRIM-	001006 201205 250250 301313	2
40	412N1212-4A	..SUPPORT-SHELF	001006 201205 250250 301313	2

MISSING ITEM NUMBERS NOT APPLICABLE

— ITEM NOT ILLUSTRATED

25-24-00-02

25-24-00
FIG. 02
PAGE 1
OCT 10/06

TCI

Fig. B.9 Example drawing for ATA 25-24-00-02 extracted from **AIPC Boeing 2007 –** page 1

BOEING
737-600/700/800/900
PARTS CATALOG (MAINTENANCE)

FIG ITEM	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	EFFECT FROM TO	UNITS PER ASSY
2				
45	412A1213-20A	..SHELF ASSY-	001006 201205 250250 301313	2
50	412A1213-32A	..PANEL ASSY-RACK OPTIONAL PART: 412A1213-69B	001006 201205 250250 301313	1
50	412A1213-69B	..PANEL ASSY-BACK OPTIONAL PART: 412A1213-32A	001006 201205 250250 301313	1

MISSING ITEM NUMBERS NOT APPLICABLE

– ITEM NOT ILLUSTRATED

TCI

25-24-00-02

25-24-00
FIG. 02
PAGE 2
OCT 10/06

Fig. B.10 Example drawing for ATA 25-24-00-02 extracted from **AIPC Boeing 2007 –** page 2

B.3 Structural Repair Manual (SRM)

BOEING

737-700
STRUCTURAL REPAIR MANUAL

REPAIR 1 - DAMAGE ON ONE FLANGE OF A TRANSVERSE FLOOR BEAM CHORD

1. Applicability

A. Repair 1 is applicable to damage on the flanges of the upper or lower chords of:

(1) The Transverse Floor Beams (I-sections) in Fuselage Sections 41, 43, 46, and 47. Refer to Transverse Floor Beam Location, Figure 201/REPAIR 1.

(2) The Transverse Floor Beams that are made from the 7075-T6511 or 7050-T76511 extrusions that follow:

(a) Fuselage Section 41: BAC1518-1208, BAC1518-1210, and BAC1518-1218

(b) Fuselage Section 43: BAC1518-1213 and BAC1518-1214

(c) Fuselage Section 46: BAC1518-1207

(d) Fuselage Section 47: BAC1518-1207, BAC1518-1211 and BAC1518-1212.

(3) Refer to Table 201/REPAIR 1 for the thicknesses of the chords of the different Transverse Floor Beams.

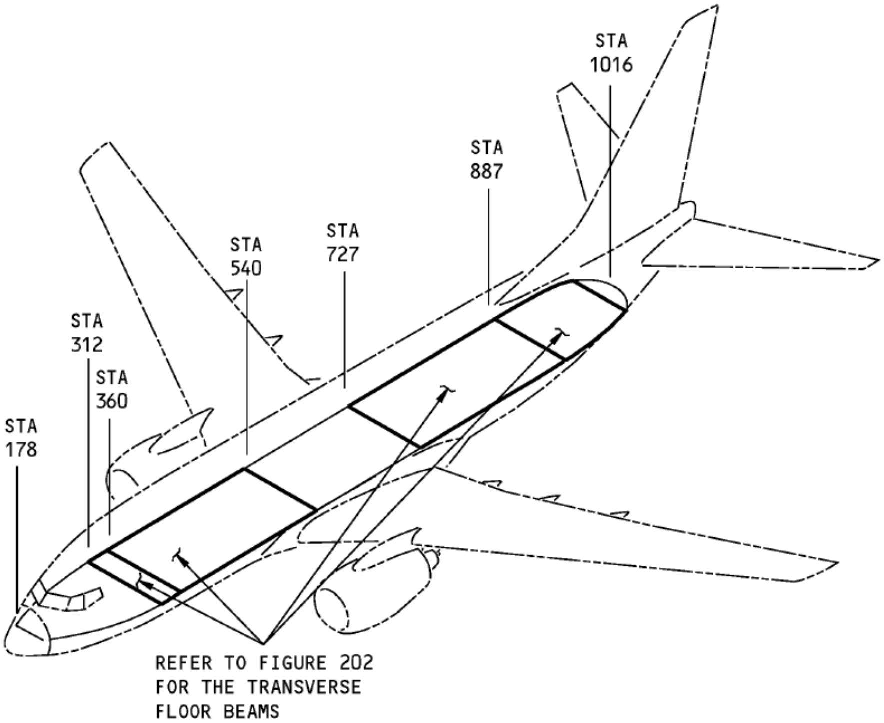
B. Repair 1 is not applicable to damage to the floor beam at a seat track location.

REPAIR 1
Page 201
Nov 01/2003

D634A201 **53-00-51**

Fig. B.11 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 201

737-700
STRUCTURAL REPAIR MANUAL

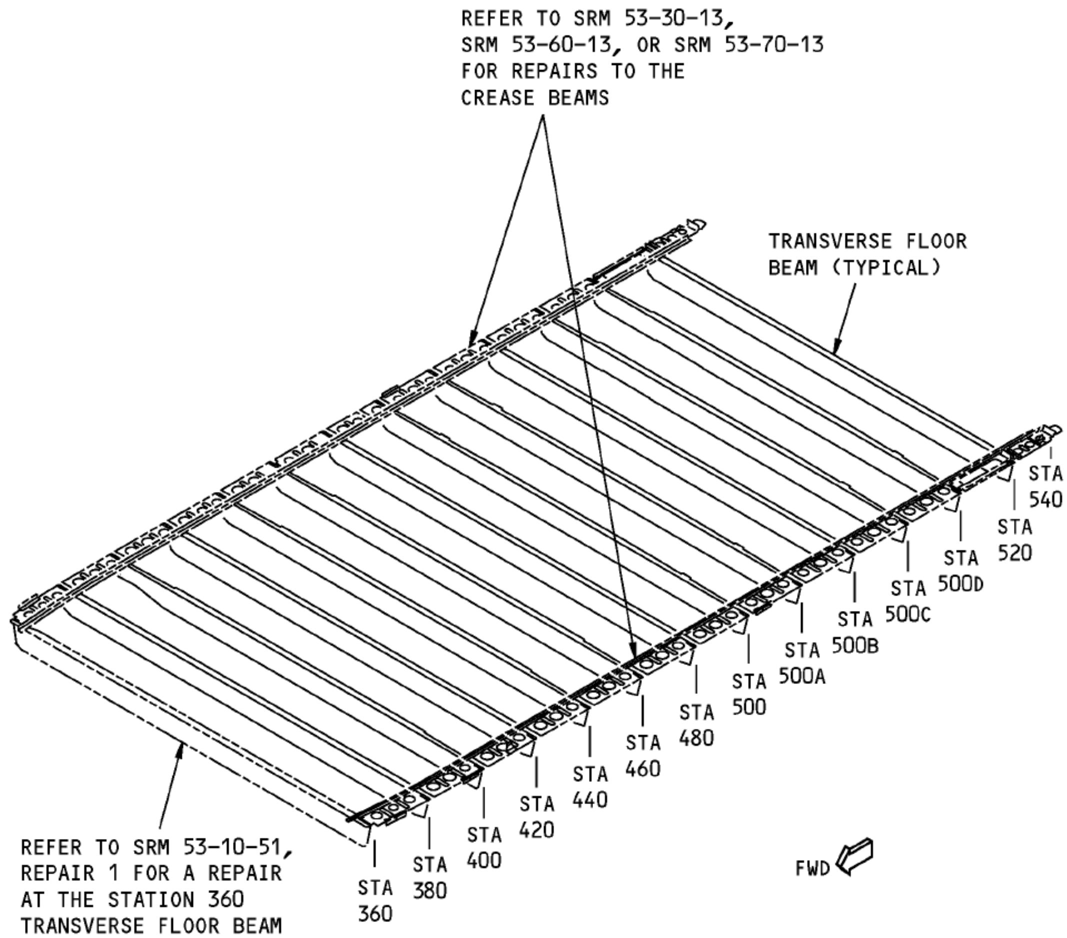


Transverse Floor Beam Location
Figure 201

REPAIR 1
Page 202
D634A201 **53-00-51** Nov 01/2003

Fig. B.12 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 202

737-700
STRUCTURAL REPAIR MANUAL



SECTION 43 TRANSVERSE FLOOR BEAMS ARE SHOWN,
SECTION 41, 46, AND 47 TRANSVERSE FLOOR BEAMS
ARE ALMOST THE SAME

Transverse Floor Beams
Figure 202

REPAIR 1
Page 203
Nov 01/2003

D634A201 **53-00-51**

Fig. B.13 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 203

BOEING

737-700
STRUCTURAL REPAIR MANUAL

2. **General**

   A. This repair gives instructions for a permanent repair of the upper or lower chord of a floor beam made from extruded aluminum. Refer to 51-00-06 for the definitions of the different types of repairs, if necessary.

   B. Refer to the applicable identification subject for the location of the floor beam you want to repair. Refer to 53-10-51, 53-30-51, 53-60-51, or 53-70-51, as necessary.

3. **References**

Reference	Title
51-00-06	STRUCTURAL REPAIR DEFINITIONS
51-10-02	INSPECTION AND REMOVAL OF DAMAGE
51-20-01	PROTECTIVE TREATMENT OF METALLIC AND COMPOSITE MATERIALS
51-20-05	REPAIR SEALING
51-40-00, GENERAL	Fasteners
51-40-02, GENERAL	Fastener Installation and Removal
51-40-03, GENERAL	Fastener Substitution
51-40-05, GENERAL	Fastener Hole Sizes
51-40-06, GENERAL	Fastener Edge Margins
53-10-51	FUSELAGE FLOOR STRUCTURE - SECTION 41
53-10-51, IDENTIFICATION 2	Section 41 Passenger Compartment Floor Structure
53-30-51	FUSELAGE FLOOR STRUCTURE - SECTION 43
53-30-51, IDENTIFICATION 1	Section 43 Transverse Floor Beams
53-60-51	FUSELAGE FLOOR STRUCTURE - SECTION 46
53-60-51, IDENTIFICATION 1	Section 46 Floor Beams
53-70-51	FUSELAGE FLOOR STRUCTURE - SECTION 47
53-70-51, IDENTIFICATION 1	Section 47 Floor Structure
AMM 51-31-00 P/B 201	SEALS AND SEALING - MAINTENANCE PRACTICES
AMM 51-21-00	Interior and Exterior Finishes - Cleaning/Painting
AMM 51-21-00/701	Interior And Exterior Finishes - Cleaning/Painting
SOPM 20-41-02	Application of Chemical and Solvent Resistant Finishes

4. **Repair Instructions**

   A. Remove the structure that follows, as necessary:

      (1) Remove the floor panels and adjacent structure to get access to the damaged floor beam.

