Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Project

Department Fahrzeugtechnik und Flugzeugbau

Business Opportunities in Aircraft Cabin Conversion and Refurbishing

Yann Reber

1 July 2009

Abstract

The need to modify the aircraft interior during its useful life has grown at an unprecedented rate since the last years. For several reasons, airlines and aircraft owners are undertaking the retrofit of their airplanes in a shorter cycle than before. It is here an attempt to investigate this emerging and growing market, and to forecast its evolution for the next 20 years. The volume of each cabin modification scenarios, along with the world distribution of this demand, will be determined. The different level of comfort and amenities among several types of cabins will be investigated and the different modification scenarios will be identified. For each of them, (overall redesign of international cabins, overall redesign of domestic cabins, cabin conversion of aircrafts on operating lease, freighter conversion, VIP cabin modification) the duration of a modification as well as the frequency of the modifications that are undertaken during the entire aircraft life will be determined. Moreover the investigation of the factors which drive the demand for cabin modifications will help to conclude about the future trend. Several aircraft databases, which include the current world fleet as well as the forecasted fleet for the next years, will be used with this information in order to forecast the volume of cabin modifications. The conclusion of this study is reflected in the following numbers: about 38000 cabin redesigns will be undertaken within the next 20 years. There will be also 2500 conversions of jetliners into freighters and 25000 cabin modifications at VIP standards. North American and European markets will have influence but there is a very strong emerging demand from Asian markets. Their big influence on the demand put them at the front rank.

Business Opportunities in Aircraft Cabin Conversion and Refurbishing

Project

Background

The life of an aircraft cabin is not static. Cabins are redesigned, refurbished and converted (Pax-to-Freighter, Pax-to-VIP, Pax-to-Pax). For this reason, business opportunities exist around cabin related activities. Even in a climate of economic downturn, the cabin market is quite strong and is expected to grow. A change of important economic factors requires airlines to adapt. Without available money to buy new aircrafts, the need to convert the fleet and to bring old aircrafts to new tasks is vital. A completion center is an organization that deals with cabin conversion and refurbishing, starting from a customer request up to delivery. Some completion centers handle the conversion of smaller aircraft types in an autonomous way. A few big companies in the field also handle conversions of large passenger aircrafts from Air bus or Boeing autonomously. Engineering offices have traditionally supported the aircraft manufacturers in selected cabin design activities under the aircraft manufacturer's guidance. The future, however, seems to belong to companies who are independent and approved design organizations, capable of offering work packages along the entire process chain for a complete cabin conversion.

Task

Analyze the demand for cabin conversion of large and small aeroplanes (CS-23 and CS-25) and predict a market volume for a hypothetical engineering office, establishing itself as a Completion Centre.

The task consists of these sub tasks:

- Investigation of aircraft data (manufacturer, aircraft family/class/model, age of aircraft).
- Deduction of criteria which are relevant for cabin conversion (conversion cycles, conversion scenario like: Pax-to-Freighter, Pax-to-VIP, Pax-to-Pax, small/large aircrafts, extend of the conversion).
- Forecast of the market volume.

- Investigation of companies offering cabin conversion and classification of these companies: position inside the process chain, aircraft types, type of conversion.

A systematic approach to the topic should be applied. Data should be collected with an apropriate software tool. All relevant sources of information should be considered ranging from libraries, internet resources, aviation statistics institutes as well as all relevant companies in the field.

The report has to be written in English based on German or international standards on report writing.

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Nomenclature

$age_{scenario\_limit}$	aircraft age for which the refurbishment is no longer planned by the operator.
$date_{aircraft\_delivery}$	date of the aircraft first delivery
$date_{modification}$	date at which the end of the next modification program is planned
$date_{previous\_modification}$	date at which ended the last retrofit program for the same aircraft
$date_{today}$	date of computation
$duration_{equivalent}$	equivalent duration of one aircraft refurbishment as if aircrafts were retrofitted one after the others
$duration_{scenario}$	duration of the retrofit program. It also depends on the scenario.
$duration_{scenario\_period}$	duration of the period within which cabin modifications should be undertaken
$frequency_{scenario}$	time between the end of the last retrofit program and the begin of the next scheduled retrofit program. It depends of course of the cabin modification scenario in which the aircraft is involved.
n	total number of cabin modifications
$n_{AdditionnalAirplanes}$	number of freighter deliveries
$n_{aircraft}$	number of cabin modifications that could be undertaken for one aircraft
$n_{FreigtherConversion}$	total amount of freighter conversions
n_{loop}	number of loop executions of the program
$n_{FreighterConversion}^{world\_region}$	amount of freighter conversions in a specific world region
$p_{FreighterConversion}$	proportion of conversions in the freighter deliveries
$p_{FreighterFleet}^{world\_region}$	proportion of the freighter fleet in a specific region
$volume_{fleet}$	volume of the fleet (same aircraft type) of an airline

List of Abbreviations

BBJ	Boeing Business Jet
BC	Business Class
CS	Certification Specification
FC	First Class
FY	Fiscal Year
IFE	In-Flight Entertainment
LCC	Low Cost Carrier
MRO	Maintenance, Repair and Overhaul
NM	Nautical Mile
OEM	Original Equipment Manufacturer
PAX	Passengers
RPK	Revenue Passenger Kilometer
TV	Television
URL	Universal Resource Locator
VBA	Visual Basic for Applications
VIP	Very Important Person
YC	Economy Class

Terms and Definitions

All-business-class airlines:
These are airlines which operate jetliners with a single-class cabin configuration (that is to say Business Class).

Cabin Configuration:
Each cabin configuration is linked to a specific type of cabin as well as to a specific seat layout: passenger version with a specific seats layout, freighter version and VIP version.

Cabin Conversion:
The cabin conversion is the modification of the cabin interiors from a configuration to another. For instance, a freighter conversion is the modification of a cabin in the passenger configuration to the freighter configuration.

Cabin Modification:
The cabin modification groups all the existing scenarios about the modification of the aircraft interior: refurbishment of a used cabin, conversion of the cabin from one seat configuration to another, completion of a VIP cabin.

Cabin Refurbishment:
The cabin refurbishment consists of the redesign of aircraft used aircraft interior and its installation onboard.

Cargo:
This is anything other than passengers, carried for hire, including both mail and freight (**ATA 2009**).

Charter service:
This is a transport service when an aircraft, typically the entire aircraft, is hired for a non-scheduled trip (**ATA 2009**).

Check C:
In maintenance, a C-Check usually refers to a comprehensive inspection performed at rather large increments of either aircraft time in service or calendar years since certification. The actual inspection increment varies between aircraft models and is determined by the manufac-

turer along with the governing authority over the certification each individual aircraft. Thus the same model of airplane may require inspections at different times depending on the country it is registered in. The scope of a C check is usually entirely comprehensive, meaning every square inch of the aircraft structure is inspected and every system tested/serviced.

Check D:
This is the heaviest check for the airplane, also known as a Heavy Maintenance visit (HMV). This check occurs approximately every 4-5 years. This is the check that, more or less, takes the entire airplane apart for inspection. This requires even more space and time than all other checks, and must be performed at a maintenance base. Often, older aircraft being phased out of a particular airlines' fleet are stored or scrapped upon reaching their next check.

Coach seats:
This is another name for Economy Class.

Completion centers:
The completion centers are the centers which are capable to carry out any modification on VIP cabins.

Full service carrier:
A Full Service Carrier provides in-flight meals, entertainment and other complementary services compared to Low Cost Carriers. Hence, the fares charged are generally higher. It services also incorporate hub and spoke networks and it offers a variety of air travel classes such as first (F), business (C) and economy (E) classes.

Green aircraft:
This designates an aircraft just after being manufactured which have still no painting. Usually, this aircraft goes to a Completion Center to get its interior completed.

Low cost carrier:
A low-cost carrier or low-cost airline is an airline that offers generally low fares in exchange for eliminating many traditional passenger services.

Modification center:
Modification centers group all the centers that are capable to carry out a cabin modification, for example, a center that carries out freighter conversions.

Narrow-body aircraft:
It designates an aircraft that is not a wide-body aircraft.

Premium cabins:
It groups several classes with different comfort standards: First, Business, and eventually Premium Economy Classes.

Scheduled service:
This is a transport service based on published flight schedules, including extra sections (**ATA 2009**).

Seat pitch:
The distance between seats in an aircraft's passenger cabin as measured from any point on a given seat to the corresponding point on the seat in front of or behind it (**ATA 2009**).

Seat width:
Seat width is the distance from armrest to armrest (**Wikipedia 2009c**).

Single-aisle:
This is an aircraft with a single aisle in the cabin. Usually, it designates a narrow-body aircraft.

Twin-aisle:
This is an aircraft with two aisles in the cabin. Usually, it designates a wide-body aircraft.

VIP Hi-end Completion:
This completion consists in completing the aircraft interior after its manufacturing according to the specific requirements of the aircraft owner.

VIP Cabin Modification:
The cabin VIP modification groups all the existing scenarios about the modification of the aircraft interiors in the VIP configuration: VIP Hi-end Completion, VIP Cabin Refurbishment and the conversion from the passenger configuration to the VIP configuration.

Wide-body aircraft:

It is generally an airliner with more than one aisle in the passenger cabin. Examples of wide-body aircraft include the Airbus A300, A310, A330, A340, A350 and A380; the Boeing B-747, B-767, B-777, B-787, DC-10 and MD-11. Technically, any aircraft with a fuselage diameter in excess of 200 inches may be considered a wide-body (**ATA 2009**).

1 Introduction

1.1 Motivation

The demand for cabin modifications is growing at an unprecedented rate and the evolution of the distribution between the different segments of this market changes very fast. For a company wanting to establish itself as a completion center, it is a major issue to identify the segments where the largest profits can be made for the next twenty years. It is also necessary to investigate the driving factors and the world regions where the growth rate of this demand will be the most important. In that way, the completion center gets a global outlook on the market for the years to come and can decide where it should be better to establish and which customers is better to target.

1.2 Objectives

The main objectives are:

- To group data from CS-23 and CS-25 world fleet
- To identify the different cabin modification scenarios for these aircrafts
- To estimate their number for the next 25 years
- To identify the completion centers existing on the market and their characteristics
- To investigate the business opportunities of this market for a completion centre

1.3 Report structure

A quick overview on the cabin modification will be first introduced. The comfort standards and the characteristics of each type of cabin will therefore be investigated. Then the different types of modifications of these cabins would be identifying and would be related to a group of airlines and to a group of aircrafts. In the second part, an analysis of the parameters of these modifications will be undertaken which will enable the forecast of the cabin modification demand. These characteristics are the factors that drive the current demand, the frequency and the duration of each modification scenario throughout the aircraft useful life, and the characteristics of the modification center which complete the work. In the third part, the current world fleet and its forecast for the period 2007-2028 will be investigated in order to get an overview about the future fleet volume and the repartition of this fleet. Then, the forecast

method will be explained along with the database used for the forecast. The results will be presented and analyzed. The last part will focus on the classification of the modification centers, their type of work and their customers.

2 Cabin Modification: Current Market Overview

Our first objective is to get a quick overview about the amenities, the look and the comfort of the exisiting cabins installed on airliners or on executive aircrafts. This will show the comfort standards currently required by operators or private owners. Then, modifications of these several types of cabins will be investigated and the characteristics of the different scenarios of cabin modification will be defined.

2.1 Airliners

2.1.1 Comfort and Amenities Standards of an Airliner Cabin

The Domestic Economy Class

Domestic Economy Class is only found on domestic flights. This type of cabin has the lowest comfort level and the lowest class of seating compared to other classes. There are slight variations in seat pitch and width among airlines and airplanes (**SeatGuru 2009***)*. In addition, some airlines (Cathay Pacific and Quantas) offer in-flight video services or laptop power ports that can make the flight more enjoyable. Low-cost carriers often offer only economy class. These airlines are often associated with short-pitch seats but also lower fares (**Wikipedia 2009a**). Figure 2.1 shows a typical Domestic Economy Class.

Figure 2.1 Domestic Economy Class on a Jazeera Airways A320-200 (**Airliners 2009a**)

Domestic First and Business Classes

Domestic First and Business Classes are only found on domestic flights. There are only small improvements over most coach class seats and there aren't any legrests. Airlines have started offering these seats to customers that pay for full fare coach tickets as they try to increase their revenue from these seats (**SeatGuru 2009**). There may be a curtain to separate business from economy class, based on demand, but the seats are in the same cabin. Some airlines (Lufthansa and British Airways) use convertible seats that seat three people across in economy, or adjust with a lever to become two seats with a half seat length between them for business class use (**Wikipedia 2009b**). In Figure 2.2 and Figure 2.3 is shown what to expect from a Domestic First Class.

Figure 2.2 Domestic First Class on an Air Canada A320-200 (**Airliners 2009b**)

Figure 2.3 Domestic First Class on Japan Airlines (**JAL 2007**)

The International Economy Class

The International Economy Class is only found on International Flights i.e. on long-haul routes. There are slight variations in seat pitch and width among airlines and airplanes. In addition, some airlines offer in-flight video services or laptop power ports that can make the flight more enjoyable (**SeatGuru 2009**). Some video screens, especially on older planes, are mounted on the ceiling of the aircraft or on a bulkhead so that all passengers in the cabin watch the same film. If there is an individual screen for each seat or partial row of seats, it may be smaller than first and business class screens, or there may be fewer video channels available (**Wikipedia 2009a**). Figure 2.4 and Figure 2.5 show a typical Economy Class.

Figure 2.4 International Economy Class on a Finnair A330-300 (**Airliners 2009c**)

Figure 2.5 International Economy Class on a Singapore Airlines B777-200ER (**Airliners 2009e**)

The International Premium Economy Class

Premium Economy is a travel class offered on some airlines, taking one of two forms **(Wikipedia 2009d**):

- a simple upgrade to the Economy class as a section of the economy/coach cabin, which generally provides more legroom by removing a few rows of seats, along with some form of leg rest, possibly enhanced In-flight entertainment and dedicated cabin crew.
- a more comprehensive upgrade, which will normally be in the form of a separate cabin section, combining the enhanced legroom of the simple upgrade with better seats.

Premium Economy is found mostly on international flights (**SeatGuru 2009**). Figure 2.6 and Figure 2.7 show typical Premium Economy cabins.

Figure 2.6 International Premium Economy Class on a Japan Airline B777 (**JAL 2007**)

Figure 2.7 International Premium Economy Class on a BMI A330-200 (**Airliners 2009d**)

The International Business Class

Business Class is found mostly on international routes and planes that are configured for long-haul travel (**SeatGuru 2009**). Its level of accommodation is higher than Domestic Economy, Domestic First and Premium Economy but lower than International First. However, many international airlines offer only Business Class as the highest level of service. In fact, they have installed "lie flat" seats into Business Class, whereas previously seats with such a recline were only available in International First Class. In Figure 2.8 is what to expect in International Business.

Figure 2.8 International Business Class of Singapore Airlines (**Wikipedia 2009b**)

There are essentially three types of long-haul Business Class seats today. These are listed in the Table 2.1 in ascending order of perceived "quality".