      (2) Remove the clip-on nuts for the floor panel fasteners in the area where the repair angles and strap will be installed.

   B. Cut and remove the damaged parts of the floor beam.

      (1) Cut the floor beam as shown in Transverse Floor Beam Upper or Lower Chord - Repair to One Flange, Figure 203/REPAIR 1.

         NOTE: If a floor beam is tapered, then keep an edge margin of 1.7D (D = fastener diameter). If this is not possible, then cut the floor beam in a location that does not have a taper.

REPAIR 1
Page 204
D634A201 **53-00-51** Nov 10/2006

Fig. B.14 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 204

BOEING

737-700
STRUCTURAL REPAIR MANUAL

(2) The edge of the cut must not be less than 2 inches (50.8 mm) from:
   (a) The center of a seat track
   (b) The center of a cargo tie-down fitting.

C. Make the repair parts. Refer to Transverse Floor Beam Upper or Lower Chord - Repair to One Flange, Figure 203/REPAIR 1 and Tables 201, 202, and 203.

NOTE: The repair parts:
- Can be made from aluminum extrusions to the dimensions given in the production drawing.
- Should be formed in the annealed condition, then heat treated as shown.

(1) Do not permit the repair parts to cause a blockage of the manufactured floor beam holes.
(2) If there is a blockage, make cutouts in the repair parts that align with the holes in the floor beam.

D. Assemble the repair parts.

E. Drill the fastener holes. Refer to Transverse Floor Beam Upper or Lower Chord - Repair to One Flange, Figure 203/REPAIR 1 and Table 204.

F. Disassemble the repair parts.

G. Remove all the nicks, scratches, and sharp edges from the repair parts and cut edges of the floor beam.

H. Apply a chemical conversion coating to the repair parts and to the cut edges of the floor beam. Refer to 51-20-01.

I. Apply one of the two finishes that follows:
(1) Apply two layers of BMS 10-11, Type I primer to the repair parts and the bare surfaces of the floor beam. Refer to SOPM 20-41-02.
(2) Apply one layer of BMS 10-11, Type I primer and one layer of BMS 10-11, Type II enamel, color 702 white gloss, to the repair parts and the cut edges of the floor beam. Refer to SOPM 20-41-02 and AMM 51-21-00/701.

J. Install the repair parts.
(1) Apply BMS 5-95 sealant to the repair as follows (Refer to 51-20-05):
   (a) Apply BMS 5-95 sealant to the mating surfaces.
   (b) Install the fasteners wet with BMS 5-95 sealant. Refer to Transverse Floor Beam Upper or Lower Chord - Repair to One Flange, Figure 203/REPAIR 1 and Table 204 for the fasteners you can use.
   (c) Fill all the spaces with BMS 5-95 sealant.

K. Apply one layer of BMS 3-23, Type II corrosion inhibiting compound followed by one layer of BMS 3-26 corrosion inhibiting compound to the surface of the repair area. Refer to 51-10-02.
(1) As an alternative, apply one layer of BMS 3-29 corrosion inhibiting compound. Refer to 51-10-02.

L. Install the adjacent structure that was removed.

M. Install the floor panels.
(1) Clean the fastener holes as given in 51-20-01.
(2) Apply a chemical conversion coating to the fastener holes as given in 51-20-01.
(3) Apply one layer of BMS 10-11, Type I primer to the fastener holes. Refer to AMM 51-21-00.
(4) Apply BMS 3-24 grease to the fastener holes.

REPAIR 1
Page 205
D634A201 **53-00-51** Nov 10/2006

Fig. B.15 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 205

737-700
STRUCTURAL REPAIR MANUAL

(5) Install the clip-on nuts at each fastener hole.
   (a) Align the clip-on nuts and the floor panel fastener holes.

(6) Put the floor panels in position and install the fasteners wet with BMS 3-24 grease. Torque the fasteners to 20-25 lb-in (2.3-2.8 Nm).

Table 201:

REPAIR MATERIALS FOR TRANSVERSE FLOOR BEAM EXTRUSIONS			
ITEM	PART	QUANTITY	MATERIAL
[1]	Repair Angle	1	See Tables 202 and 203 for the material and thickness
[2]	Repair Angle	1	See Tables 202 and 203 for the material and thickness
[3]	Strap	1	See Table 203 for the material and thickness
[4]	Filler	1	Use 7075-T6 plate that is the same thickness as the flange of the initial chord as given in Table 201
[5]	Shim	As necessary at a stiffener	Use 7075-T6 clad sheet that is 0.150 inch thick

Table 202:

TRANSVERSE FLOOR BEAM DIMENSIONS			
FLOOR BEAM EXTRUSION	CHORD THICKNESS IN INCHES	PART [1] REPAIR ANGLE - CHORD THICKNESS/MATERIAL	PART [2] REPAIR ANGLE - CHORD THICKNESS/MATERIAL
BAC1518-1207 BAC1518-1210 BAC1518-1213 BAC1518-1214	0.125	0.071 / 7075-T6 PART [1] REPAIR ANGLE CAN BE MADE FROM BAC1490-2811 FORMED ANGLE, 7075-T6	0.080 / 7075-T6 PART [2] REPAIR ANGLE CAN BE MADE FROM BAC1490-2887 FORMED ANGLE, 7075-T6

Table 203:

TRANSVERSE FLOOR BEAM DIMENSIONS				
FLOOR BEAM EXTRUSION	CHORD THICKNESS IN INCHES	PART [1] REPAIR ANGLE - CHORD THICKNESS/MATERIAL	PART [2] REPAIR ANGLE - CHORD THICKNESS/MATERIAL	PART [3] STRAP
BAC1518-1208 BAC1518-1211 BAC1518-1212 BAC1518-1218	0.170 0.150 0.180 0.175	0.071 / 7075-T6 PART [1] REPAIR ANGLE CAN BE MADE FROM BAC1490-2811 FORMED ANGLE, 7075-T6	0.080 / 7075-T6 PART [2] REPAIR ANGLE CAN BE MADE FROM BAC1490-2887 FORMED ANGLE, 7075-T6	0.080 7075-T6

Table 204:

REPAIR FASTENERS		
INITIAL FASTENER	REPAIR FASTENER TYPE	REPAIR FASTENER (FOR HOLE CLEANUP, USE A MAXIMUM OF 1/32 INCH OVERSIZE)
5/32 INCH DIAMETER PROTRUDING HEAD RIVET	BACB30MY6K() hex drive bolt with a BACC30M collar (Optional: BACB30FM6 hex drive bolt with a BACC30M collar)	BACB30MY6K()Y hex drive bolt with a BACC30M collar (Optional: BACB30FP6 hex drive bolt with a BACC30M collar)
3/16 INCH DIAMETER PROTRUDING HEAD RIVET	BACB30MY6K()X hex drive bolt with a BACC30M collar (Optional: BACB30FP6 hex drive bolt with a BACC30M collar)	BACB30MY6K()Y hex drive bolt with a BACC30R collar (Optional: BACB30KK6 hex drive bolt with a BACC30R collar)

Fig. B.16 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 206

REPAIR FASTENERS		
INITIAL FASTENER	REPAIR FASTENER TYPE	REPAIR FASTENER (FOR HOLE CLEANUP, USE A MAXIMUM OF 1/32 INCH OVERSIZE)
1/4 INCH DIAMETER PROTRUDING HEAD RIVET	BACB30MY8K()X hex drive bolt with a BACC30M collar (Optional: BACB30FP8 hex drive bolt with a BACC30M collar)	BACB30MY8K()Y hex drive bolt with a BACC30R collar (Optional: BACB30KK8 hex drive bolt with a BACC30R collar)
3/16 INCH DIAMETER HEX DRIVE BOLT OR LOCK BOLT	BACB30MY6K()X hex drive bolt with a BACC30M collar (Optional: BACB30FP6 hex drive bolt with a BACC30M collar)	BACB30MY6K()Y hex drive bolt with a BACC30R collar (Optional: BACB30KK6 hex drive bolt with a BACC30R collar)

NOTE: Use protruding head fasteners only in the floor beam web. Use flush head fasteners [BACB30NW6K()] in the floor beam chord.

Fig. B.17 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 207

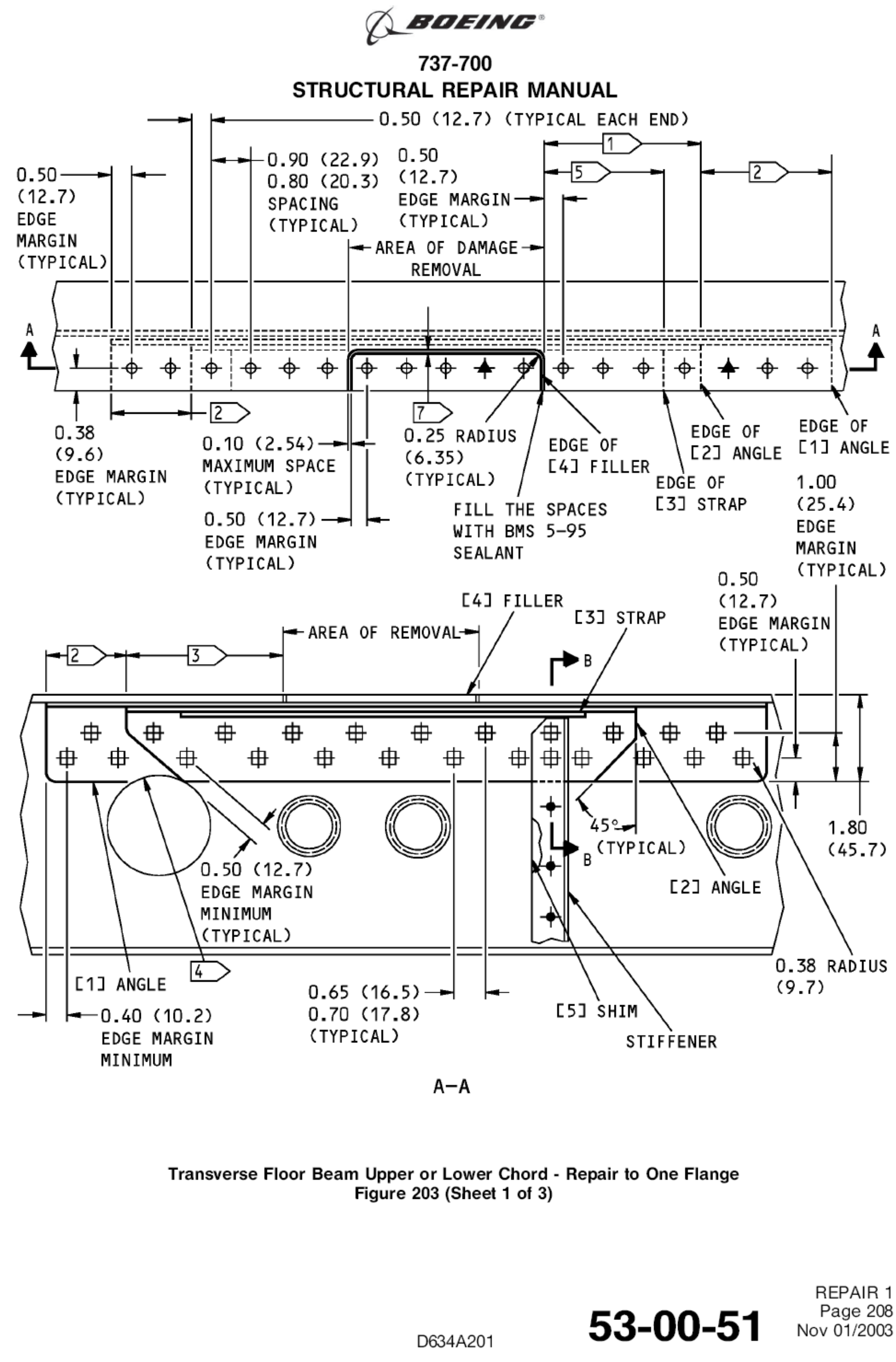
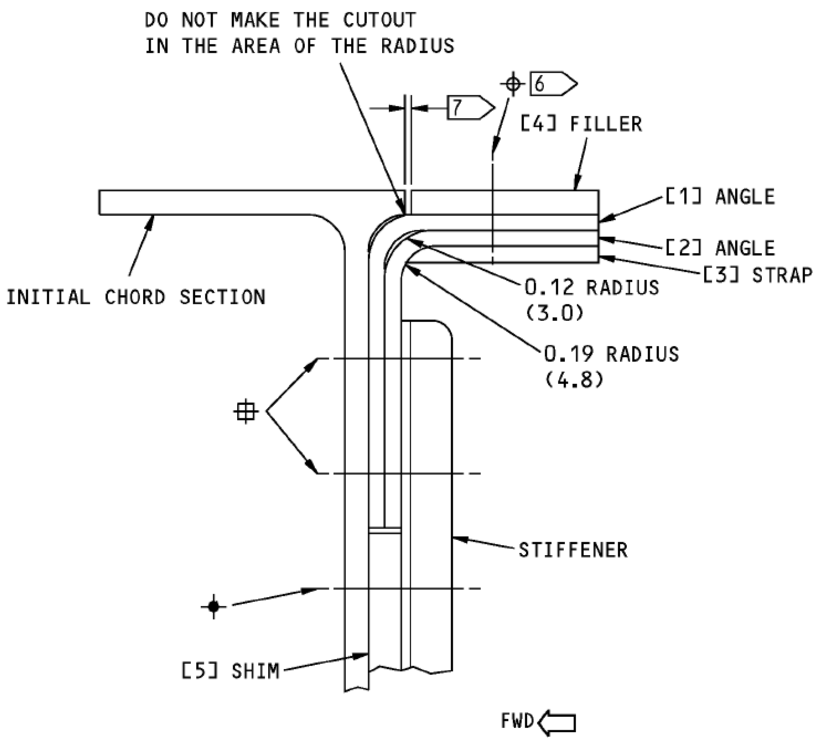


Fig. B.18 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 208

737-700
STRUCTURAL REPAIR MANUAL



B–B

Transverse Floor Beam Upper or Lower Chord - Repair to One Flange
Figure 203 (Sheet 2 of 3)

D634A201 **53-00-51** REPAIR 1 Page 209 Nov 01/2003

Fig. B.19 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 209

BOEING

737-700
STRUCTURAL REPAIR MANUAL

NOTES

- ALL DIMENSIONS ARE IN INCHES (mm).

1. USE A MINIMUM OF 4 REPAIR FASTENERS THROUGH THE HORIZONTAL FLANGE OF THE PART [2] ANGLE. THIS DOES NOT INCLUDE A FLOOR PANEL FASTENER.
2. USE A MINIMUM OF 2 REPAIR FASTENERS THROUGH THE HORIZONTAL AND VERTICAL FLANGES AT EACH END OF THE PART [1] SUPPORT ANGLE.
3. USE A MINIMUM OF 4 REPAIR FASTENERS THROUGH THE VERTICAL FLANGE OF THE PART [2] ANGLE. THIS DOES NOT INCLUDE FLOOR PANEL OR CARGO LINER FASTENERS.
4. DO NOT PERMIT THE REPAIR PARTS TO CAUSE A BLOCKAGE OF THE MANUFACTURED HOLES IN THE FLOOR BEAM WEB. IF THERE IS BLOCKAGE MAKE CUTOUTS IN THE REPAIR PARTS THAT ARE THE SAME SHAPE AS THE HOLES IN THE FLOOR BEAM.
5. USE A MINIMUM OF 3 FASTENERS THROUGH THE PART [3] STRAP.
6. KEEP A MINIMUM EDGE MARGIN OF 1.7D ON THE EDGES OF THE PARTS [1] AND [2] ANGLES AND THE PART [3] STRAP.
7. MAKE SURE THAT THE GAP BETWEEN THE PART [4] FILLER AND THE INTIAL CHORD IS NOT MORE THAN 0.010 INCH (0.12 mm) BEFORE FASTENER INSTALLATION.

FASTENER SYMBOLS

FLOOR PANEL OR CARGO LINER FASTENER LOCATION. INSTALL A BACN10FX() CLIP-ON NUT. INSTALL THE SAME TYPE AND SIZE OF FLOOR PANEL OR CARGO LINER FASTENER AS THE ONE THAT WAS REMOVED.

INITIAL FASTENER LOCATION. INSTALL A FASTENER AS GIVEN IN TABLE 203. USE THE DIAMETER NECESSARY TO KEEP TRANSITION FIT HOLES.

REPAIR FASTENER LOCATION. INSTALL A BACB30NW6K() (PREFERRED) OR A BACB30FN6 (ALTERNATIVE) HEX DRIVE BOLT WITH A BACC30M COLLAR.

REPAIR FASTENER LOCATION. INSTALL A BACB30MY6K() (PREFERRED) OR A BACB30FM6() (ALTERNATIVE) HEX DRIVE BOLT WITH A BACC30M COLLAR.

Transverse Floor Beam Upper or Lower Chord - Repair to One Flange
Figure 203 (Sheet 3 of 3)

REPAIR 1
Page 210
D634A201 **53-00-51** Nov 01/2003

Fig. B.20 Example drawing for ATA 53-00-51 extracted from **SRM Boeing 2006 –** page 210

B.4 System Schematic Manual (SSM)

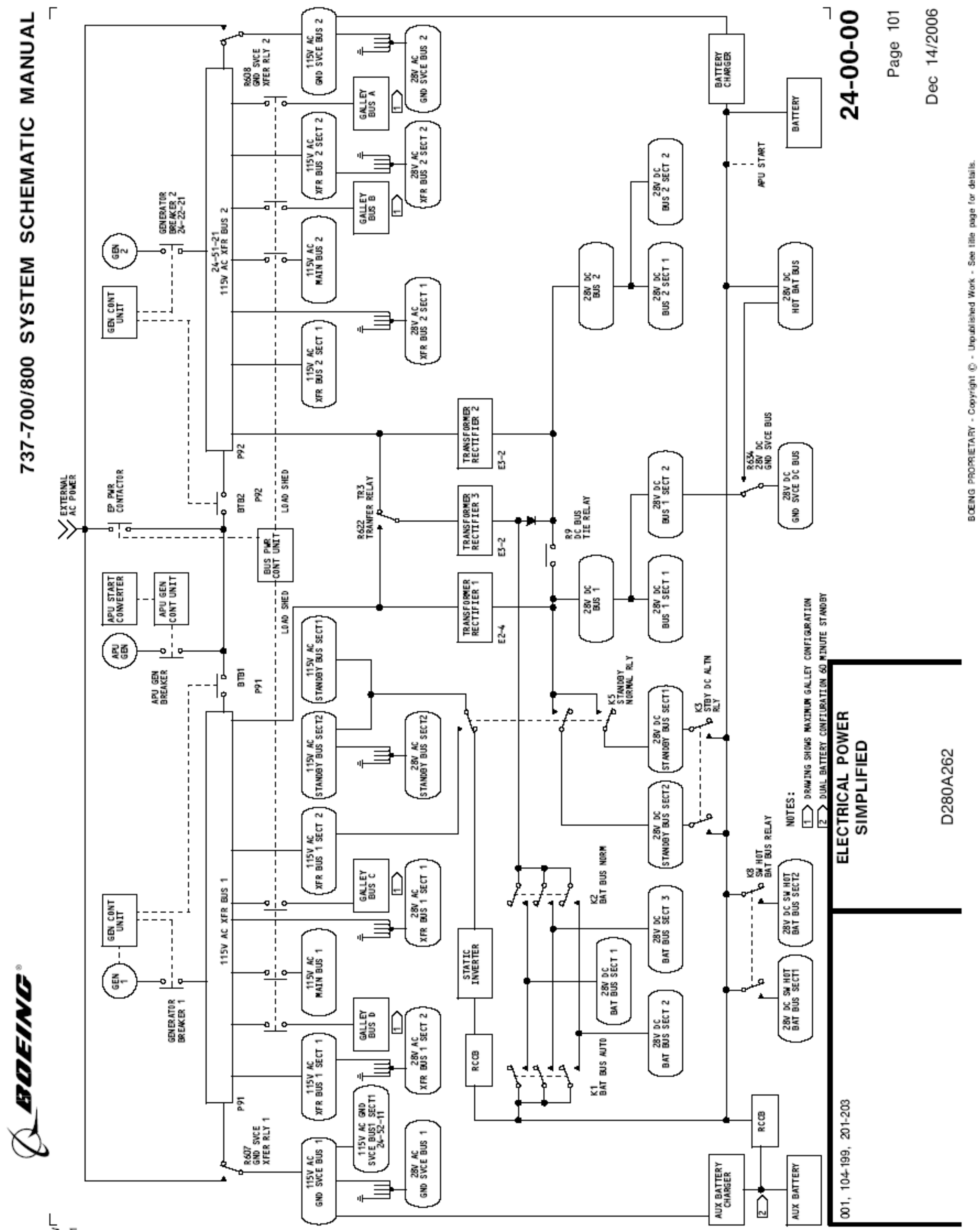


Fig. B.21 Example drawing for ATA 24-00-00 extracted from **SSM Boeing 2007 –** page 101