Table 2.1 Seat Types in International Business Class (**SeatGuru 2009**)

Seat Type	Drawing	Description
Recliner Seats or Cradle Seats		around 160 degrees of recline
Angled Lie-Flat Seats		recline 180 degrees to provide a flat sleeping surface
Flat Bed Seats		recline into a flat sleeping surface which is parallel to the floor

The International First Class

International First Class is only found on long-haul routes (**SeatGuru 2009**). This class of service offers more comfort and amenities than International Business. There are not significant differences between airlines concerning IFE, service and amenities. However, the type of seat offered can vary significantly. Additionaly to all seat types offered in International Business, another type of seats called Suites is available. It is an individual mini-cabin which includes a fully-flat bed, work station and television. In Figure 2.9 and Figure 2.10 is what to expect in International First Class.

Figure 2.9 International First Class of Swiss Air Lines (**PSFK 2009**)

Figure 2.10 International First Class on a A380 of Lufthansa (**NYT 2009**)

Comfort comparison between classes

The Table 2.2 summarizes the differences between all classes available on airliners. These data come from **SeatGuru 2009**.

Table 2.2 The different comfort standards on airliners

	Seat Pitch (inch)	Seat Width (inch)	Degree of recline	Electric Seat Controls	Legrest and Lumbar Support	Overhead or Personal TV	Laptop Power Ports	Mini-Cabin
Domestic Economy	30-32 (average)	17-18 (average)	+	No	No	0	No	No
Domestic First or Business	35-39 (legroom)	19-20	+	No	No	0	No	No
International Economy	30-36	17-18	+	No	No	+	No	No
Premium Economy	35-43 (legroom)	19-20	++	No	Yes	++	Yes	No
International Business	62-64 (legroom)	20-21	+++	Yes	Yes	+++	Yes	No
International First	73-93 (legroom)	21-23	++++	Yes	Yes	++++	Yes	Yes

2.1.2 Cabin Modification Scenarios in PAX Configuration

According to the last paragraph, airlines have the choice among different standards to meet passenger requirements. As the demand changes quickly, they have to reconfigure the seats layout and retrofit the cabin in order to remain competitive. Modifications that are usually undertaken by airlines will now be investigated

Overall Redesign of International Cabins

The first modification scenario that should be considered is the overall redesign of international cabins. In this term is included:

- The International First and Business Class
- The International Premium Economy and Economy Class

Swiss Air has redesigned its first class cabin in 2009 (**PSFK 2009**). It has completed the installation of new seats offering passengers additional privacy, space, and connectivity (23″ screen, fold out tables, full length bed, touch screen remote to control all seating and rest arrangements).

In 2004, China Southern Airlines has retrofitted its International First Class on B777s (**BNet 2004**). The carrier has undertaken:

- a reconfiguration of its premium cabin, increasing the number of seats in the First Class cabin while removing some Business Class seats.
- The new First Class seats facility with more degree of recline (expanding from 60 inches to 70 inches)

United Airlines has undertaken a refurbishment (that should be finished in 2009) of their Business Class cabin for the entire international fleet (**Luxist 2007**) including the installation of new seats (reclining to a 6-foot and 4-inch lie-flat bed, audio and video on-demand, and video screen).

Malaysia Airlines began in 2004 to overhaul its B777-200 fleet (**ATT 2004**). The upgrading includes:

- Cabin Reconfiguration from three to two classes (Business Class and Economy Class)
- 58-inch seat pitch with angled flat beds facility for the Business Class
- Installation of new IFE system for Economy Class

In 2009, Finnair renews for its brand new A330 the look of the cabin interior and its seats, the form language of fittings, colours, textiles and coverings as well as materials and lighting. The designer began preparing for the latest cabin facelift two years ago (**Finnair 2009**).

Japan Airlines has introduced in FY 2007 a Premium Economy Class on long-haul B777 (**JAL 2007**). In FY 2008, they introduced new seats in all international passenger classes (First, Business and Economy)

Figure 2.11 shows an example of an A340-300 cabin reconfiguration undertaken by Cathay Pacific (**Cathay 2009**). On the left side is the new version where First Class has been removed.

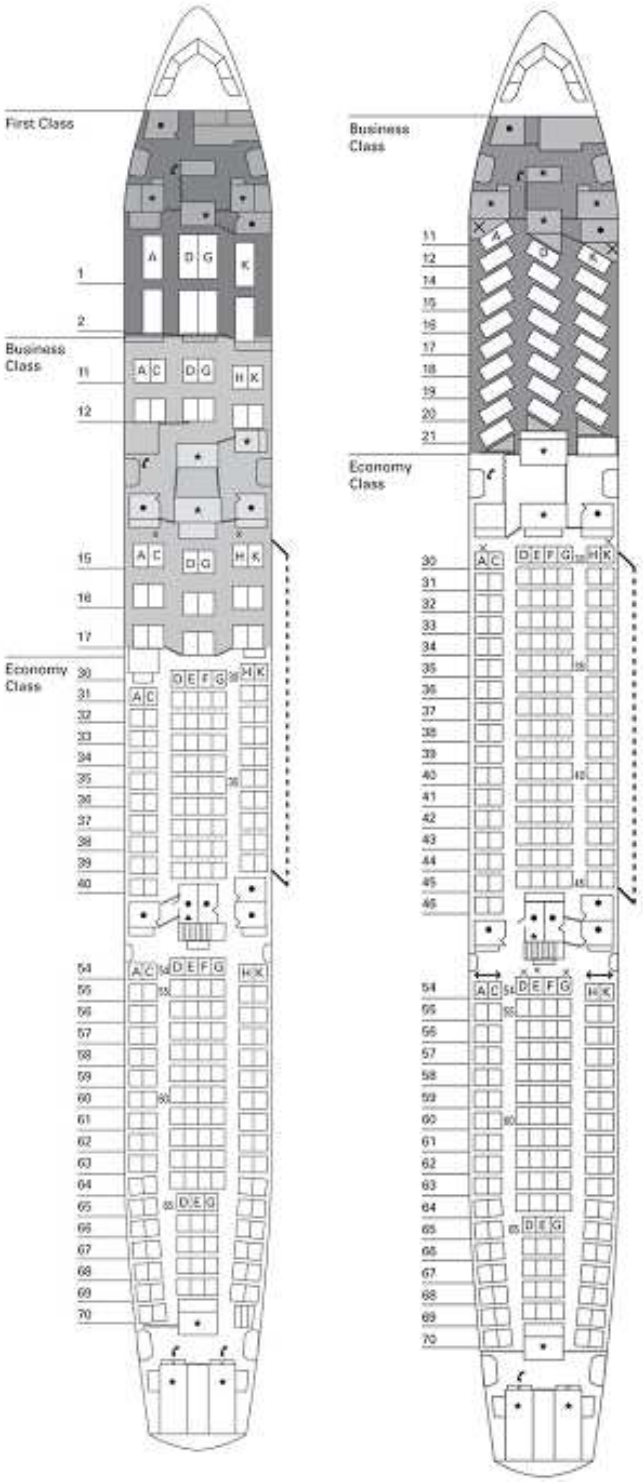


Figure 2.11 A340-300 Cabin Reconfiguration of Cathay Pacific

The Table 2.3 groups all examples found about the redesign of International Cabins (**PAL 2009, JAL 2007, PSFK 2009, Luxist 2007, ATT 2004, BNet 2004, Air France 2009b, Swiss 2008a, Dragonair 2003, Cathay 2007, Cathay 2009**).

Table 2.3 International Cabin Redesign: exemplary specifications

	Aircraft Type Affected	Entire fleet type Re-design	Premium Economy Introduction	Layout re-configura-tion	New seats facility		
					FC	BC	YC
Malaysia Airlines	B777-200	Yes	No	Yes	removed	Yes	Only IFE
	B747-400	Yes	No	Yes	Yes	Yes	Only IFE
Japan Airlines	B777	Yes	Yes	Yes	Yes	Yes	Yes
United Airlines	Entire long-haul fleet	Yes	No	No	No	Yes	No
Swiss Airlines	A330-300 A340	Yes	No	No	Yes	Yes	No
China Southern Airlines	B777	Yes	No	Yes	Yes	No	No
Air France	B777 A330 A340	Yes	Yes	Yes	Yes	Yes	Only IFE
Philippine Airlines	B747-400	Yes	No	Yes	removed	Yes	Yes
Dragonair	Entire long-haul fleet	Yes	No	Yes	Yes	Yes	Only re-covered
Cathay Pacific	Entire long-haul fleet	Yes	No	Yes	Yes	Yes	Yes

According to the Table 2.3, most of the refurbishments include:

- New distribution of classes due to:
    - Premium Economy Class apparition
    - First Class removal
    - Seats Removal to gain space
- New seats facility for First Class and Business Class
- New look of the cabin (new carpets, curtains, lighting, galleys, lavatories)
- IFE upgrading for Economy Class

The refurbishment of an aircraft type affects always the entire fleet as part of a retrofit program. If the retrofit is undertaken, the layout is reconfigured; First and Business Class are upgraded. If new Economy Class seats facility is needed, it is completed at the same time.

Aircrafts affected by these modifications are configured for long-haul flights. These aircrafts are usually wide-bodies. Moreover these aircrafts are not leased ones (see paragraph 2.1.2.3).

Airlines that undertake such a modification are full service carriers operating wide-bodies with premium service. Therefore they should be differentiated from LCC or full service carrier operating charter service. Indeed almost all LCC do not operate wide-bodies.

The Table 2.4 summarizes the specifications of the Overall Redesign of International Cabins and the characteristics of the airlines and aircrafts affected by this modification.

Table 2.4 Overall Redesign of International Cabins: usual specifications

Type of modification	Description	Aircraft Type affected	Airline affected
Overall redesing of International Cabins	New distribution of classes, new seats facility for premium cabins, IFE upgrading for Economy Class, New cabin look	Wide-body No aircraft on operating lease	Full service carrier without charter service

Overall Redesign of Domestic Cabins

The second modification scenario that should be considered is the overall redesign of domestic cabins. In this term is included:

- Domestic Economy Class
- Domestic Business or First Class

Business class has started to disappear from some short/medium haul routes, to be replaced with full fare economy and discount economy (KLM and SAS). On these routes, the seats are the same for all passengers.

On shorter routes (typically less than one hour) many airlines have removed business class entirely (e.g. BMI on many routes) and offer only one class of service.

Most low-cost carriers, such as Ryanair in Europe and JetBlue in the United States, do not offer any premium classes of service (**Wikipedia 2009b**).

The programme to re-equip all 52 aircraft of SWISS's European fleet with new seats has now been completed. As a result, passengers on all SWISS flights within Europe can now enjoy the greater legroom and seating comfort offered by the new high-quality seats. Since then, not only its entire short-haul Airbus fleet but also all the Avro RJ100s of its Swiss European Air Lines subsidiary have been equipped with the new seats. By having the seat pocket at the rear placed higher than on previous seating models, the new Recaro seats provide more legroom for the passenger seated behind (**Swiss 2008b**). Figure 2.12 shows an example of seats refurbishment program for short-haul aircrafts.

Figure 2.12 Seats refurbishment program for an A320 of Swiss Airlines. News seats are on the left figure (**Airliners 2009f, Airliners 2009g**).

In 2007, Finnair fitted its Airbus A320 aircraft with new light structure seating that makes it possible to add as many as 15 seats to configurations. The Recaro Slimline CL3510 seating model uses new technology with a light build and modern design, allowing more leg room even though the seats are closer together (**BNet 2007**).

In 2001, Olympic Airways undertook the fully refurbishment of 11 Boeing 737-200, 3 Airbus and 13 Boeing 737-400s. The refurbishment which affects the entire short-haul fleet consists of changing the colours and materials used on carpeting, wallpaper, the plastic and foam rubber on passenger seats, seatbelts, wall coverings and flight attendants seats. All entrance ways and other surfaces of the cabin have been upgraded. Part of the refurbishment is the installation of new Business Class seats in the Boeing 737 -200, -300 and -400 aircraft family. Convertible leather seats that convert from a 3-3 layout to a more comfortable 2-3 layout and 35 inches of seat pitch giving increased personal space. A spacious drinks table now separates two seats from each other. The seats also have footrests, adjustable headrests and backs that recline at a greater angle than before (**Captain Chris 2000**).

Cronus Airlines refurbished the cabins of its 6 aircrafts (B737-300 and B737-400) in 2001. All cabins have comfortable leather seats with leg room with new configuration for the Business Class from 3-3 to 2-3 seats abreast (**Captain Chris 2000**).

Delta Airlines undertook in 2004 a refurbishment for the MD 90 and MD 88 fleet which include all-new leather seating, both in first class and coach, new wall coverings, and updated lavatories (**Cheap Flights 2006**).

The Table 2.5 groups all examples found about the redesign of Domestic Cabins (**Swiss 2008b, BNet 2007, Wikipedia 2009b, ATT 2005, Captain Chris 2000, Cheap Flights 2006**).

Table 2.5 Domestic Cabin Redesign: exemplary specifications

Airlines	Aircraft Type affected	Entire fleet type Re-design	Cabin sur-faces up-grade	Seats re-configura-tio	New seats facility	
					BC	YC
Swiss Airlines	Entire short-haul fleet	Yes	Yes	No	Yes	Yes
Finnair	A320	Yes	-	Yes	Yes	Yes
KLM	Entire short-haul fleet				removed	
SAS	Entire short-haul fleet				removed	
Olympic Airways	Entire short-haul fleet	Yes	Yes	Yes	Yes	Only recovered
Cronus Airlines	Entire short-haul fleet	Yes	Yes	Yes	Yes	Only recovered
Air Canada	Entire short-haul fleet	Yes	Yes	-	Yes	Yes
Delta Airlines	MD 90, MD 88	Yes	Yes	-	Yes	Yes

The Table 2.6 summarizes the specifications of the Overall Redesign of Domestic Cabins and the characteristics of the airlines and aircrafts involved in this modification.

Table 2.6 Overall Redesign of Domestic Cabins: usual specifications

Type of modification	Description	Aircraft Type affected	Airline affected
Overall redesing of Domestic Cabins	New distribution of classes, new seats facility for all classes, New cabin look	Narrow-body No aircraft on operating lease	All carriers

Cabin Conversion for Aircrafts on Operating Lease

The last cabin modification in PAX configuration that should be considered is the cabin refurbishment on leased aircraft.

The aircraft lease is for airlines an alternative solution to the purchase of brand new aircrafts (**Aeroconseil 2009**). It is the best way for these operators to adapt their fleet to the air traffic and to passenger demand. As a result, more and more airliners are transferred from an airline to another during its useful life.

Once these aircrafts are operated by the new airline, they have to meet the operator policy and requirements. The airline needs therefore to modify the cabin interior. The aircraft is sent for Post Delivery Modification (PDM) and is refurbished so as to fully conform with the equipment and location specification for the airline standards (**SAS 1998**). This operation usually includes:

- New seats facility
- New classes distribution
- New seat pitch

For instance, an ex. Swissair DC-9-80 was leased in 1998 by SAS. The work consisted, among other things, of cabin refurbishment to SAS standards (**SAS 1998**).