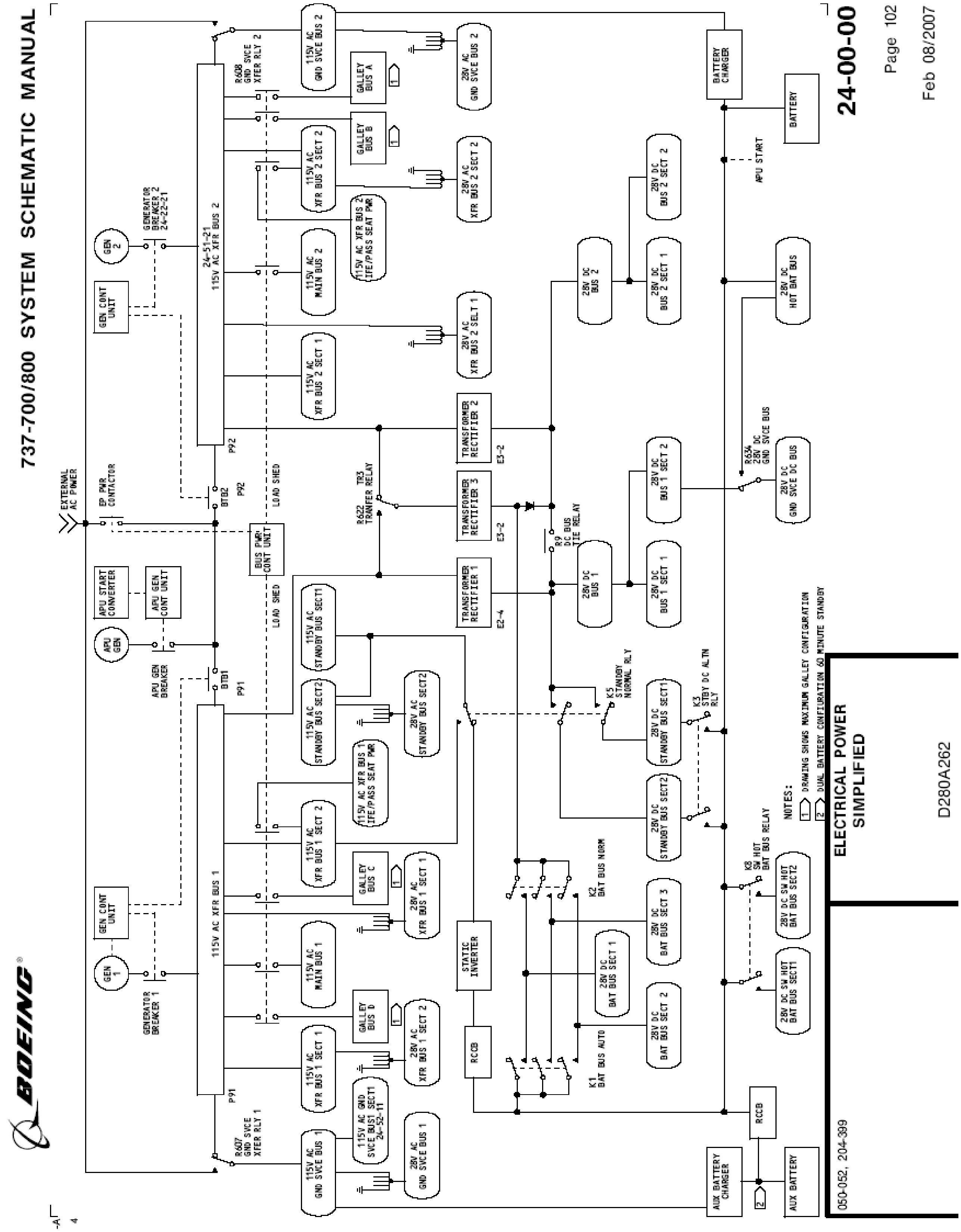


Fig. B.22 Example drawing for ATA 24-00-00 extracted from **SSM Boeing 2007 –** page 102

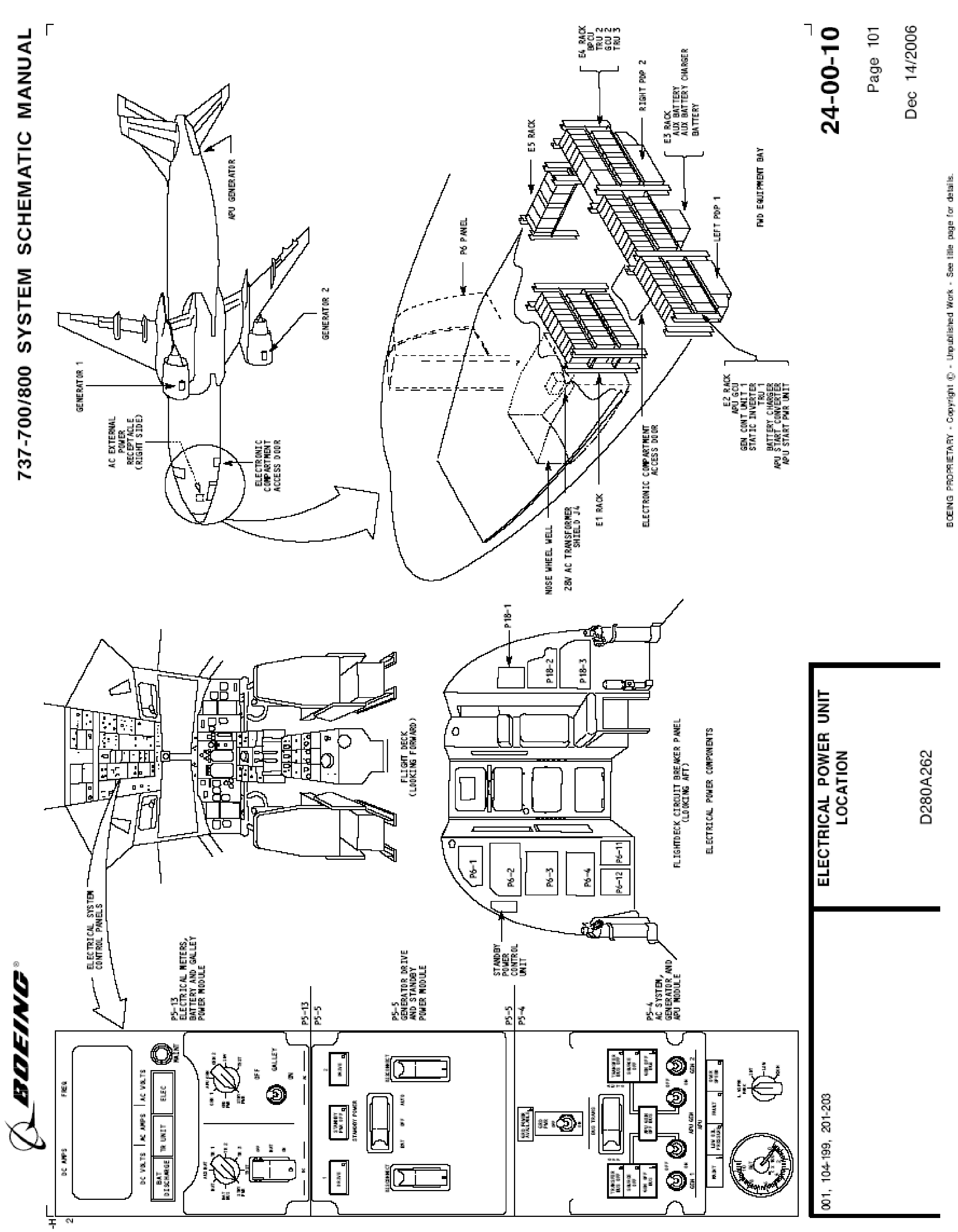


Fig. B.23 Example drawing for ATA 24-00-10 extracted from **SSM Boeing 2007 –** page 101

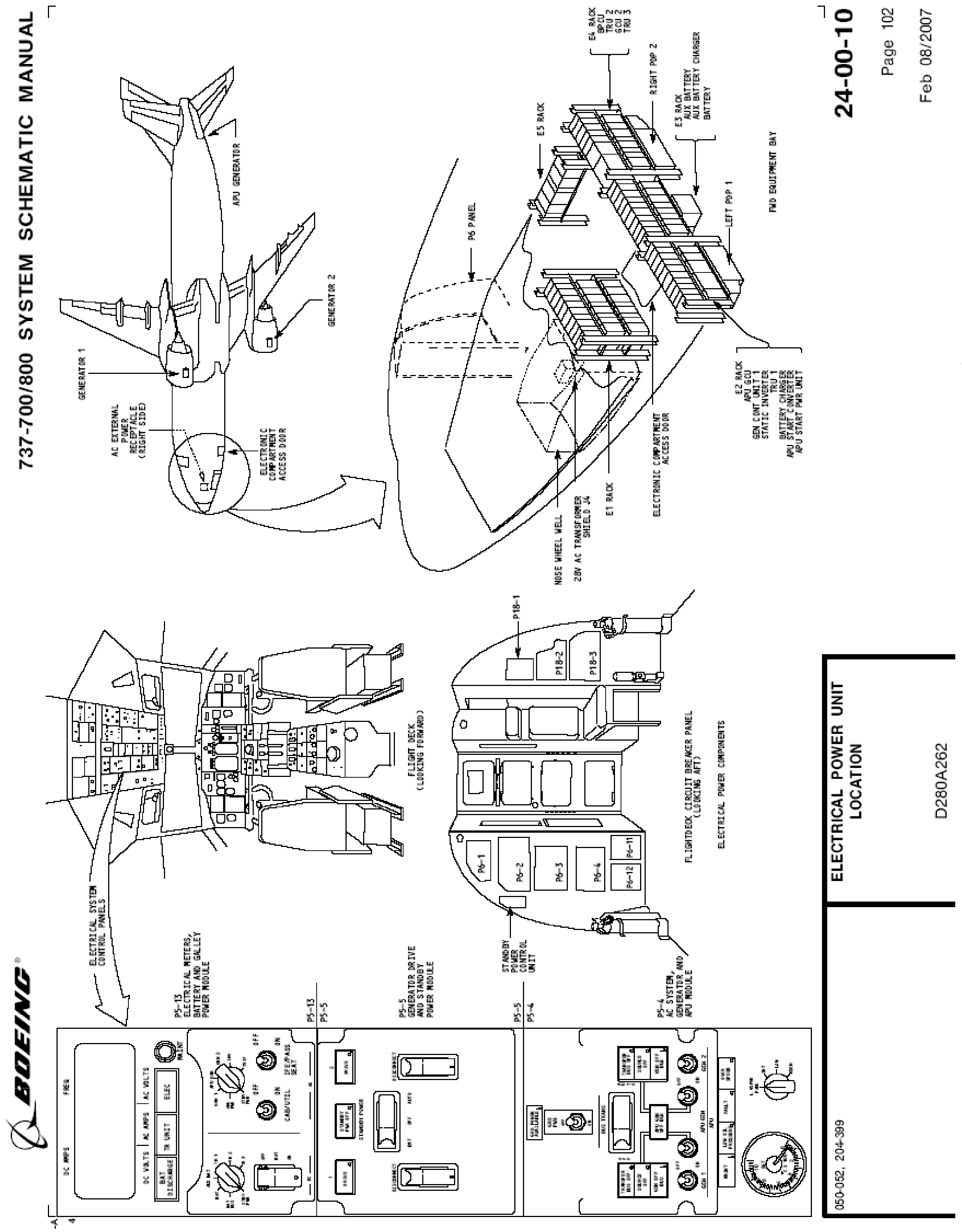


Fig. B.24 Example drawing for ATA 24-00-10 extracted from **SSM Boeing 2007 –** page 102