The Table 2.7 summarizes the specifications of the cabin conversion for aircrafts on operating lease and the characteristics of the airlines and aircrafts involved in this modification.

Table 2.7 Cabin Conversion for aircrafts on operating lease: usual specifications

Type of modification	Description	Aircraft Type affected	Airline affected
Cabin Conversion for aircrafts on operating lease	Same operations as for international or domestic cabins	aircrafts on operating lease	All carriers

2.2 Freighters

2.2.1 Freighter cabin requirements

Freighter aircrafts normally have strengthened cabin floors and the inclusion of a broad top-hinged door on the port fuselage in addition to an absence of passenger cabin windows which are "plugged" (**Wikipedia 2009e**).

Figure 2.13 gives an example of a Freighter cabin.

Figure 2.13 Freighter Cabin of an A300 (**EADS 2009**)

2.2.2 Freighter Jetliner Retrofit Program

A freighter jetliner retrofit is the conversion of an airliner cabin (in PAX configuration) into a freighter cabin. Modification centers will utilise aircrafts that have completed their useful lives as passenger jetliners, and will transform them to the freighter configuration (**Airbus 2009**).

As an example, the freighter conversion completed by *EFW* is investigated. After removal of all structural and system components that are no longer needed, such as seats or floor structures, the new freighter kits are installed (**EADS 2009**):

- A cargo door and the related structural parts are installed.

- The cabin floor designed for passengers is replaced by a new floor structure with higher strength.
- Ball mats and roller tracks for loading of containers complete the conversion of the floor structure.
- Necessary adjustments and completions of the aircraft systems are carried out.

Finally, system tests are performed. After customer inspection and acceptance flight, the conversion work is documented and the aircraft handed over to the customer.

Figure 2.14 shows the completion of such a conversion with new floor structure installation.

Figure 2.14 Freighter Conversion of an A300 (**EADS 2009**)

For the freighter conversion completed by Boeing, the B747 will be modified with a side cargo door and layout that is identical to the 747-400 production freighter, with 30 pallets on the main deck and comparable volume. The longer upper deck of the Special Freighter will include seating for up to 19 people, an option found on no other converted freighter. Also included in the conversion is a strengthened main-deck floor, full main-deck lining, provisions for a new cargo handling system and revised flight-deck systems (**Boeing 2003**).

The process of freighter conversion usually includes incorporating a large wide cargo door in the fuselage, installing a new reinforced main deck floor, and integrating cargo loading systems.

Not each type of aircrafts would be used as freighter. Over the next decade, ACMG predicts that 737-300s/-400s and 757-200s will be the most popular narrow-body models for freighter application (**ACW 2003**). In the medium wide-body category, it will be A300-600s and 767-

200s, and in the large capacity segment it will be 747-400s and MD-11s. Only the A300-600F, 747-400F, 777F, A320P2F and A321P2F are available as new-built production freighters, which means the majority of the additional freighters will be passenger-to-freighter conversions.

The Table 2.8 summarizes the specifications of the Freighter Conversions, the characteristics of the airlines and aircrafts affected by this modification.

Table 2.8 Freighter Conversion: usual specifications

Type of modification	Description	Aircraft Type affected	Airline affected
Freighter conversion	Incorporating a large wide cargo door in the fuselage installing a new reinforced main deck floor Integrating cargo loading systems .	B737-300/400 B757-200 A300-600 B767-200 B747-400	All airlines which provide freighter service and passenger service

2.3 Executive Aircrafts

2.3.1 Comfort and Amenities Standards on Executive Aircrafts

The interior plays an increasingly important role for business jet operators and private individuals.

Figure 2.15 Lufthansa Technik includes a conference dining room in its concept of the A380 main deck (**Aviation Today 2008**).

Whether it's taking a warm shower, relaxing on a corner couch, sleeping on a queen-size mattress or enjoying a Ralph Lauren or Versace-themed interior, the range of cabin options available to business jet and private operators is limited only by what can be certified. Through the years, customers ask for a lot of different things ranging from waterbeds, hot tubs, stationary bikes, bean bag chairs, chandelier to unique materials, whether it be cork flooring or a granite or marble floor in the entry area, to custom artwork that they wanted to display or stingray skins on the lower sidewalls (**Aviation Today 2008**).

Figure 2.16 On the same A380, the upper deck includes a separate office area in the forward cabin (**Aviation Today 2008**).

The interior of the modern business aircraft has evolved, incorporating cabin management systems, wireless Internet and PDA connections, stain-proof seat fabrics and modern design elements. People now outfit the aircraft much like they outfit their home. Because it's their area, their place to relax, while going from point A to point B. They treat the aircraft as a house now, or a place to do business, a mobile office (**Aviation Today 2008**).

2.3.2 Modification Scenarios for a VIP Cabin

VIP High-End Completion

When they buy a brand new aircraft, most of VIPs have so special requirements about the interior equipment and design that the aircraft manufacturer can't carry out the completion of the cabin. The green aircraft is sent to a specialised and independent company, often called a completion center, which takes charge of the design and the completion of the aircraft interior. This work is called Hi-End Completion.

The biggest challenges when completing a custom interior involve certification, engineering and timelines.A lot of thought and energy are invested in the initial conceptual design phase, so that the completion center does not lead the customer down a path that they know they can't get to (**Aviation Today 2008**).

Specialized cabins that involve one or more elements that have never been certified before can also add time to a completion project. It's important to meet with the customer first, establish realistic timelines, set milestones and keep communication open throughout the process.

Moreover, additional weight is always a major issue. When a customer asks for something specialized, anything that is moving inside the cabin has to withstand the various turbulence and movement that an aircraft does (**Aviation Today 2008**).

VIP Cabin Refurbishment

For several reasons, executive jet owners need to refurbish the aircraft interior during its useful life.

Aircraft owners today often use corporate jets to impress new clients or solidify the long-awaited business deal. Then, an aircraft interior can often reflect a positive or negative image about its owners and/or corporation. Therefore the need to refurbish the business jets interiors is a major issue (**SEM 2009**).

In the corporate/private/charter market, extra pounds don't mean as much in the cabin as they do in the airframe. The owners of these aircrafts do not want to reduce what they have in the cabin to save a few dollars by conserving fuel. They simply aim to maximize the comfort and functionality of the flying office/hotel room that's going to get them from Point A to Point B (**Aviation Week 2008a**).

Rather than gutting an aircraft to install all-new structures, the desire to make these structures look less dated and more suited to one's personal tastes underscores most projects. These refresh projects usually involves stripping and replacing (Aviation Week 2008a):

- cabinetry veneers
- soft coverings of the seats
- carpets
- the lighting

Sometimes these refresh projects involve exotic materials, such as inlaying cabin surfaces with rare, imported hardwoods from Asia and Africa. This trend is now identified by several manufacturers and equipment providers for completion centers and leads to big challenges (**Aviation Week 2008a**):

- The use of exotic materials that never have been installed in the aircraft environment has to pass flammability and certification tests.
- Getting into bigger changes in the cabin, such as reconfiguring seating or moving lavatories and galleys around, involves meeting recertification requirements.

PAX to VIP Conversion

Some VIPs buy a former Jetliner to use it as an executive aircraft. Therefore they need to convert the cabin to their own taste.

As an example of conversion from PAX to VIP configuration, 328 Support Services has signed a contract for the conversion of two VIP Dornier 328s with a private individual. This

aircraft, a former 31-seat airliner-configured 328 Jet will be modified into a 10-seat VIP aircraft. Special interiors features will include new sidewall with electric window blinds, a noise reduction kit, a Sat phone system, IFE system with eight individual TV monitors and soft leather seats. 328 Support Services will also carry out a series of heavy maintenance checks and other modifications prior to delivery (**BJII 2009**).

VIP Cabin Modification Summary

The Table 2.9 summarizes the specifications of the VIP Cabin Modification and the characteristics of the airlines and aircrafts involved in this modification.

Table 2.9 VIP Cabin Modification: usual specifications

Type of modification	Description	Aircraft Type affected	Type of owner
VIP Cabin Modification: VIP High-End Completion VIP cabin refurbishment PAX to VIP conversion	Stripping and replacing: Cabinetry veneers Seats soft coverings Carpets Lighting Installation of specific equipment	All Executive aircrafts: Business Jets Business Turboprops Corporate versions of Airliners	VIP owner State Government Business Airlines

3 Cabin Modification Characteristics

In this paragraph, relevant parameters for each cabin modification scenario will be identified in order to make the market volume forecast possible. First it will be determined when an airline proceeds to the retrofit of its aircraft cabins. Then, the factors which drive the demand of each scenario will be identifying along with the frequency (time between two retrofits) and the duration of the modification.

3.1 Modification Occurrence throughout the Aircraft Life Cycle

A cabin modification happens when a Check-D is scheduled as shown in the Figure 3.1. The Check-D requires the aircraft to be parked for a while. The operator can take this advantage to make a cabin modification completed. According to **Arzenheimer 2009**, airlines can even schedule a cabin retrofit for the check C. In that way, airlines loss less money as if they carried out a modification between two checks.

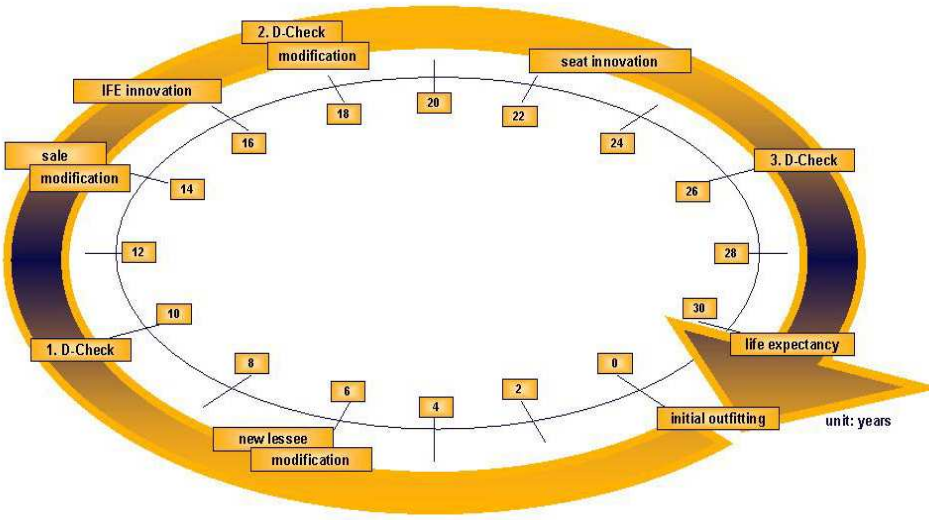


Figure 3.1 Exemplary Life Cycle of an Aircraft (**Lufthansa 2009**)

This observation is verified by some examples.

First Air Pacific's Boeing 747-400 refurbishment was part of a planned maintenance program in Singapore during October and November 2008. Air Pacific's second Boeing 747-400 aircraft received the same extensive refurbishment during scheduled maintenance in February and March 2009 (**Air Pacific 2008**).

Currently, Pakistan International Airlines has launched cabin refurbishment programme for the entire fleet wherein all the aircrafts, which will be coming for checks, will go out after

cabin refurbishment. So far one Boeing 737, two Airbus A310 and one Fokker F-27 have undergone through cabin refurbishment exercise. In addition one Airbus A-300B4, one Airbus A310 and one Fokker F27 are also undergoing the cabin refurbishment (**Pakistan 2000**).

An average C-check on a narrow-bodied aircraft is carried out every 4,000 flying hours or every 20 months, whichever comes first. It takes a ground time from five to eight days, meaning 2,500-3,500 man hours (**TOM 2007**).

A D-check on a wide-bodied aircraft means a complete strip-down and refurbishment of the aircraft. This is the heaviest check for the airplane, also known as a Heavy Maintenance visit (HMV). This check occurs approximately every 4-5 years (**Wikipedia 2009g**). This takes an average ground time of 30 days and between 28,000-40,000 man hours depending on the condition of the aircraft and additional work requested by the customer (**TOM 2007**).

3.2 Cabin Modification Characteristics in PAX Configuration

3.2.1 Overall Redesign of International Cabins

For more details about the definition and the specifications of the overall redesign of international cabins, see paragraph 2.1.2.1.

Driving factors

According to **ATW 2007a**, an airline has to remake their cabin in order to keep up with competiton. In fact an alliance partner or another competitor may have a better product and may be better perceived by passengers. Nowadays passengers expect comfort, service and entertainment. Cabin equipment together with service and speed are the decisive factors in forming passenger perception of the airline's efficiency. Therefore interiors are becoming an increasingly important element for differentiation of airlines (**Lufthansa 2009**).

In **Punch 2009**, industry experts explain that carriers now pay more attention to their cabin layout, design and IFE rather than the level of their aircraft competitivity. The aviation sector has become one of the hardest hit by the current global economy crisis:

- According to the International Air Transport Association’s statistics released in March 2009, passengers and cargo traffics continue to drop, standing at 10.1% and 23.2 % respectively.
- Middle East carriers, apparently with more cash, received support from their state governments.
- The meltdown has led to the preservation of cash among airlines and it is now forcing them to postpone major expenditures such as jet orders and deliveries.

All these economical factors have made competition tougher for European, American and Asian airlines. As a result, airlines have to focus more on cabin design to win passengers.

A new trend is the apparition of a new class called Premium Economy which usually request the reconfiguration of the seats distribution. Airlines offer more and more seats in this new premium cabin because if a full-service airline has a good reputation for flying premium class passengers, it is not difficult to attract economy class passengers, assuming the fares are structured in a competitive way (**ATW 2007b**). Moreover, many business travelers are not permitted by their employers to fly in traditional premium cabins. Providing an upgraded economy product, for high-mileage passengers or those willing to pay a few hundred dollars more makes sense in building and retaining a base of loyal customers (**ATW 2007b**).

In the last decade, some airlines began eliminating first class, though they have kept the amenities that make their highest-paying passengers feel like the most important people on board. The airlines themselves were, in part, responsible for the declining number of first-class seats. Once they improved business class - with bigger seats that opened into fully flat beds, menus

designed by celebrity chefs, individual entertainment systems and airport lounges where first- and business-class travelers rubbed elbows, it became more difficult for travelers to justify the additional exorbitant price of first class. The recent rise of all-business-class airlines has just added to the pressure on first class. With corporate business travelers demanding the most comfortable ride possible but not willing to pay the price, the demand for first class shrunk (**NYT 2008**).

However, for airlines, at a time of immense financial pressure, the prospect of using bonus points to upgrade to first class may make the difference between a passenger taking one airline or another competitor. Bonus programs, and upgrades into first, play a big part in keeping first class. It also makes sense for an airline to bump a high fare-paying passenger into first if it opens up a space to meet extra demand in coach. It's a marketing tool in a recession, and in the best of times it's a genuine yield tool. Moreover, in some circles, flying first class remains the status symbol of a person's success in business (**NYT 2009**).

The Table 3.1 summarizes the driving factors of the demand for overall redesign of international cabins.