B.5 Wiring Diagram Manual (WDM)

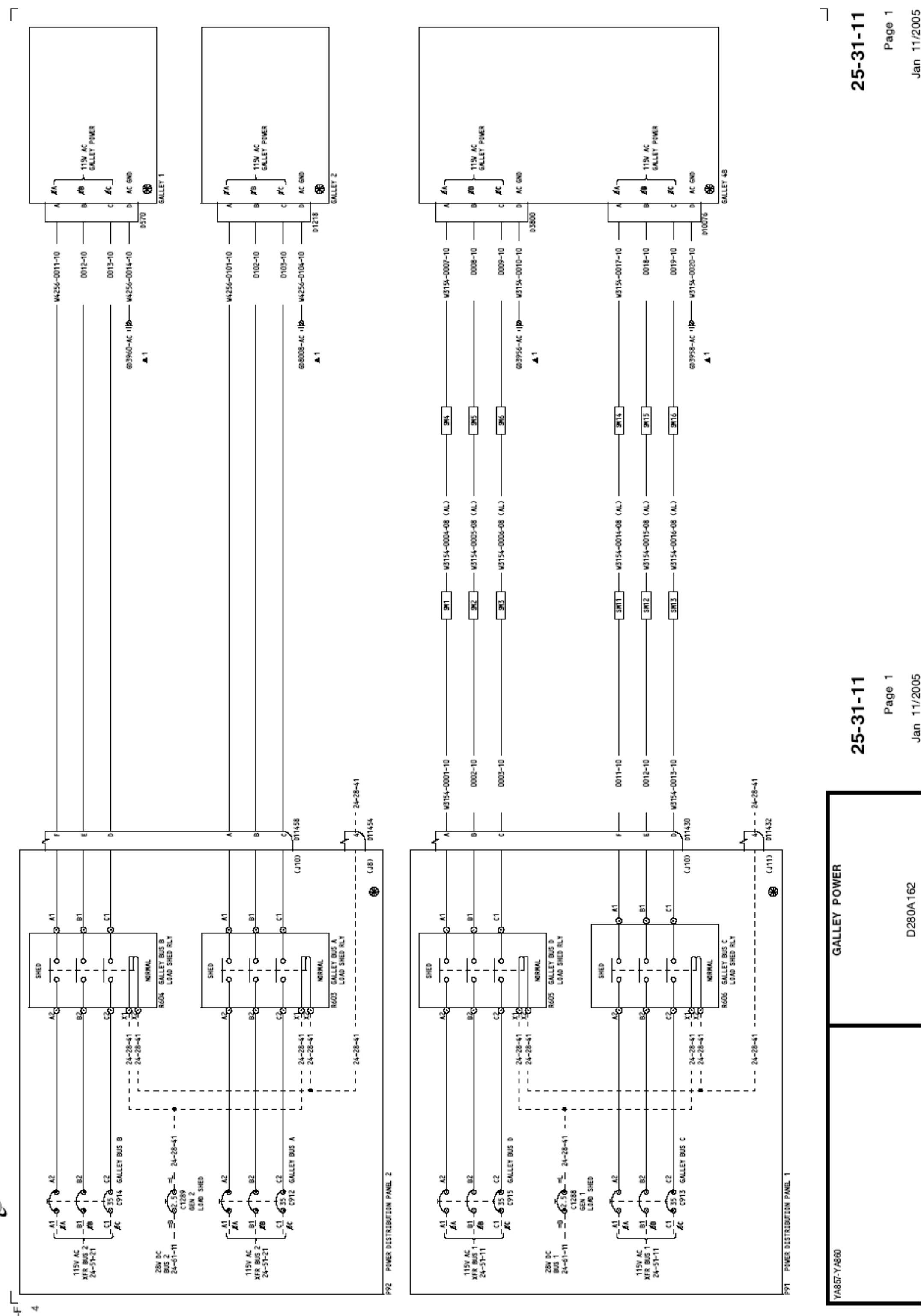


Fig. B.25 Example drawing for ATA 25-31-11 extracted from **WDM Boeing 2006 –** page 1

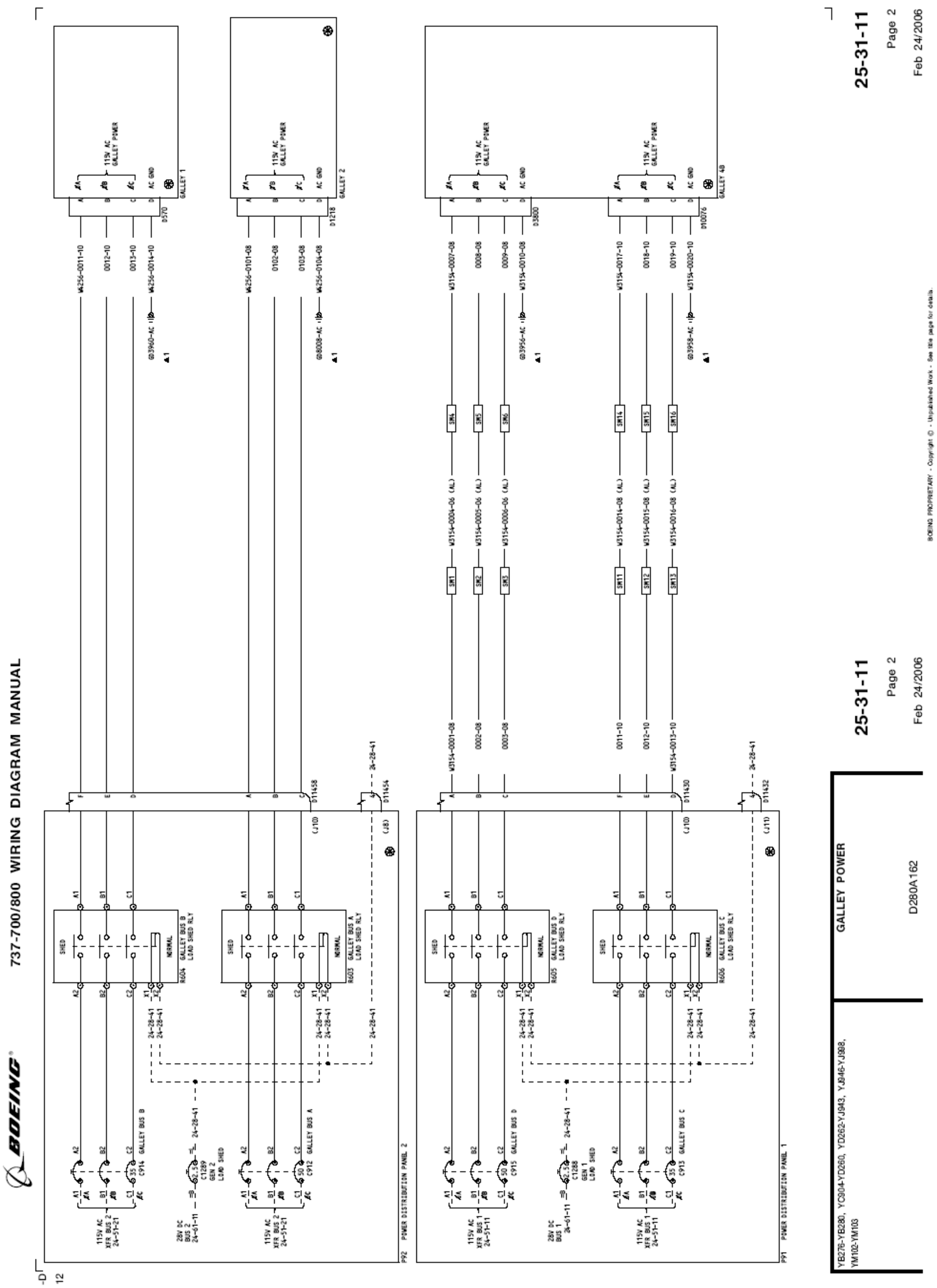


Fig. B.26 Example drawing for ATA 25-31-11 extracted from **WDM Boeing 2006 –** page 2