Table 3.1 Overall Redesign of International Cabins: driving factors

Type of demand	Factors
Overall redesing Of International Cabins	Tool for differentiation between airlines Aircrafts orders and deliveries are postponed
Premium Economy apparition	To enhance airline reputation among travellers in Standard Economy To retain a base of loyal customers
First Class redesign	Demand from sucessful people even in economical downturn Demand from passengers upgraded to First Class
First class removal	More and more luxury in Business Class for a lower fare Rise of all-business-class airlines

Frequency and duration of the refurbishment

As with profitability and aircraft orders, cabin makeovers appear to occur in cycles. Based on the number of announcements over the past months (October 2006 - April 2007), it is clear that a new cycle is well underway. Full service carriers don't wait until the international cabins become shabby and worn (**ATW 2007b**).

As described in paragraph 2.1.2.1, full-service carriers (with no charter service) usually undertake a cabin redesign program for their international cabins. This includes the refurbishment for the entire fleet of one model and could even affect the entire fleet of wide-bodies.

Certain numbers of airlines in the top 20 carriers (such as British Airways, Emirates, Air France, Qantas, Continental Airlines, United Airlines, Japan Airlines and Korean Air) are always programing fleet renewal even in times of a downturn in the economy (**ATW 2007b**).

Table 3.2 International Cabin Redesign: exemplary Frequency and Duration

	Aircraft Type affected	Number of aircrafts	Begin of retrofit program	End of retrofit program	Retrofit duration (months)	Equivalent duration for one aircraft retrofit (days)	Date of Last Retrofit Program begin	Retrofit Frequency (months)
United Airlines	Entire Fleet	-	-	2009	17-29	-	-	-
Britsh Airways	B777	32	2006-11	2010-01	39	37	2004-04 (end of program)	65
	B747	56	2006-11	2009-04	30	16	2004-04 (end of program)	60
	B767	-	No refurbishment in 2007	-	-	-	2000	-
Air Canada	-	20	2004-10	2007-02	29	44	1994	(120)
Cathay Pacific	A340, A330, B777-300, B747-400	42	2006-09	2009-04	32	23	2001	57-69
Singapore Airlines	-	-	-	-	-	-	2002	46-58
	B777-300ER	18	2006-10	2009	27	43	(new delivery)	-
Japan Air Lines	B777-200	15	2007-04	-	-	-	-	-
Air New Zealand	B777-200ER	8	-	2009-06	-	-	2005-10	45
Delta Airlines	B777	-	-	2010	38-50	-	-	-
	B767	63	2006-10	2010	38-50	21	-	-
Swiss Airlines	A330, A340	34	Early 2009	2011-07	31	27	-	-
Malaysia Airlines	B777-200	17	2004-12	2006-09-30	22	40	-	-
	B747-200	19	2004-10	2006-07-31	20	32	-	-
Finnair	-	-	2009-04	-	-	-	2000	108

The Table 3.2 groups all the examples found about cabin makeovers cycles (**Luxist 2007, ATW 2007b, Punch 2009, Aeroweb 2009, Flight Global 2006, Swiss 2008a, ATT 2004, BA 2009, Air Canada 2004, Finnair 2009, Company 2009**). This data should be considered with attention. The column “Begin of retrofit program” contains the date of the retrofit program annoucement. If it was possible the date of the first aircraft refurbishment of the program was entered. However these two dates seem to be close compared with the total retrofit program duration. The column “End of retrofit program” contains the date of the completion

of the last aircraft affected by the retrofit program. The column “Date of last retrofit program” almost contains the date of the last program begin.

According the Table 3.2, the cabin redesign program of one wide-body type is undertaken each 65 months in average. This is the frequency of international cabin makeovers cycle. In **Aviation Week 2008,** it was also estimated that business class upgrade happens typically around a 5-7 year cycle.

The refurbishment of one Air Pacific’s Boeing 747-400 last 2 months (**Air Pacific 2008**) and the retrofit of one Philippines Airlines’ B747-400 last 3 months (**PAL 2009**). It can be assumed that the refurbishment for one wide-body aircraft usually last 3 months.

The refurbishment program lasts around 31 months but this duration depends of the number of aircrafts that are refurbished at the same time. That is why the equivalent duration of one aircraft refurbishment, which amounts to 31 days, should be considered. This describes the duration of one refurbishment as if aircrafts were completed one after the other. Of course, this is not the case because completion centers have usually more than one production line. However the equivalent duration of one aircraft refurbishment will give the duration of a redesign programm, no matter how many aircrafts are retrofitted.

The Table 3.3 summarizes the average frequency and the average duration of the Overall Redesign of International Cabins that will be taken into account in our cabin modification forecast.

Table 3.3 Overall Redesign of International Cabins: average frequency and duration

Type of modification	Frequency of cabin redesign program	Duration of one aircraft refurbishment	Equivalent duration of one aircraft refurbishment
Overall redesing Of International Cabins	65 months	3 months	31 days

Aircraft age limits for a cabin refurbishment

The airline undertakes a cabin completion on new aircraft from the outset, just after its delivery (green aircraft). From now on, Air France will install its new cabin design on new aircraft, including the forthcoming A380 (**Business 2008**).

Then, the airline proceeds to regular cabin refurbishments until the aircraft age makes it no longer suitable for passenger use (**Feir 2001**). This age ranges from 15 to 25 years (**Feir 2001**, **All experts 2006**, **Financial 2009**). For instance, in 2008 Air France didn’t plan to retrofit its

B747 fleet with an average age of 17 years as it is due to be phase out at he average age of 21 years (**Business 2008**).

The Table 3.4 summarizes the average lower and upper aircraft age limits for which a cabin refurbishment is no longer planned.

Table 3.4 Overall Redesign of International Cabins: average age limits for a refurbishment

Type of modification	Lower age limit	Upper age limit
Overall redesing Of International Cabins	0 year	20 years

3.2.2 Overall Redesign of Domestic Cabins

Driving factors

While most carriers view upgrades as a way to attract or ensure loyalty from passengers willing to pay premium fares (on long-haul flights), others also see the importance of tending to customers in the back of the bus on short-haul flights. If the short-haul business isn't good, the long-haul traveler won't take the same airline (**ATW 2007b**).

With their lightweight construction, the new seats substantially lower aircraft weight, which permits corresponding further reductions in fuel burn. (**Swiss 2008b**). Delta's cabin refurbishment program enables the installation of lighter seats and removal of coach-class ovens and airphones to reduce weight onboard MD-88 and MD-90 aircraft (**RedOrbit 2005**).

With new light structure seating, Finnair makes it possible to add as many as 15 seats to configurations. As a result of this extra seating, Finnair's capacity on European and domestic routes increased by 5% (**BNet 2007**).

The Table 3.5 summarizes the driving factors of the demand for overall redesign of domestic cabins.

Table 3.5 Overall Redesign of Domestic Cabins: driving factors

Type of demand	Factors
New business seats facility	Short-haul flights drive the reputation of the airline among long-haul business travellers
New seats facility	Reduction of fuel burn Extra seating capacity

Frequency and duration of a refurbishment program

The Table 3.6 groups all the examples found about cabin makeovers cycles (**Captain Chris 2000, Swiss 2008b, FFL 2008, ATT 2005, Cheap Flights 2006**). These data should be considered with attention. The column "Begin of retrofit program" contains the date of the retrofit program annoucement. If possible the date of the first aircraft refurbishment of the program was entered. However these two dates seem to be close compared with the total retrofit program duration. The column "End of retrofit program" contains the date of the completion of

the last aircraft affected by the retrofit program. The column “Date of last retrofit program” almost contains the date of the last program begin.

Table 3.6 Domestic Cabin Redesign: examplary Frequency and Duration

Airline	Aircraft Type affected	Number of aircrafts	Begin of retrofit program	End of retrofit program	Retrofit duration (months)	Equivalent duration for one aircraft retrofit (days)	Date of Last Retrofit program	Retrofit Fre-quency
Olympic Airways	B737-400	13	2000-09	2001-03	7	16	-	-
Cronus Airlines	B737-300, B737-400	6	2000-09	2001-03	7	36		
Swiss Airlines	Entire short-haul fleet	52	2006-10-15	2008-04-10	18	10	-	-
Air Canada	Entire short-haul fleet	142	2006-04	2008-06-01	22	5	-	-
Delta Airlines	MD88, MD90	94 (2/3 of the fleet)	2004	2006-09	21-33	9	-	-

No example has been found on the frequency of domestic cabin makeovers cycle. However It can be assumed that domestic cabins retrofits happen less frequently than international cabin retrofits. It is estimated this frequency amounts to 84 months (7 years).

The retrofit of an Air Canada A320 was completed in 16 days time (**Achorizons 2008**). It can be assumed that the refurbishment for one narrow-body aircraft usually last 15 days.

The refurbishment program last around 16 months but this duration depends of the number of aircrafts that are refurbished at the same time. That is why the equivalent duration of one aircraft refurbishment, which amounts to 15 days, should be considered. This describes the duration of one refurbishment as if aircrafts were completed one after the others. Of course, this is not the case because completion centers have usually more than one production line. However the equivalent duration of one aircraft refurbishment will give the duration of a redesign programm no matter of how many aircrafts are retrofitted.

The Table 3.7 summarizes the average frequency and the average duration of the Overall Redesign of Domestic Cabins that will be taken into account in our cabin modification forecast.

Table 3.7 Overall Redesign of Domestic Cabins: average frequency and duration

Type of modification	Frequency of cabin redesign program	Duration of one aircraft refurbishment	Equivalent duration of one aircraft refurbishment
Overall redesing Of Domestic Cabins	84 months	15 days	15 days

Aircraft age limits for a cabin refurbishment

The same parameters and values as described in paragraph 3.2.1.3 will be taken. The Table 3.8 summarizes the average lower and upper aircraft age limits for which a cabin refurbishment is no longer planned.

Table 3.8 Overall Redesign of Domestic Cabins: average age limits for a refurbishment

Type of modification	Lower age limit	Upper age limit
Overall redesing Of Domestic Cabins	0 year	20 years

3.2.3 Cabin Conversion for Aircrafts on Operating Lease

Driving factors

For airlines interested in aircraft on operating lease, benefits are lower cash outlays to preserve working capital, fleet flexibility to introduce new routes or aircraft types, flexibility to increase or reduce capacity quickly, no residual value risk and newer aircraft models with no need for pre-delivery payments or significant down payments with the manufacturers (**GECAS 2009**).

Operating leases are generally short-term making them attractive when aircraft are needed for a start-up venture, or for the tentative expansion of an established carrier. The short duration of an operating lease also protects against aircraft obsolescence, an important consideration in many countries due to changing noise and environmental laws. In some countries where airlines may be deemed less creditworthy (e.g. the former Soviet Union) operating leases may be the only way for an airline to acquire aircraft (**Wikipedia 2009f**).

The Table 3.9 summarizes the driving factors of the demand for cabin conversion for aircraft on operating lease.

Table 3.9 Cabin Conversion for Aircraft on Operation Lease: driving factors

Type of demand	Factors
Aircraft lease	Lower cash outlays
	Protects against aircraft obsolescence
	Fleet flexibility (change of capacity, new routes introduction, changing laws)

Frequency and duration of a cabin conversion

Operating leases are generally less than 10 years in duration (**Wikipedia 2009f**). For airlines interested in aircraft on operating lease, while each transaction has individually tailored lease terms, operating leases typically range 3-12 years in length (**GECAS 2009**). The average lease duration amounts to 7 years (84 months).

Regarding the frequency of an overall cabin redesign planned by an airline for an owned aircraft, the cabin conversion occurs only when the aircraft is transferred from an airline to another. Moreover, these airlines choose the aircraft leasing in order to operate a young fleet and therefore don’t have to refurbish the interiors.

The Table 3.10 summarizes the average frequency and the average duration of the Cabin Conversion for Aircrafts on Operating lease (**Wikipedia 2009f, GECAS 2009**).

Table 3.10 Cabin Conversion for Aircraft on Operation Lease: Frequency and Duration

Type of modification	Frequency of cabin conversion	Equivalent Duration of the aircraft conversion
Cabin conversion for aircrafts on operating lease	84 months	15 or 31 days

It is assumed that the conversion program has the same duration as a complete cabin redesign. Indeed, the tasks are quite the same. Therefore, it will be taken an equivalent duration of 15 days for Narrow-bodies and 31 days for Wide-bodies (see paragraphs 3.2.1.2 and 3.2.2.2). The Equivalent Duration describes the duration of one refurbishment as if aircrafts were completed one after the others. Of course, this is not the case because completion centers have usually more than one production line. However the equivalent duration of one aircraft refurbishment will give the duration of a redesign programm no matter of how many aircrafts are retrofitted.

Aircraft age limits for a cabin conversion

The same parameters and values as described in paragraph 3.2.1.3 will be considered. The Table 3.11 summarizes the average lower and upper aircraft age limits for which a cabin conversion could be no longer planned.

Table 3.11 Cabin Conversion for Aircraft on Operation Lease: average age limits

Type of modification	Lower age limit	Upper age limit
Cabin conversion for aircrafts on operating lease	0 year	20 years

3.3 Freighter Conversion Characteristics

3.3.1 Driving Factors

Most conversions are carried out on older aircraft no longer suitable for passenger use, often due to changing safety or noise requirements, or when the aircraft type is considered to have become uncompetitive in passenger airline service (**Wikipedia 2009e**).

The freighter conversions combine the advantages of a low empty weight with the resulting possibility to increase the useful load (**EADS 2009**).

The conversion of passenger aircraft into freighters offers an economic alternative to the purchase of new freighter aircraft (**EADS 2009**).

The situation is more dynamic in the freighter conversion market than in freigthers production, where the original equipment manufacturers and independent third-party converters offer modifications for virtually every modern aircraft type (**ACW 2003**).

The use of wide-body aircraft - aircraft with a large fuselage cross-section - guarantees a high degree of economic efficiency by combining excellent freight volume and quick cargo handling. They provide sufficient space for standard containers and pallets in the main and underfloor cargo compartments (**EADS 2009**).

The Table 3.12 summarizes the driving factors of the demand for freighter conversion.

Table 3.12 Freighter conversion: driving factors

Type of demand	Factors
Freighter conversion	Economic alternative to the purchase of new freighter aircraft Possibility to keep an aircraft no longer suitable for passenger use modifications for virtually every modern aircraft type
Wide-body conversion	high degree of economic efficiency

3.3.2 Occurence and duration of a Freighter Conversion

The freighter conversion itself takes approximately four months (**EADS 2009**).

The freighter conversion might occur only one time in the aircraft life. After an age of fifteen or twenty years old aircrafts would not be modified anymore for passenger service because of their marketability. As their first and second operators have used them, these planes are great candidates for freighter conversion (**Feir 2001**). So the freighter conversion occurs when the aircraft is no longer suitable for passenger use.

The Table 3.13 summarizes the occurrence and duration of the demand for freighter conversion.

Table 3.13 Freighter conversion: Occurrence and duration

Type of modification	Occurrence of the conversion	Duration of one conversion
Freighter conversion	Aircraft average age : 20 years	4 months

3.4 VIP Cabin Modification Characteristics

3.4.1 Driving Factors

A number of factors persuade business jet owner/operators to refresh big cabin structures. Typically, changes to these aircrafts are done more for aesthetics than wear (**Aviation Week 2008a**).