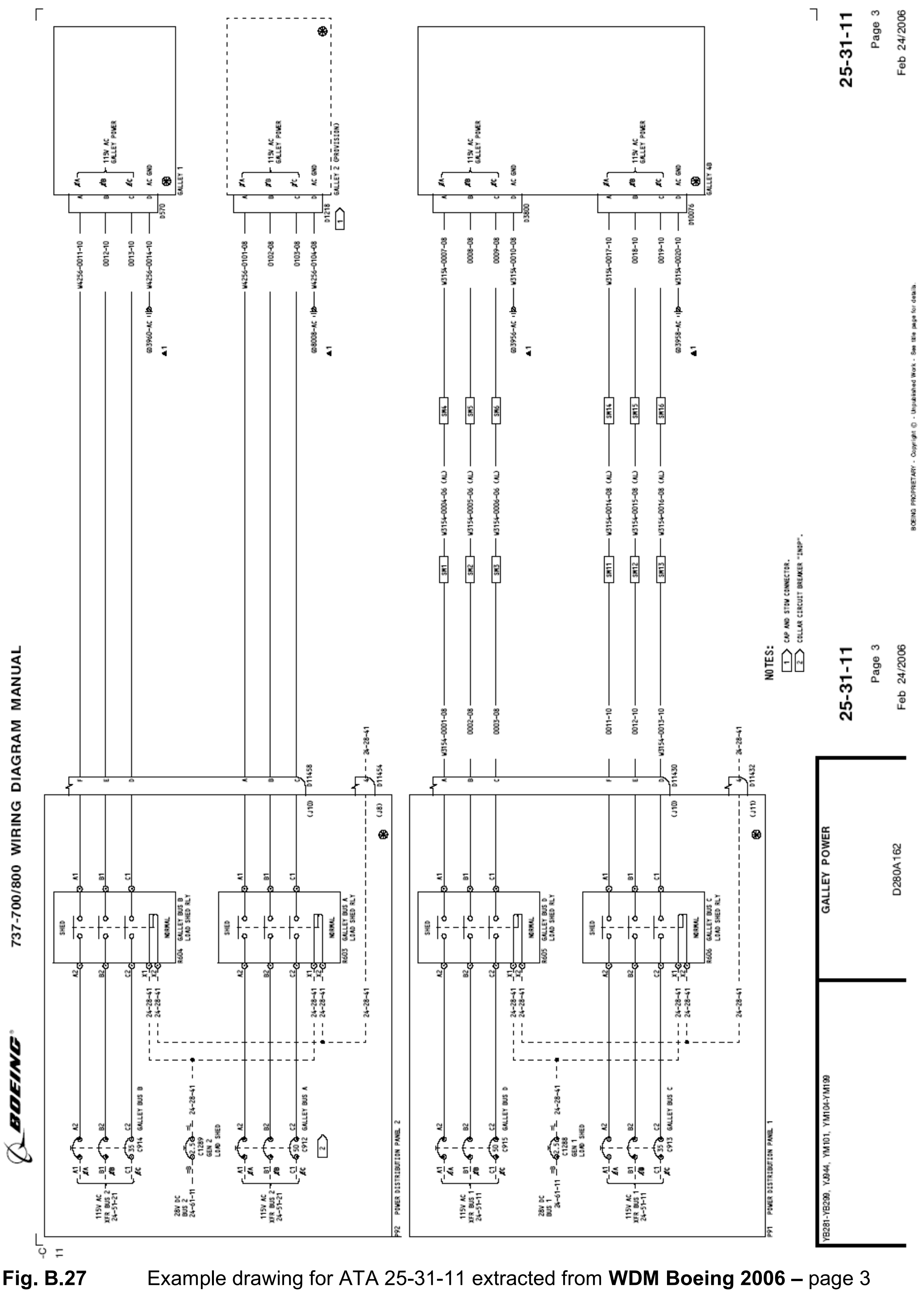


Fig. B.27 Example drawing for ATA 25-31-11 extracted from **WDM Boeing 2006 –** page 3

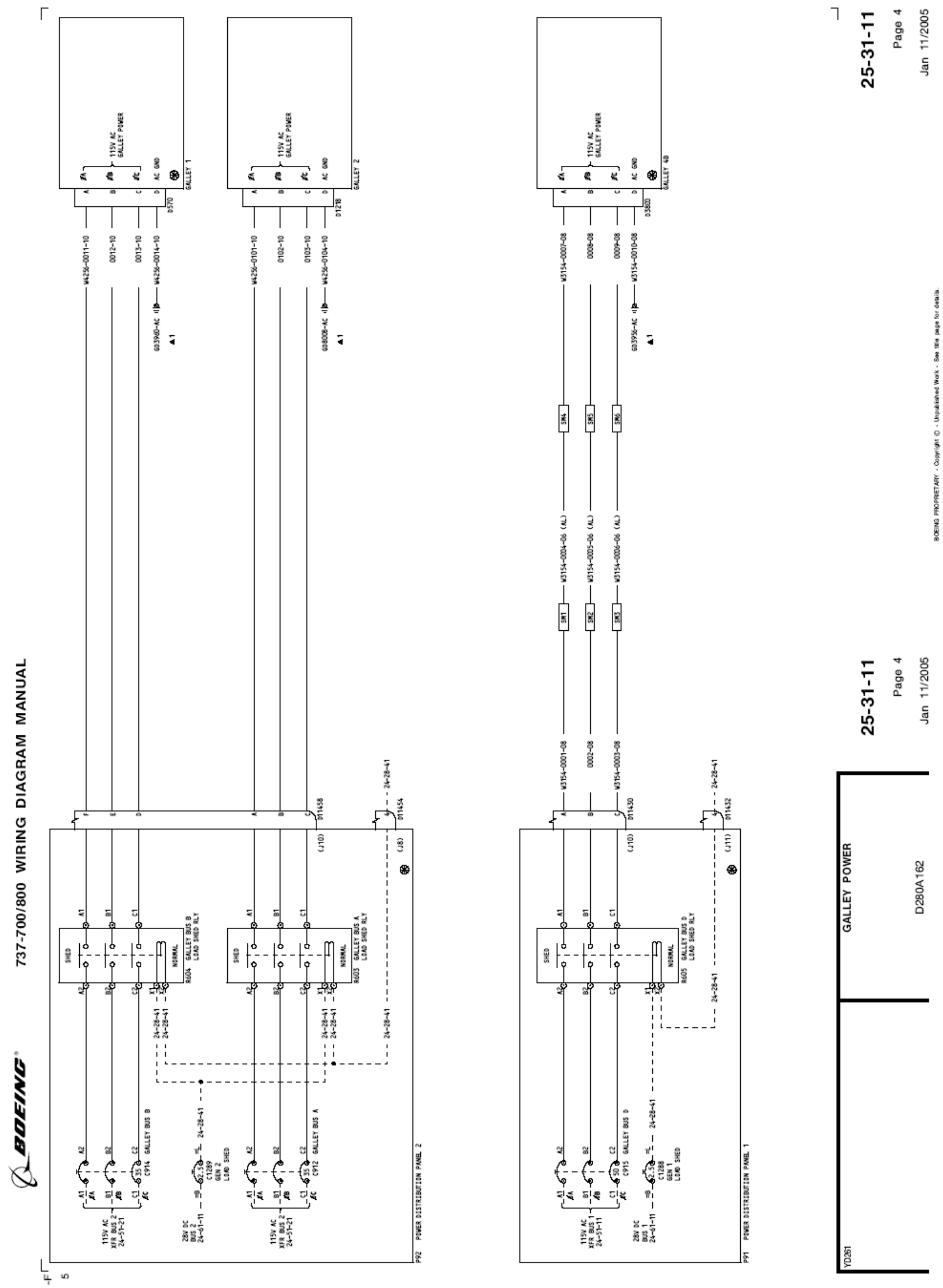


Fig. B.28 Example drawing for ATA 25-31-11 extracted from **WDM Boeing 2006 –** page 4

B.6 Illustrated Tool and Equipment Manual (ITEM)

BOEING

737-600/700/800/900
ILLUSTRATED TOOL AND EQUIPMENT MANUAL

PART NUMBER: ST2580-334C, -1, -145, -185

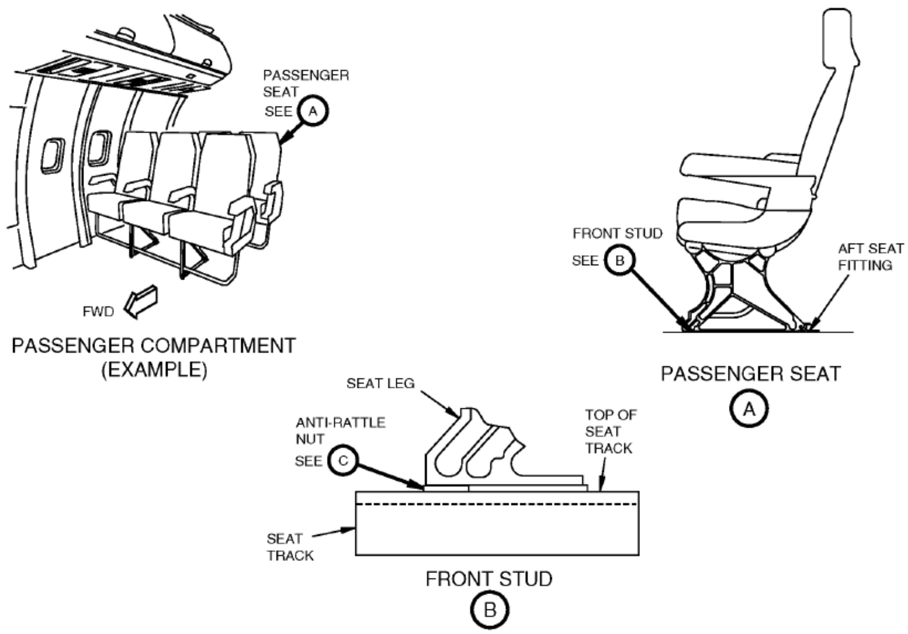
NAME:	Standard Tool - Spanner Nose Pliers
AIRPLANE MAINTENANCE:	YES
COMPONENT MAINTENANCE:	NO
USAGE & DESCRIPTION:	This tool is used to loosen or tighten anti-rattle nuts during removal/ installation of the passenger seats from the seat tracks. The tool is manufactured from a Klein D301-7C spring open pliers. The tool comes in two sizes: -145, (.145" spanner teeth) used on Rumbold seats and -185, (.185" spanner teeth) used on Weber, Sicma and Recaro seats. This tool is common to customer airlines and Boeing manufacturing.
WEIGHT:	.5 lb (0.25 kg) (Excluding box)
DIMENSIONS:	10 x 3 x 3 inches (254 x 76 x 76 mm) (Excluding box)

D634A501 **25-20-01** Page 1 Jun 05/2005

Fig. B.29 Example drawing for ATA 25-20-01 extracted from **ITEM Boeing 2006 –** page 1

BOEING

737-600/700/800/900
ILLUSTRATED TOOL AND EQUIPMENT MANUAL



Anti-Rattle Nut Location
Figure 1

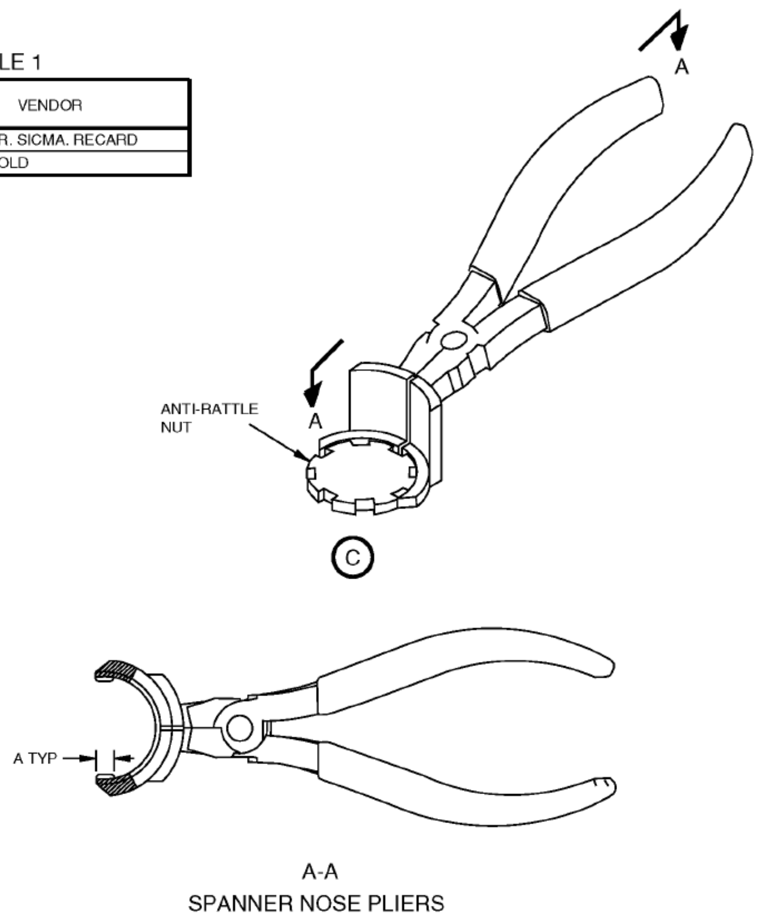
D634A501 **25-20-01** Page 2
Jun 05/2005

Fig. B.30 Example drawing for ATA 25-20-01 extracted from **ITEM Boeing 2006 –** page 2

737-600/700/800/900
ILLUSTRATED TOOL AND EQUIPMENT MANUAL

TABLE 1

A DIM ±.005	VENDOR
.085	WEBER. SICMA. RECARD
.145	RUMBOLD



Spanner Nose Pliers
Figure 2

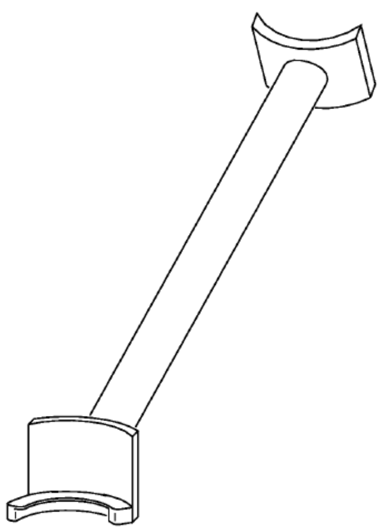
D634A501 **25-20-01** Page 3 Jun 05/2005

Fig. B.31 Example drawing for ATA 25-20-01 extracted from **ITEM Boeing 2006 –** page 3

737-600/700/800/900
ILLUSTRATED TOOL AND EQUIPMENT MANUAL

PART NUMBER: C25001-1

NAME:	Wrench - Anti-rattle Nut
AIRPLANE MAINTENANCE:	YES
COMPONENT MAINTENANCE:	NO
USAGE & DESCRIPTION:	Wrench is used to tighten and loosen the anti-rattle nuts on Recardo, Sicma, Weber and Rumbold passenger seats fitted with with the following ant-rattle nuts: Recardo p/n 134-00-101-09, Sicma p/n 91-000100-726-0, Weber p/n 823377-403, Weber p/n 845901-401, Rumbold p/n M78203-662 during removal/ installation of the passenger seats.
WEIGHT:	0.7 lbs (0.318 kg)
DIMENSIONS:	1.1 x 9.4 x 6.0 inches (28 x 239 x 152 mm)

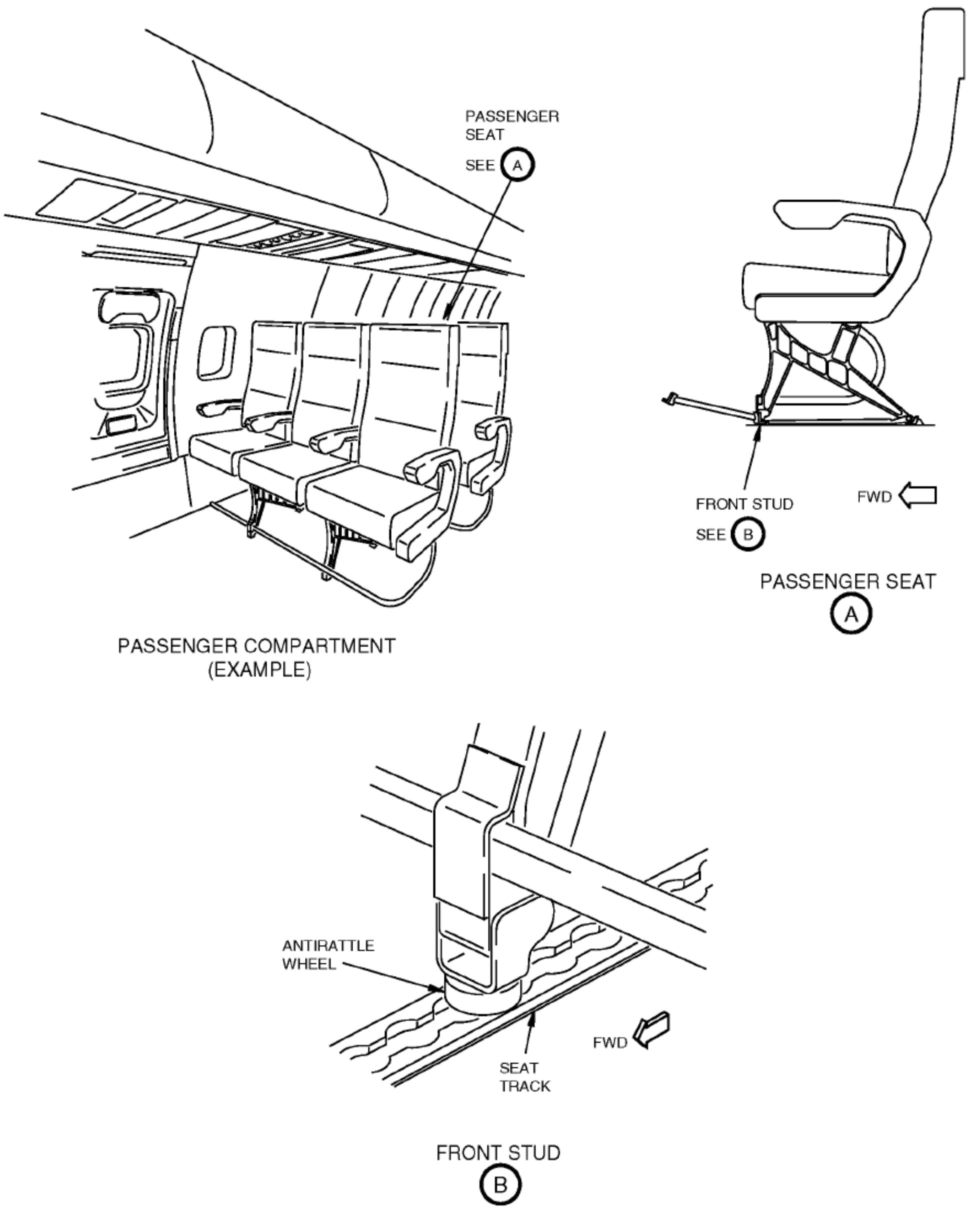


Wrench - Anti-Rattle Nut
Figure 1

D634A501 **25-20-02** Page 1 Oct 05/2005

Fig. B.32 Example drawing for ATA 25-20-02 extracted from **ITEM Boeing 2006 –** page 1

737-600/700/800/900
ILLUSTRATED TOOL AND EQUIPMENT MANUAL



Ant-Rattle Nut Location
Figure 2

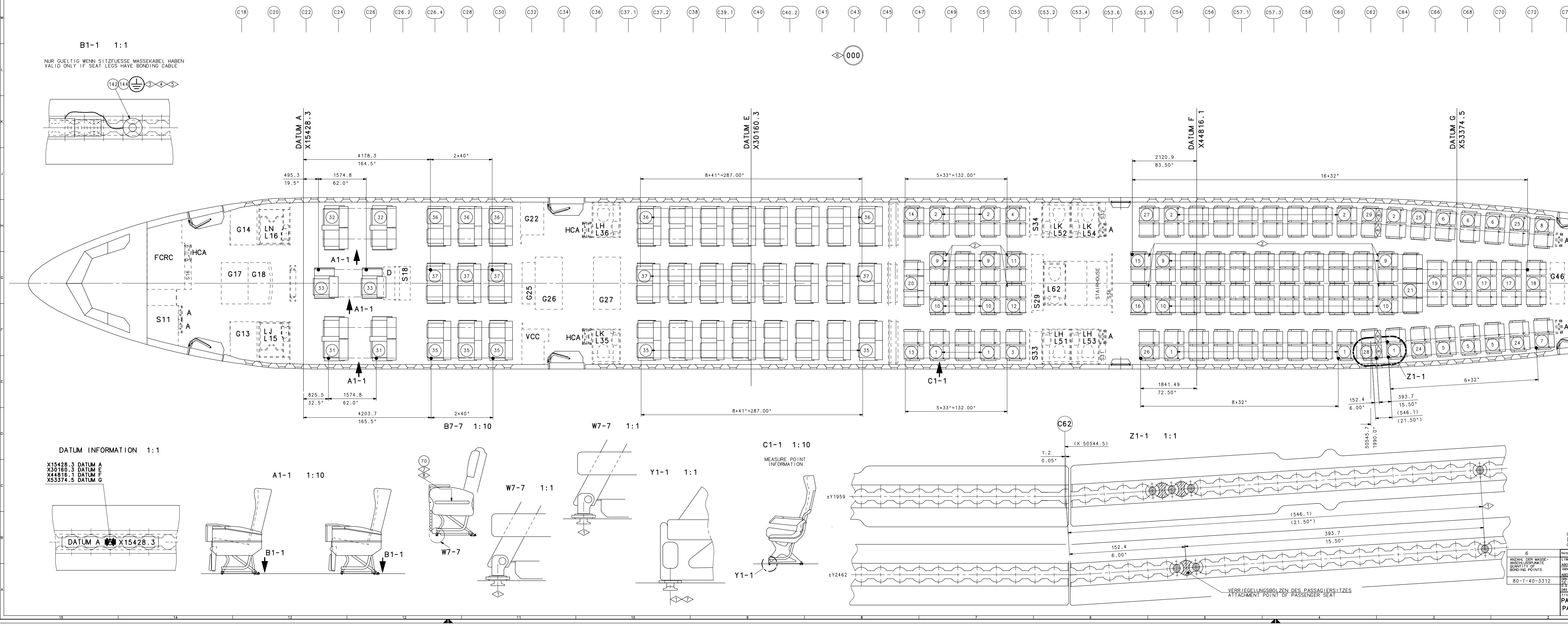
D634A501 **25-20-02** Page 2 Jun 05/2005

Fig. B.33 Example drawing for ATA 25-20-02 extracted from **ITEM Boeing 2006 –** page 2

Appendix C

Predefined Reference Points for a Long Range Aircraft

MODIFICATIONS



SITZ BEKAM FUER DIESEN EINBAUORT SPEZIELLE ADAPTER AN DEN VORDEREN SITZBEINEN.