The need to refresh cabin structures and surfaces is set to grow in the fractional aircraft arena where (**Aviation Week 2008a**):

- More traffic from extra people means additional wear.
- Fractional owners are not as concerned about bumping a door panel because they don't own this aircraft. These airplanes therefore are more likely to see some wear and tear on the interior than other aircrafts. The market for refreshing these interiors to keep them looking nice should be busy over the next year.

Demand for high-end completions has grown at a dramatic rate of 25 to 30 percent in projects on the market in the last 10 years (**Aviation Week 2008b**):

- The unprecedented growth is due to the high demand for large business/VIP aircraft.
- New airplanes and technologies are also expanding additional demand for large-cabin airplanes.
- The arrival of these new types of VIP aircraft will create a secondary market for the ones that operators will trade in when they take delivery of their new jets. If those earlier BBJs, ACJs and other VIP transports change hands, they likely will be repainted and have their cabins refurbished
- This demand has been driven to a large extent by demand from emerging markets such as Middle East ─ that has not subsided ─ but it is now compounded by demand from India, China and many of the former Soviet republics.

The Table 3.14 summarizes the driving factors of the demand for VIP cabin modification.

Table 3.14 VIP Cabin Modification: driving factors

Type of demand	Factors
VIP Hi-end Completion	High demand for large business aircraft New airplanes and technologies New emerging markets : China, India, Russia
VIP cabin refurbishment	Need to keep interiors looking always nice Fractionnal owners make the cabin more used

3.4.2 Frequency and Duration of a VIP Cabin Modification

The average duration of a VIP cabin modification will be now determined.

PATS Aircraft Completions undertook the completion of a green Embraer Lineage 1000 in 9 months time (**Aviation Week 2008b**).

On average, Lufthansa Technik completes a VIP BBJ in around five months, but with specialized cabin elements involved, it can take up to eight or nine months. Lufthansa Technik conducts a requirement-capturing or fact-finding phase, sort of an initial design process, before a contract is signed. This phase, which can take between a few weeks to eight months and averages around six months, involves answering questions about the mission profile of the aircraft, typical city pairs the operator flies, what the living quarters should look like and if the operator is willing to trade off some range to include unique interior elements (**Aviation Today 2008**).

328 Support Services will complete the conversion of two VIP Dornier 328s in 6 months time for each aircraft (**BJII 2009**).

BizJet International, Lufthansa Technik's wholly owned US subsidiary, has received its first Airbus A318 Elite which is scheduled to be completed and delivered back to Airbus in autumn with an FAA and EASA Type Certificate. The green completion will last around 6 months (**ATI 2009**).

The frequency, at which the interiors are refreshed during the aircraft useful life, couldn’t be determined precisely. It is estimated that the time between two VIP modifications amounts to approximetaly 100 months.

Usually, the refreshing of aircraft interiors happens when aircraft is purchased by a new owner (**Aviation Week 2008a**).

The Table 3.15 summarizes the average frequency and the average duration of the Cabin Conversion for Executive Aircrafts.

Table 3.15 VIP Cabin Modification: Frequency and Duration

Type of modification	Frequency of cabin modification	Duration of the cabin modification
VIP Cabin Modification	100 months	10 months

3.4.3 Aircraft age limits for a VIP Cabin Modification

The Table 3.16 summarizes the average lower and upper aircraft age limits for which a VIP cabin modification could be no longer planned.

Table 3.16 VIP Cabin Modification: average age limits

Type of modification	Lower age limit	Upper age limit
VIP Cabin Modification	0 year	10 years

3.4.4 Completion Centers Characteristics

With OEM backlogs for large executive jets at record levels, completion centers are working overtime to finish green aircraft and refurbish older airplanes. But, for the foreseeable future, there will be more aircrafts in the market than completion centers can take. For instance, the backlog at *Jet Aviation* stretches out to 2011 for U.S. facilities and to 2014 for Basel facilities. *Associated Air Center* also reported that its facilities are fully booked through 2009, and *Gore*'s backlog extends into 2010 (**Aviation Week 2008b**).

Due to the unprecedented demand for green completions, commitments to complete green aircraft affect the quantity and type of refurbishment projects some completion centers can accept. Nearly all completion centers are therefore scrambling to add floor space to enhance their ability to handle VIP completions and refurbishments. For example, eighty-five percent of *Jet Aviation* Basel's work involves completions, and *Fokker Services* is concentrating on finishing green aircraft and performing executive conversions. Other companies, however, are taking on some refurbishment projects such as *Lufthansa Technik* which has one production line dedicated to wide-body completions and another devoted to refurbishments. The company plans to open a second wide-body completion line in 2010 (**Aviation Week 2008b**).

Limited completion capacity obviously can inhibit new sales of large VIP aircraft, so *Airbus* has joined in efforts to expand the industry's ability to finish green aircraft by opening in July 2007 the Corporate Jet Centre. The facility, which features a 70,000-square foot hangar, is expected to eventually be able to outfit three ACJs per year (**Aviation Week 2008b**).

4 CS-23 and CS-25 World fleet

This paragraph aims at presenting the current world fleet and its forecast in order to conclude about the growing markets that will influence the fleet volume, its distribution in the world and the cabin modification demand. The passenger fleet will be first presented, then the freighter fleet evolution and finally the executive jets fleet.

4.1 Passenger Fleet

4.1.1 Aircraft Classification

A classification of the aircrafts is needed in order to identify the type of cabin modification scenario which affects each of them.

Long-haul service or international flights are operated by aircrafts with extended range. Generally wide-body aircrafts are operated for long-haul flights. We can notice on Figure 4.1 that still air range is increasing as the number of one class seats is increasing. Therefore, we will consider that all wide-body aircrafts are operated for long-haul routes.

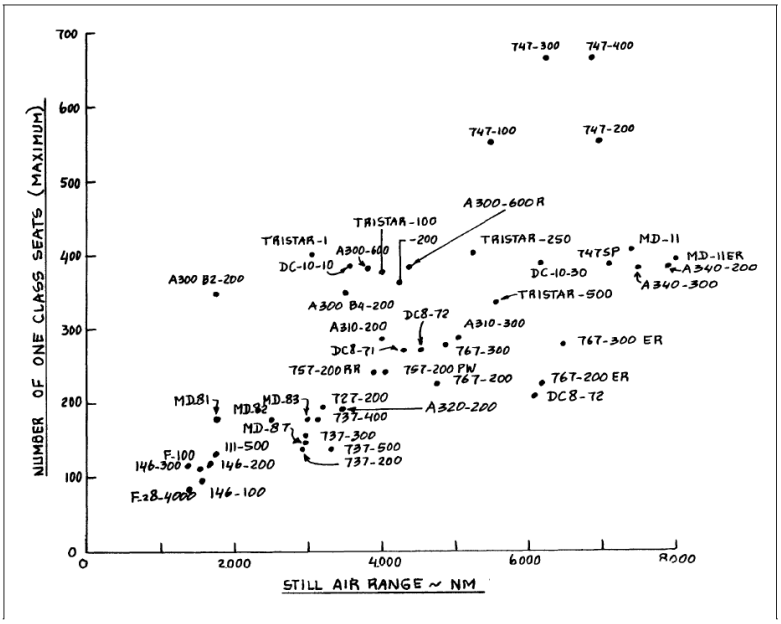


Figure 4.1 Typical Seat-Range Diagram (**Scholz 1999**)

The aircrafts of the database are sorted by the size in the Table 4.2.

Table 4.1 Aircraft classification by size

Aircraft body size	Type of flight	Aircraft model
Wide-body	long-haul routes	B747, B767, B777, B787 A300, A310, A330, A340, A350, A380 MD-11, DC-10
Narrow-body	Short-haul routes Medium-haul routes	B717, B727, B737, B757 A319, A320, A321 ARJ-21 BAe-146 CRJ-700, CRJ-900 Embraer models Dornier models Fokker 100, Fokker 70 MD-80, MD-90 SSJ-100

4.1.2 Passenger Fleet Evolution

All the data come from the Current Market Outlook made by Boeing (**Boeing 2009**).

Airplanes in 2027 will be more productive. Each will carry about 40 percent more traffic (RPKs) than the average airplane today. Fewer airplanes will be needed to accommodate the same volume of travel. So the fleet needs to grow by only 3.2 percent each year, although travel will grow at 5.0 percent as shown in the Figure 4.2 (**Boeing 2009**).

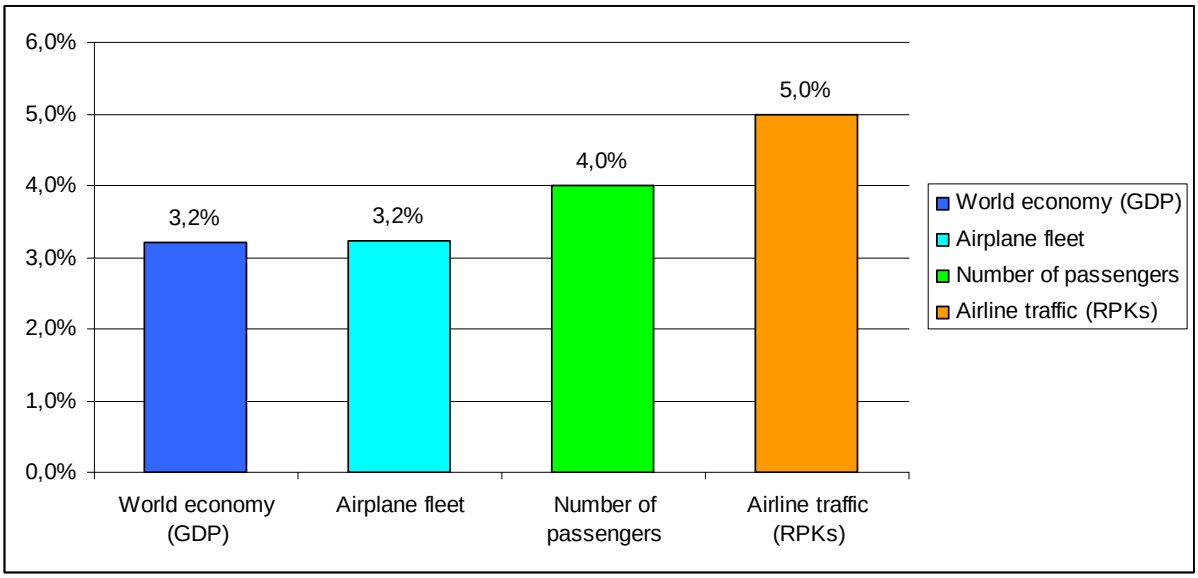


Figure 4.2 Passenger key growth rates

66% of the fleet development will be due to new deliveries. 3% of the current fleet will be converted which will generate demand for freighter conversion. The current fleet counts 17050 airplanes and this number will rise to 31910 airplanes as shown in the Figure 4.3.

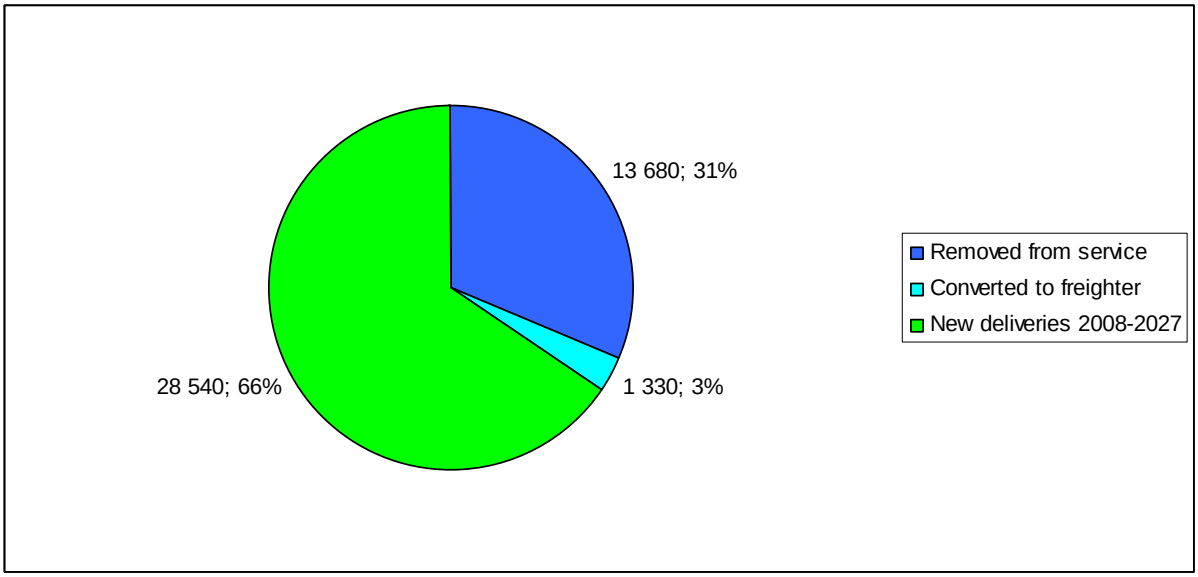


Figure 4.3 Passenger fleet development 2008-2027

Aircraft category evolution

As market liberalization stimulates opening of new international routes and aircraft capabilities improve, twin-aisle airplanes will be the fastest growing market segment. It will rise from 3200 to a fleet of 7130 airplanes.

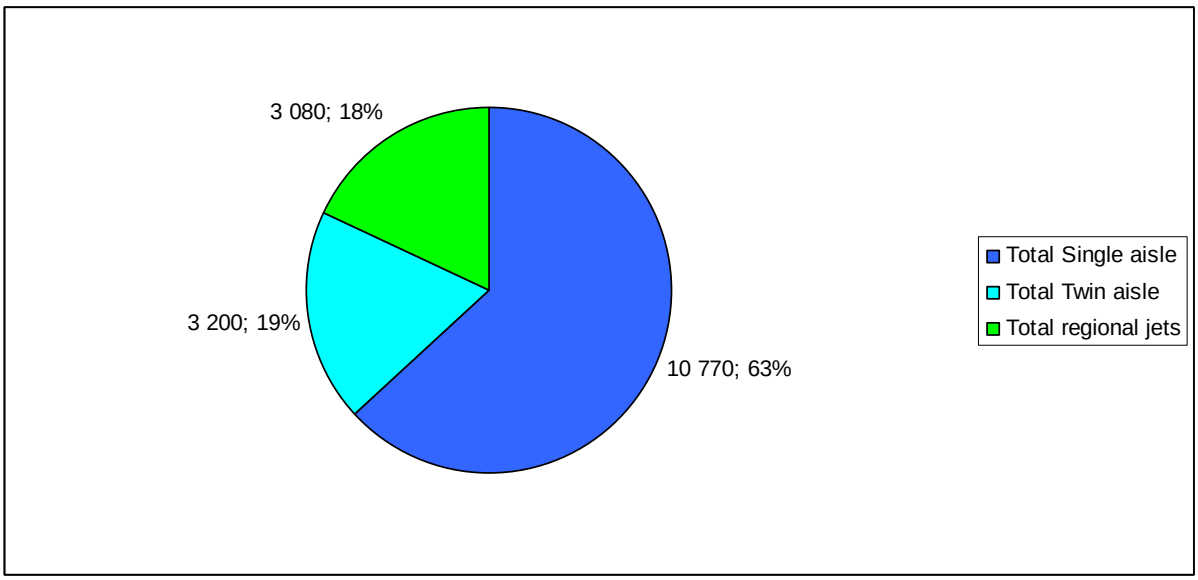


Figure 4.4 Passenger fleet by airplane size in 2007

Single-aisle airplanes primarily serve markets within regions. The sheer size of these markets means that the single-aisle category accounts for the largest share of future deliveries (from 63% to 70% of the global market in 2027).

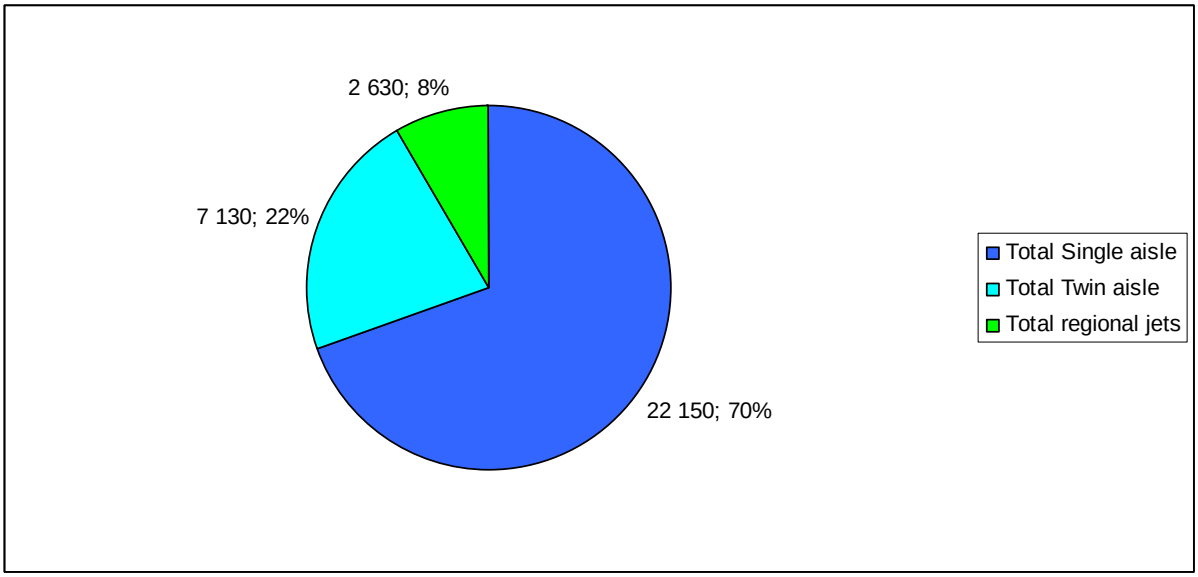


Figure 4.5 Passenger fleet by airplane size in 2027

Airline requirements for economic and environmental efficiency are pushing toward larger aircraft, and congestion at major airports is driving demand away from the smallest airplanes. Therefore, regional jets currently account for 18 percent of the worldwide fleet, but this will reduce to 8 percent by 2027. Therefore, twin-aisle and single-aisle demand should be investigated.

Fleet world repartition

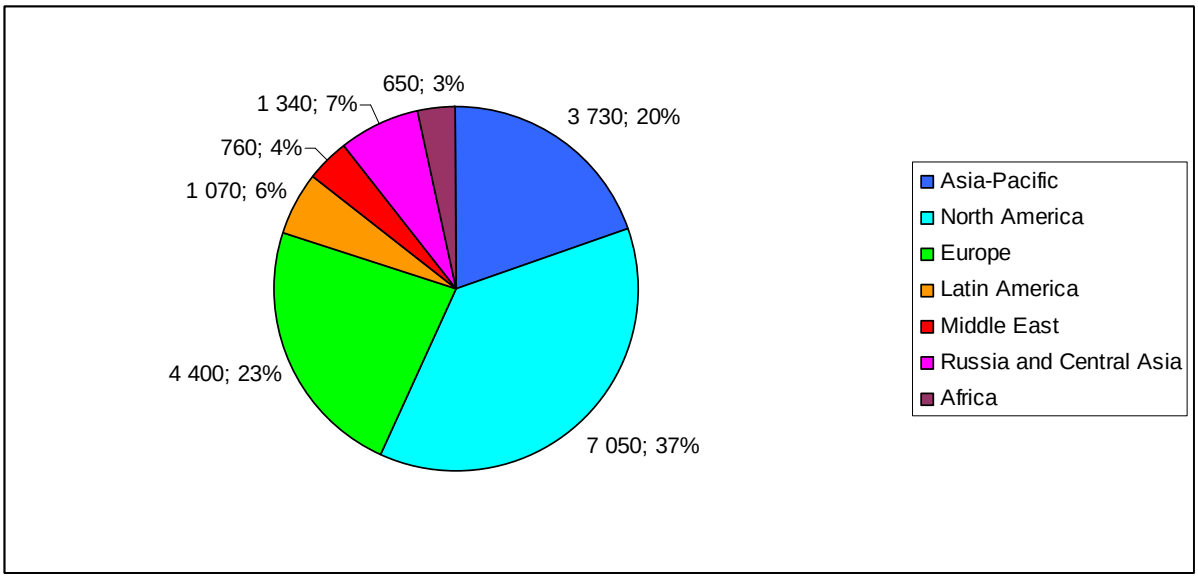


Figure 4.6 Passenger fleet by region in 2007

According to Figure 4.6 and 4.7, 20% of the world fleet is currently operated by airlines in Asia-Pacific and this will rise to 30% by 2027. It means there is a significant growth in Asian market as European and North American market growths will decline.

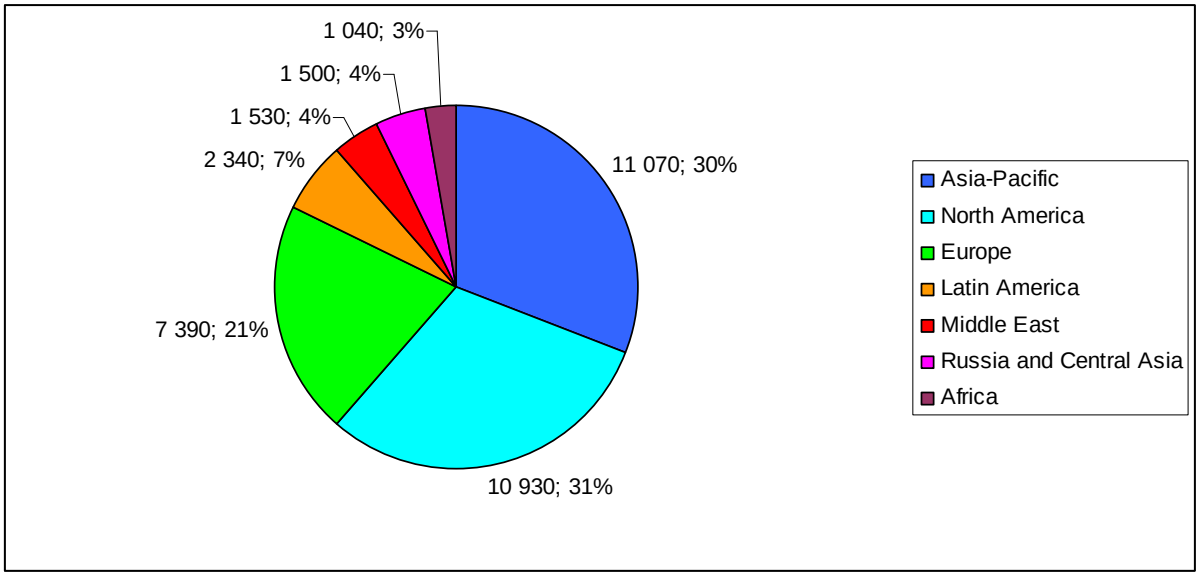


Figure 4.7 Passenger fleet by region in 2027

Twin-aisle demand by regions

Asia-Pacific, Middle East, and European markets will drive the demand of twin-aisle airplanes. Over 40 percent of twin aisles will be delivered to airlines in Asia-Pacific.

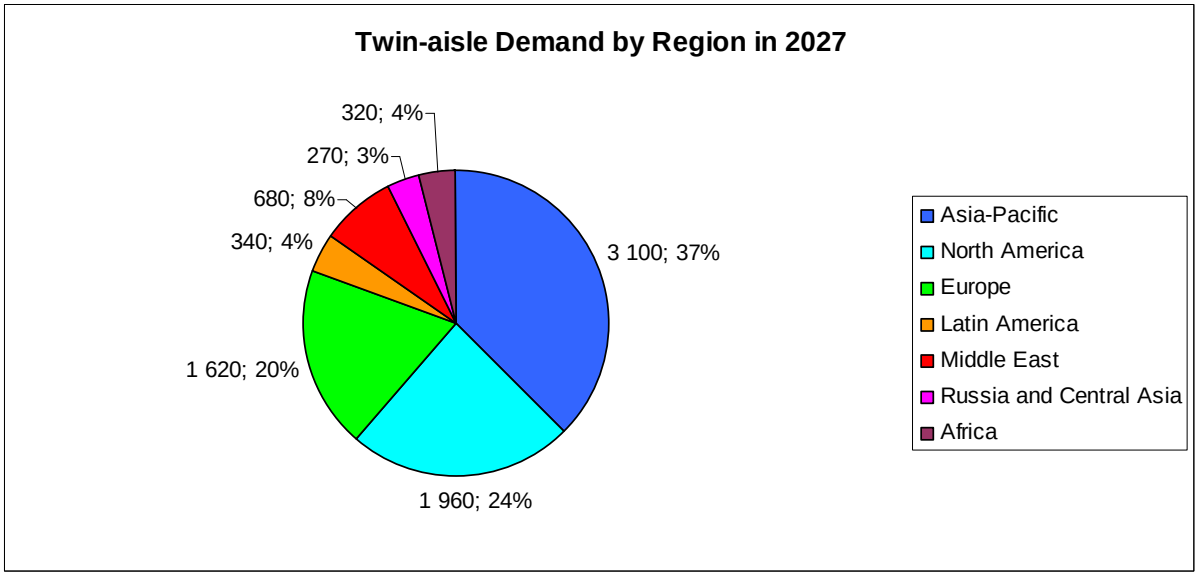


Figure 4.8 Twin-aisle demand by region in 2027

Single-aisle demand by regions

Strong domestic growth in China, India, and other emerging Asian nations is contributing to high demand for single-aisle airplanes in Asia-Pacific. Approximately 60 percent of new airplanes needed in Asia will be in the single-aisle category.

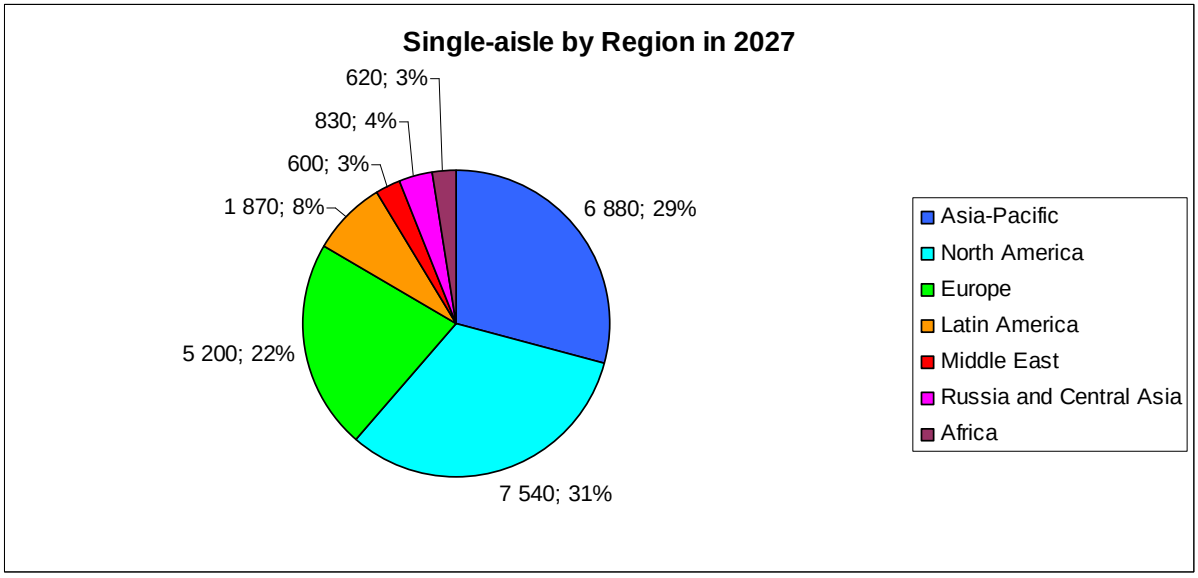


Figure 4.9 Single-aisle demand by region in 2027

As a conclusion, the growing market takes place in Asia-Pacific for single-aisle or for twin-aisle category.

4.2 Freighters

The company *ACMG* believed in 2003 **(ACW 2003)** that growth in the global economy can sustain a long-term growth rate of 6 percent per year in the air freight market. Boeing has obtained the same result as shown in Figure 4.10. All the figures have been drawn with data from the Current Market Outlook made by Boeing (**Boeing 2009**).

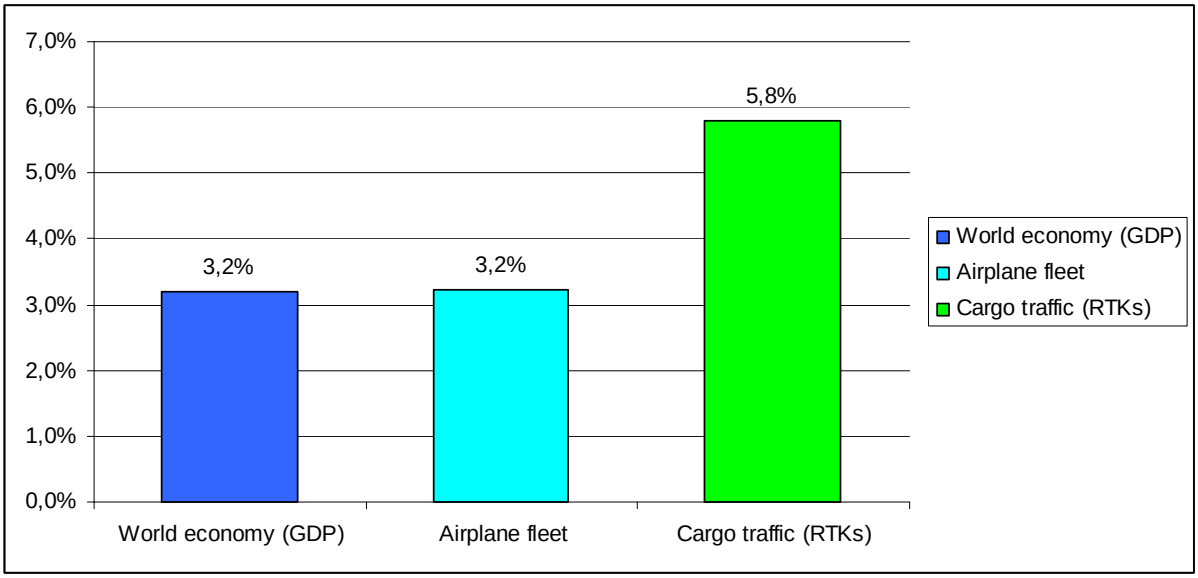


Figure 4.10 Air cargo key growth rates

From the *EADS* company's point of view, in the next two decades, the average annual growth of world wide airfreight is forecasted with 6 %. The world freighter fleet is predicted to double, as air freight will more than triple. More than 3000 additional freighters will be needed to accommodate traffic growth and to allow fleet renewal - three quarters of this demand will be satisfied by the conversion of mid-life passenger aircrafts (**EADS 2009**).