8 SEAT RECEIVED FOR THIS LOCATION SPECIAL ADAPTER ON THE FRONT LEGS

NOTE:

DER VORDERE SITZFUSSBESCHLAG IST SO EINZUSTELLEN, DAS DER SITZ NACH DEM EINBAU SPIELFREI IN DER SITZSCHIENE GEHALTEN WIRD

7 FOR SEAT INSTALLATION THE FWD. SEAT TO TRACK FITTING SHALL BE ADJUSTED TO ENSURE SNUG FIT WITH SEAT TRACK

6 LICHTKEGEL DER LESELAMPEN EINSTELLEN NACH DER ZEICHNUNG "VERSORGUNGSKANAELE"/"46 F252 90042"

LIGHT CONE OF READING LIGHTS ADJUSTED BY DRAWING "INSTL.SERVICE CHANNEL"/"46 F252 90042"

5 NACH AUSBAU DES MASSEBANDES OS NACH SRM: 51.75.12 SEITE 201 U.W.

AFTER REMOVABLE OF BONDING PT AS PER: SRM 51.75.12 PAGE 201 A.O.

4 MASSEVERBINDUNG NACH AMM

BONDINGS POINTS AS PER AMM

3 Ø 25 GILT FUER ALLE MASSEANSCHLUSSPUNKTE

EFFECTIVE FOR ALL BONDIGS POINTS

POS.9,10,11,12,15 UND 16 ENTERTAINMENT SITZ ZU SITZ VERKABELUNG BEI PASSAGIERSITZEINBAU

2 ITEM 9,10,11,12,15 AND 16 ENTERTAINMENT SEAT TO SEAT WIRING WITH PAX SEAT INSTALLATION

MITTE VORDERER STUD =MESSPUNKT DER PASSAGIERSITZE

1 CENTER OF FRONT STUD =TO BE DEFINED AS MEASURE POINT OF PASSENGER SEATS

INCHES 0 1 2 3 4

0 10 20 30 40 50 60 70 80 90 100 MILLIMETER

6 ANZAHL DER MASSEANSCHLUSSPUNKTE QUANTITY OF BONDING POINTS	LIMITS NOT STATED ABD 0001(DAN11304-M)	SURFACE FINISH MICRONS ABD 0002	DAIMLER-BENZ AEROSPACE AIRBUS GMBH
80-1-40-3312	IDENTIFICATION MARKINGS ABD 0003(DAN369)	INTERCHANGEABLE PART YES NO DRAWING NO:	SCALE VALID FOR MASTER DRAWING ONLY 1:25 (1:1 ; 1:10)
	DRN.: ELAN SEIDEL	CHK.D: ELAN SPINDLER	STRESS : / SYST. :
	D.O.ORIG. D8518 DA	APP.D: ELAN MUELLER	WT.s : / PROCESS :

TITLE : AIRBUS

PASS.SITZ EINB. BHA08

PAX SEAT INST'N BHA08

PROJECTION SIZE 2A0

46 F252 99999 A ISSUE

CAD-DWG SHEET : 01

Appendix D

The Model of a Supplemental Type Certificate

SUPPLEMENTAL TYPE CERTIFICATE

10098880

Comment [r1]: **EASA Approval number:** This is the EASA approval number generated by the Agency's ERP system only once the technical visa has been issued and the project is technically closed.

This Supplemental Type Certificate is issued by EASA, acting in accordance with Regulation (EC) No. 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation and in accordance with Commission Regulation (EC) No. 1702/2003 to

Company Name
Any Road, 1
12345, Any Town
Any Country

and certifies that the change in the type design for the product listed below with the limitations and conditions specified meets the applicable Type Certification Basis and environmental protection requirements when operated within the conditions and limitations specified below:

Original Product Type Certificate Number:	EASA TCDS IM.A.XXX
Type Certificate Holder:	Company
Model:	1234
Original STC Number:	FAA STC STXXXXX-DE

EASA Certification Basis:
Certification Basis in accordance with EASA TCDS IM.A.XXX

Description of Design Change:
Installation of Digital Video Player (DVP) on a a/c

Associated Technical Documentation:
- Master Technical Drawing List Document N° XXXX, Revision C dated 24 December 2008
- Airplane Flight Manual Supplement Document N° XXXXX

or later revisions of the above listed documents approved by EASA in accordance with EASA ED Decision 2004/04/CF (or subsequent revisions of this decision)

Limitations and Conditions Sections are on the following sheet

For the European Aviation Safety Agency,

Date of issue: 24.09.2009

[Signatory
[Title]

Note:
The following numbers are listed on the certificate
EASA current Project Number: 0010007777-001
EASA old Project Number: P-EASA.A.R.XXXXX
Minor Repair Approval – 10098880 – Company Name

Comment [r2]: **Current project number:** This is the EASA project number which is communicated at task allocation and throughout the technical investigation.

Comment [r3]: **Old project number:** This is the project number used in the former project numbering system prior to the implantation of the Agency's ERP system. This number will only appear on EASA approvals related to projects started before Agency's ERP system Go-Live.

EASA Form 91, Issue 3 – 14/09/2009

Fig. C.1 Example of STC from EASA – page 1

Limitations:
Limited to Aircraft s/n 555

Conditions:

Prior to installation of this modification it must be determined that the interrelationship between this modification and any other previously installed modification and/ or repair will introduce no adverse effect upon the airworthiness of the product.

This Certificate shall remain valid unless otherwise surrendered or revoked.

-End-

Note:
The following numbers are listed on the certificate
EASA current Project Number: 0010007777-001
EASA old Project Number: P-EASA.A.R.XXXXX
Minor Repair Approval – 10098880 – Company Name

Comment [r4]:
Current project number:
This is the EASA project number which is communicated at task allocation and throughout the technical investigation.

Comment [r5]:
Old project number:
This is the project number used in the former project numbering system prior to the implantation of the Agency's ERP system. This number will only appear on EASA approvals related to projects started before Agency's ERP system Go-Live.

EASA Form 91, Issue 3 – 14/09/2009

Fig. C.2 Example of STC from EASA – page 2

Appendix E

GANNT Chart

This appendix lists the processes and their duration for the CIB case study expressed in a Gantt chart summing activities of both Airbus and ELAN.

Number	Task	Start	End	Duration
1	CR answering period	27/10/2008	14/11/2008	15
1.1	TO Build-up	27/10/2008	7/11/2008	10
1.2	RMO Build-up	10/11/2008	14/11/2008	5
2	Create Acceptance Telex	9/2/2009	10/2/2009	2
3	Create SB Order (SB Comp)	16/2/2009	17/2/2009	2
4	DFM coord.&Internal Kickoff	11/2/2009	26/2/2009	12
5	DFM Follow up	9/2/2009	27/2/2009	15
6	Start Production Activity	10/2/2009	10/2/2009	1
7	TRS/MP Creation/Input to Par 23-1	17/2/2009	23/2/2009	5
8	MOD Opening	11/2/2009	16/2/2009	4
9	CDF Contract. definite freeze	11/2/2009	10/3/2009	20
10	SU Eng.Design/Drawing & PLOC	6/3/2009	10/6/2009	69
10.1	Z01: Delivery LLT ATA 25	6/3/2009	12/3/2009	5
10.2	Z02: Drawing Set#1	12/3/2009	31/3/2009	14
10.3	Z03: Drawing Set#2	31/3/2009	21/4/2009	16
10.4	Z04: Drawing Set#3	21/4/2009	6/5/2009	12
10.5	Z06: Drawing Set#4	6/5/2009	27/5/2009	16
10.6	Z07: Top Drawing Delivery	27/5/2009	10/6/2009	11
10.7	Z05: Delivery LLT ATA 23	21/4/2009	6/5/2009	12
11	Spec. & Drawing follow-up	25/2/2009	16/6/2009	80
12	SUCVOUT Activities	11/2/2009	16/6/2009	90
13	LLT-P-Loc	12/5/2009	13/5/2009	2
14	LLT-Kit Defi./Procurement	14/5/2009	13/10/2009	109
15	100% KitDefi./Procurement	25/6/2009	15/10/2009	81
16	1st Shipset Delivery	16/10/2009	19/10/2009	2
17	SB Authoring & Draft schedule	29/6/2009	3/8/2009	26
18	TD Creat. & Engin.Follow-up	25/6/2009	3/7/2009	7
19	MAS Creat.& Engin.Follow-up	13/7/2009	3/8/2009	16
20	Certification follow-up	24/6/2009	3/8/2009	29
21	SB Draft Target Date	3/8/2009	3/8/2009	1
22	SB Scrutiny	4/8/2009	10/8/2009	5
23	SB Approval	11/8/2009	17/8/2009	5
24	SB Coordination & Issue sche	11/2/2009	3/3/2009	15
25	SB Issue Target Date	17/8/2009	17/8/2009	1
26	WP support/assistance	17/8/2009	17/8/2009	1
27	SB Contractual Date	17/8/2009	17/8/2009	1
28	SUCSOUT Activities	25/2/2009	28/7/2009	110
29	TRS/TD/MAS Approval	17/2/2009	2/6/2009	76
30	KIT ALERT	9/2/2009	9/2/2009	1
31	Current Kit Contractual Date	19/10/2009	19/10/2009	1
32	Last Kit Delivered	19/10/2009	20/10/2009	2
33	List of MOD/MP	9/2/2009	20/2/2009	10
34	SUY Contribution	7/10/2008	20/1/2009	76
35	Acceptance Telex	12/2/2009	12/2/2009	1
36	MOD/MP List	18/2/2009	18/2/2009	1
37	PMP FUP Planif	13/2/2009	13/2/2009	1
38	SB Order by SUC	18/2/2009	18/2/2009	1
39	SB Order for Contrib. TD	18/2/2009	18/2/2009	1
40	TRS / TD / MAS	19/2/2009	25/3/2009	25
41	SB Elec Drawing	26/2/2009	1/4/2009	25
42	P-LOC	26/2/2009	4/3/2009	5
43	SB Preparation Sheet	19/2/2009	1/4/2009	30
44	SB Authoring	12/3/2009	1/4/2009	15
45	LOC France	23/3/2009	23/3/2009	1
46	SB Quality Check	2/4/2009	8/4/2009	5
47	SB Draft Contrib. Scheduled	8/4/2009	8/4/2009	1
48	SB Contribution Target Date	6/7/2009	6/7/2009	1
49	SB Draft Target Date SB COM	3/8/2009	3/8/2009	1

Legend:

- Blue – Airbus processes
- Red – ELAN processes
- Light red – Airbus processes direct inlfuenced by ELAN input
- Light blue – Airbus processes indirectly influenced by ELAN input