From the *Boeing* company's point of view, over the next 20 years, the freighter fleet will nearly double, expanding from 1.948 airplanes in 2007 to 3.892 airplanes in 2027.Taking the forecast 1.414 retirements into account, 3.358 airplanes will be added to the freighter fleet by 2027. Nearly three-quarters of freighter fleet additions will come from modified passenger and combi airplanes, with 863 new production freighters entering the fleet during the forecast period (**Boeing 2009**) as shown in the Figure 4.11.

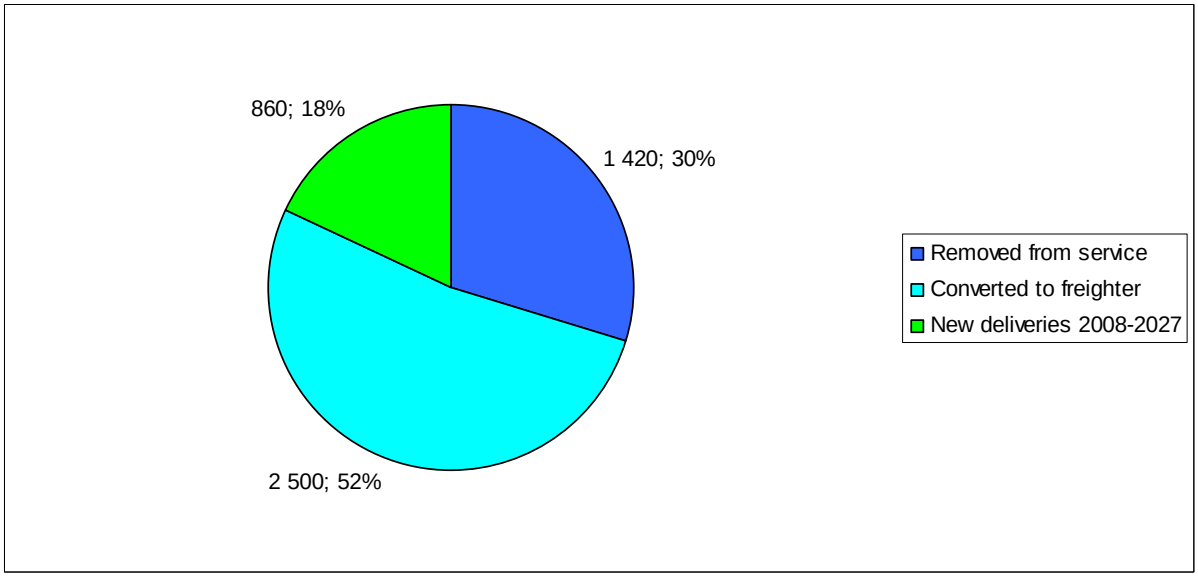


Figure 4.11 Cargo fleet development 2007-2027

The disparity between tripling traffic growth and doubling fleet growth owes to the shift toward wide-body freighters, which will result in a fleetwide increase in average freighter airplane payload. More than 60 percent of all additions to the fleet will be in the wide-body category, that is, medium wide-body plus large freighters. This aggregate category will increase in share to 65 percent of the fleet in 2027 (**Boeing 2009**).

In many cases, operators such as express carriers prefer medium widebodies as replacements for retiring standard-body freighters. Thus, the share of standard-body freighters will slightly decrease from 39 percent to 35 percent over the next two decades. Nevertheless, more than 1,334 standard-body units will be delivered, representing an 84 percent increase in their number. As with production models, breadth of product family is important in the conversion market, so both airplane manufacturers continue to expand their offerings. Freighters will maintain about a 10 percent share of the total airplane fleet during the forecast period (**Boeing 2009**).

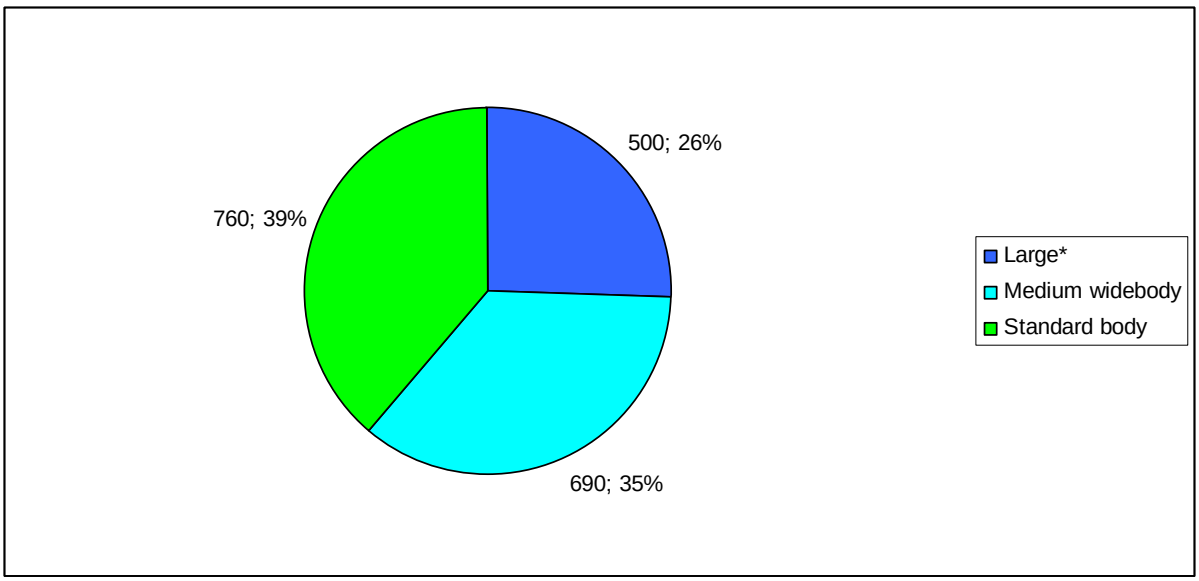


Figure 4.12 Cargo fleet by airplane size in 2007

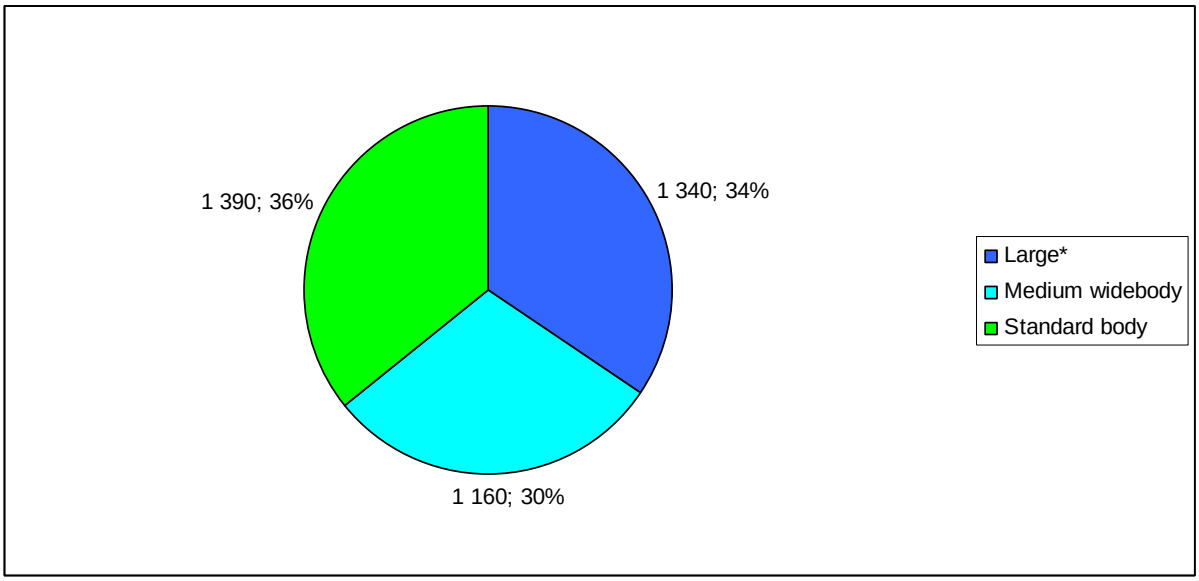


Figure 4.13 Cargo fleet by airplane size in 2027

There is a significant growth in large aeroplanes demand which rise from 26% to 34% of the global market in 2027.

4.3 Executive Jets

In 2008, the global business aircraft fleet consisted of 27,000 turbine airplanes (jets and turboprops), of which 68 percent belong to U.S. operators (**Aviation 2009**).

The latest market forecast of the *Teal Group* company predicts deliveries of 12,768 business aircraft worth $195.7 billion over the next 10 years (**Flight Global 2009**). If the same annual growth rate and the same market share between the different segments are kept, the forecast for the period 2009-2029 can be obtained in the following chart (Figure 4.14):

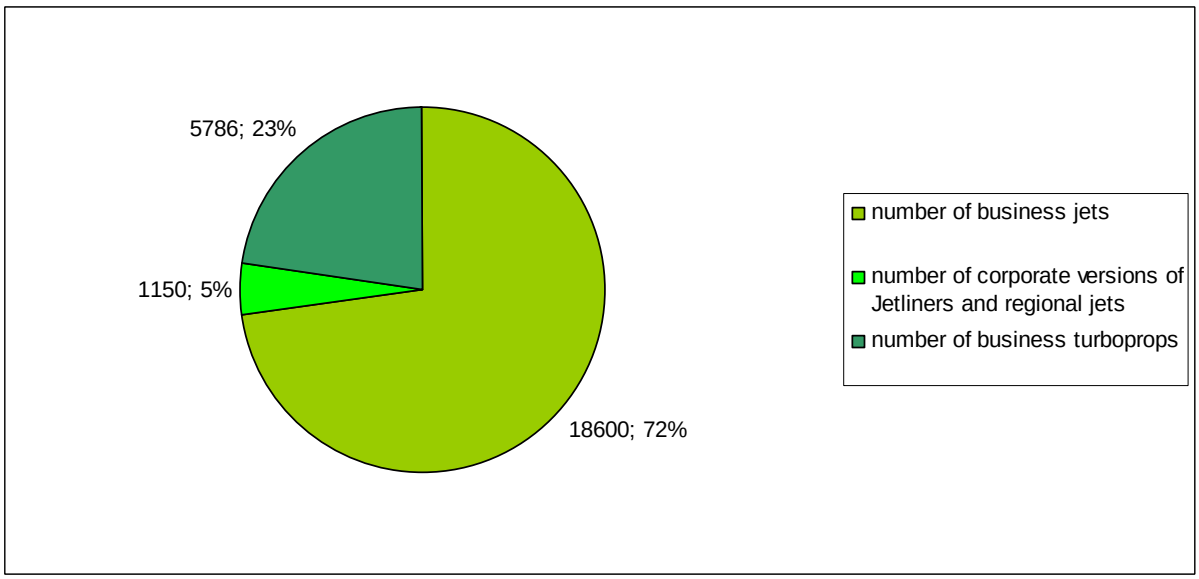


Figure 4.14 Business Aircraft Deliveries 2009-2029

Business jet deliveries will take a big part of the market with a share of 72%. This forecast is in strong contrast to Teal company's previous report issued a year ago in which it called for 18,401 business aircraft deliveries between 2008 and 2017. Indeed, the business aircraft market has been hit harder by the economic crisis than any other aerospace market. After unprecedented growth, the market is falling at an unprecedented rate. All meaningful indicators ─ utilisation, prices, used aircraft availability and corporate profits ─ indicate a prolonged and painful downturn. Financing business jets is also more difficult than financing jetliners. Teal's forecast assumes a three-year downturn. The key demand drivers ─ economic growth and corporate profits ─ will only recover in late 2010/early 2011 (**Flight Global 2009**).

5 Forecast of the Cabin Modification Volume

In this paragraph, the database used for the whole forecast and its characteristics will be introduced. Then the hypothesis made in the forecast will be explained along with the integration in the forecast of the previous analysis about the current world market. Finally, the forecast results will be presented and analysed.

5.1 Database

The forecast will use the enclosed *Excel* database which groups the entire current and future world fleet of freighters and executive jets. It also includes 63 types of the biggest airplanes on commercial use (23311 aircrafts). The information about all aircrafts on commercial use comes from **Aviation Week 2008c**.

The first sheet is called „Forecast“. It contains all the parameters of the different scenarios and the result of the computation. The Figure 5.1 shows the table where the frequency and the duration of each modification scenario can be modified by the user. It groups all the results of the market investigation done in the paragraph 3. This table is read by the code in order to compute the amount of cabin modifications for each aircraft.

Aircraft Cabin Modifications: Market Volume Forecast until 2029

Computation Parameters for the Cabin Modification Scenarios

	Occurrence (age in years)	Frequency (months)	Duration of one aircraft modification (days)	Equivalent Duration (days)	Aircraft Age Lower Limit (years)	Aircraft Age Upper Limit (years)
Overall Redesign of International Cabins		65		31	0	20
Overall Redesign of Domestic Cabins		84		15	0	20
Cabin Conversion for Narrow-bodies on Operating Lease		84	15		0	20
Cabin Conversion for Wide-bodies on Operating Lease		84	90		0	20
Freighter Conversion	20					
VIP completion						

Figure 5.1 Database: scenarios parameters

The Figure 5.2 shows the table which groups all the results of the market investigation done in the paragraph 2. This table is used by the code to identify the cabin modification scenario for each aircraft.

Criteria for the identification of the Cabin Modification Scenarios						
	Wide-body Aircraft	Narrow-body Aircraft	Freighter	Full Service Carrier	LCC or Charter Service	Aircraft on Operating Lease
Overall Redesign of International Cabins	1	0	0	1	0	0
Overall Redesign of Domestic Cabins	0	1	0	1	1	0
Cabin Conversion for Narrow-bodies on Operating Lease	0	1	0	1	1	1
Cabin Conversion for Wide-bodies on Operating Lease	1	0	0	1	1	1

Figure 5.2 Database: scenarios identification

The Figure 5.3 shows the table where all the results are written by the code. The total amount of cabin modifications for each scenario and each world region can be founded.

Forecast Results						
	Total Number of Cabin Modifications	Western Europe	Eastern Europe	China	Asia Pacific	Africa
Overall Redesign of International Cabins	10156	1959	301	1007	2938	
Overall Redesign of Domestic Cabins	23234	5417	1501	3381	3197	
Cabin Conversion for Aircrafts on Operating Lease	4246	1277	406	550	441	
Freighter Conversion	2625	?	?	?	?	?
VIP completion						

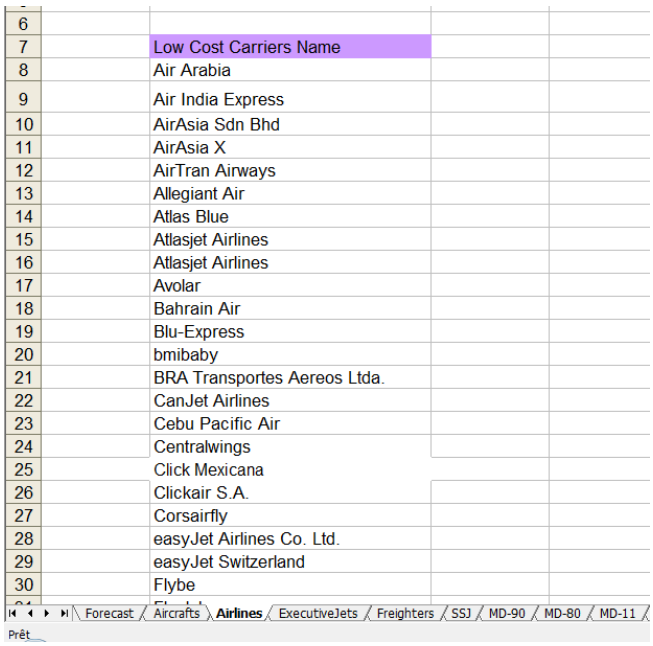
Figure 5.3 Database: Forecast Results

Then, in the sheet “Aircrafts” the characteristics of each aircraft model in the database can be founded. As shown in the Figure 5.4, the table indicates if a specific aircraft model is a wide-body or not.

		Aircraft full name	Aircraft model	Wide-body?
6				
7		Aircraft full name	Aircraft model	Wide-body?
8		Sukhoi Superjet 100	Superjet 100	0
9		Boeing (McDonnell Douglas) MD-90	MD-90	0
10		Boeing (McDonnell Douglas) MD-80	MD-80	0
11		Boeing (McDonnell Douglas) MD-11	MD-11	1
12		Fokker 100	100	0
13		Fokker 70	70	0
14		Embraer 195	195	0
15		Embraer 190	190	0
16		Embraer 175	175	0
17		Embraer 170	170	0
18		Dornier 328JET	328JET	0
19		Boeing (McDonnell Douglas) DC-10	DC-10	1
20		Boeing (McDonnell Douglas) DC-9	DC-9	0

Figure 5.4 Database: aircraft characteristics

In the sheet “Airlines” the characteristics of all the airlines of the database can be founded. As shown in the Figure 5.5, the table indicates if a specific airline is a LCC or not.



6	
7	Low Cost Carriers Name
8	Air Arabia
9	Air India Express
10	AirAsia Sdn Bhd
11	AirAsia X
12	AirTran Airways
13	Allegiant Air
14	Atlas Blue
15	Atlasjet Airlines
16	Atlasjet Airlines
17	Avolar
18	Bahrain Air
19	Blu-Express
20	bmibaby
21	BRA Transportes Aereos Ltda.
22	CanJet Airlines
23	Cebu Pacific Air
24	Centralwings
25	Click Mexicana
26	Clickair S.A.
27	Corsairfly
28	easyJet Airlines Co. Ltd.
29	easyJet Switzerland
30	Flybe

Figure 5.5 Database: aircraft characteristics

The other sheets group a database of the major part of the large aeroplanes world fleet. Each sheet groups all the aircrafts of the same model and type. Each row corresponds to a specific aircraft. There is a lot of information in the sheets but, as shown in the Figure 5.6 and Figure 5.7, the code read only the most important parameters (columns in light blue):

- Aircraft model
- Freighter
- Operator name
- World region
- Aircraft First Delivery date
- Aircraft Lease termination

	A	B	C	D	E	F	G	H
17	Aircraft Full Name	Aircraft Manufacturer	Aircraft Model	Aircraft Model Variant	Freighter ?	Operator Name	World Region	Aircraft Variant Detail
18	Boeing 777-300ER (GE)	Boeing	777	200LR/300ER	0	Air Austral	Western Europ	300ER (GE)
19	Boeing 777-300ER (GE)	Boeing	777	200LR/300ER	0	Air Austral	Western Europ	300ER (GE)
20	Boeing 777-300ER (GE)	Boeing	777	200LR/300ER	0	Air Canada	North America	300ER (GE)
21	Boeing 777-300ER (GE)	Boeing	777	200LR/300ER	0	Air Canada	North America	300ER (GE)
22	Boeing 777-300ER (GE)	Boeing	777	200LR/300ER	0	Air Canada	North America	300ER (GE)
23	Boeing 777-300ER (GE)	Boeing	777	200LR/300ER	0	Air Canada	North America	300ER (GE)
24	Boeing 777-300ER (GE)	Boeing	777	200LR/300ER	0	Air Canada	North America	300ER (GE)
25	Boeing 777-300ER (GE)	Boeing	777	200LR/300ER	0	Air Canada	North America	300ER (GE)

Figure 5.6 Database: aircraft major parameters

Finally the code writes, for each aircraft, the scenario in which this aircraft is involved and the number of modification that will be undertaken. This information can be found in the two red columns:

- Type of modification
- Number of modification until 2029

Aircraft Delivery Date	Pass. A/C in Service Delivery	Pass. A/C on Order Delivery	Aircraft Life in Days	Aircraft in Service > 1 year	Pass. Aircraft in Service > 1 year	Block Hours per Day	Manager Name	Aircraft Lease Termination	Type of modification	Number of modifications until 2029
15 févr 2009	FAUX	2009	-85	FAUX	FAUX	0	ILFC	15 févr 2017	Cabin Conversion for Wide-bodies on Operating Lease	2
##########	FAUX	2009	-115	FAUX	FAUX	0	ILFC	##########	Cabin Conversion for Wide-bodies on Operating Lease	2
15 déc 2008	FAUX	2008	-25	FAUX	FAUX	0	Air Canada		Overall Redesign of International Cabins	3
15 janv 2009	FAUX	2009	-55	FAUX	FAUX	0	Air Canada		Overall Redesign of International Cabins	3
27 juil 2007	2007	FAUX	473	VRAI	VRAI	12,7040169	Air Canada		Overall Redesign of International Cabins	3
##########	2008	FAUX	246	FAUX	FAUX	10,5853659	BOC Aviation	##########	Cabin Conversion for Wide-bodies on Operating Lease	2
22 avr 2008	2008	FAUX	208	FAUX	FAUX	10,5096154	BOC Aviation	22 avr 2020	Cabin Conversion for Wide-bodies on Operating Lease	2
25 juin 2008	2008	FAUX	145	FAUX	FAUX	10,6	BOC Aviation	25 juin 2020	Cabin Conversion for Wide-bodies on Operating Lease	2
13 mai 2008	2008	FAUX	187	FAUX	FAUX	10,7807487	Air Canada		Overall Redesign of International Cabins	3
30 avr 2007	2007	FAUX	560	VRAI	VRAI	12,9375	Air Canada		Overall Redesign of International Cabins	3
29 juin 2007	2007	FAUX	501	VRAI	VRAI	13,497006	Air Canada		Overall Redesign of International Cabins	3
##########	2007	FAUX	590	VRAI	VRAI	12,779661	Air Canada		Overall Redesign of International Cabins	3
1 juin 2007	2007	FAUX	529	VRAI	VRAI	12,7901701	ILFC	1 juin 2017	Cabin Conversion for Wide-bodies on Operating Lease	2
15 avr 2009	FAUX	2009	-145	FAUX	FAUX	0	ILFC	15 avr 2019	Cabin Conversion for Wide-bodies on Operating Lease	2
15 avr 2011	FAUX	2011	-865	FAUX	FAUX	0	Air China		Overall Redesign of International Cabins	3
15 août 2011	FAUX	2011	-985	FAUX	FAUX	0	Air China		Overall Redesign of International Cabins	3

DC9 / CRJ-700 / BAe146+Avroliner / ARJ-21 / B787-900&1000 / B787-800 / B787-300 / **B777-300ER** / B777-300 / B777-200LR / B777-200ER / B777-200 / B767-400ER

Figure 5.7 Database: aircraft major parameters

5.2 Hypothesis

Following hypothesis will be considered in the forecast:

- CS-23 airplanes are not considered. As not enough elements could be founded about cabin modifications for these small airplanes, this demand certainly doesn't affect the whole market of cabin modifications. The error about the cabin modification volume is therefore considered as negligible.
- Future aircrafts (i.e. the world fleet forecast) which will be operated whithin the next 20 years and which will modify the future world fleet are not specifically identified, as the fleet forecast is already included in the database under aircraft orders. This will lead to a negligible error as airlines usually plan their fleet at least for the next twenty years.
- It is computed a forecast for the next 20 years i.e. all cabin modifications that will be undertaken before 01/07/2029 are counted.
- For each aircraft, the modification scenario will be identified and it will contain the specific time between two modification programs undetaken by the operator
- For each aircraft, the number of modifications will be obtained by the computation of the specific time between two modification programs and the duration of a refurbishment program.
- For each aircraft, the first modification that will be calculated will occur the 01/07/2009
- For each aircraft, the last modification that will be calculated will occur either before the 01/07/2029 or before the end of the aircraft useful life.

5.3 Forecast Method

5.3.1 Method for airplanes on commercial use

The method used for the computation is to scan each sheet and each row.
For each aircraft:

- the tables “Aircraft Model Characteristics” in the sheet “Aircrafts” and “Airline Characteristics” in the sheet “Airlines” are scanned.
- the characteristics of the aircraft is completed.
- the scenario is identified thanks to the table “scenarios identification” in the sheet “Forecast” and is written in the database under the column “type of modification”.
- the scenario parameters are scanned in the sheet “Forecast” (table “Computation Parameters”)
- the number of modifications is computed thanks to the scenario parameters and is written in the database.

Then, the total amount of modifications is obtained by the following process. For each sheet and each row the code scans in the database:

- the world region where the aircraft is based
- the scenario in which it is involved
- the number of modifications

The modifications for each scenario and each world region are counted and results are written in the table “Forecast table” in the sheet “Forecast”.

For aircrafts which are not on operating lease, the total duration of the whole retrofit program has to be determined. As airlines are always undertaking retrofit programs, the code has to-compute the fleet volume (same aircraft model, aircraft type and operator). This is multiplied with the equivalent duration in order to get the real duration of a retrofit program.The Figure 6.8 describes all these processes.

The formula used in the computation is the recursive formula.

$date_{\mathrm{modification}}$ is the date at which the end of the next modification program is planned and $date_{today}$ is the date of computation. A new retrofit program has already been completed for the aircraft from the date of computation, as described in the formula (5.1).

$$date_{\mathrm{modification}} = date_{today} \tag{5.1}$$

Then, thanks to (5.2), the date at which ends the next modification program, $date_{modification}$ is computed. $date_{previous\_modification}$ is the date at which ended the last retrofit program for the same aircraft. $frequency_{scenario}$ is the time between the end of the last retrofit program and the begin of the next scheduled retrofit program. It depends of course of the cabin modification scenario in which the aircraft is involved. $duration_{scenario}$ is the duration of the retrofit program. It also depends of the scenario.

$$date_{modification} = date_{previous\_modification} + frequency_{scenario} + duration_{scenario} \tag{5.2}$$

The equation (5.2) is executed until (5.3) is no more valid. It is checked if the date of the computed retrofit program ($date_{modification}$) is not exceeding the deadline of the forecast (01/07/2029) or the second deadline, corresponding to the aircraft age ($age_{scenario\_limit}$) for which the refurbishment is no longer planned by the operator. This second deadline is calculated thanks to the date of the aircraft first delivery $date_{aircraft\_delivery}$.

$$date_{modification} < \max(01/07/2009, date_{aircraft\_delivery} + age_{scenario\_limit}) \tag{5.3}$$

The number of modifications n is given by the number of loop executions, n_{loop}.

$$n = n_{loop} + 1 \tag{5.4}$$

For aircrafts on operating lease, the duration of the retrofit program ($duration_{scenario}$) is the duration of one aircraft refurbishment, $duration_{modification}$. It is considered in fact that these aircrafts don't take part into a refurbishment program (like wide-bodies and narrow-bodies owned by the operator) but they need to be reconfigured just after the aircraft lease termination.

$$duration_{scenario} = duration_{modification} \tag{5.5}$$

For aircrafts owned by an operator, a retrofit program is usually undertaken by the airline for the whole fleet. Therefore the volume of the fleet ($volume_{fleet}$) has to be taken into account. It will, along with the equivalent duration of one aircraft refurbishment ($duration_{equivalent}$), help to determine the duration of the whole retrofit program for the fleet ($duration_{scenario}$). $duration_{scenario}$ do not correspond to the real duration of one aircraft refurbishment but deter-

mine the real time between two refurbishment programs for the same aircraft (for further details about equivalent duration, see paragraph 3.2.1.2).

$$duration_{scenario} = duration_{total} = duration_{equivalent} \times volume_{fleet} \tag{5.6}$$

The Figure 5.8a decribes how the total number of modification for an aircraft on commercial use is computed. The Figure 5.8b describes how the number of modification for one aircraft on commercial use is computed.

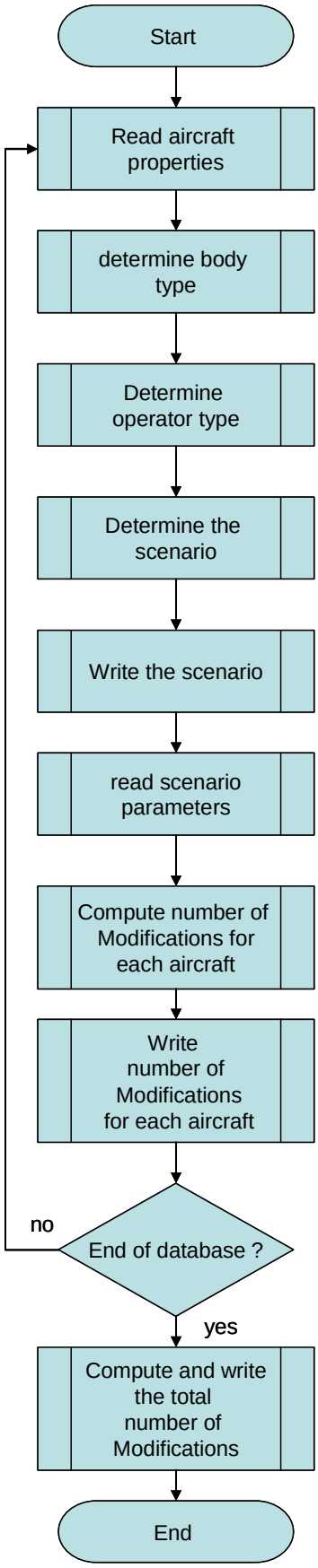


Figure 5.8a Database: computation method for aircrafts on commercial use

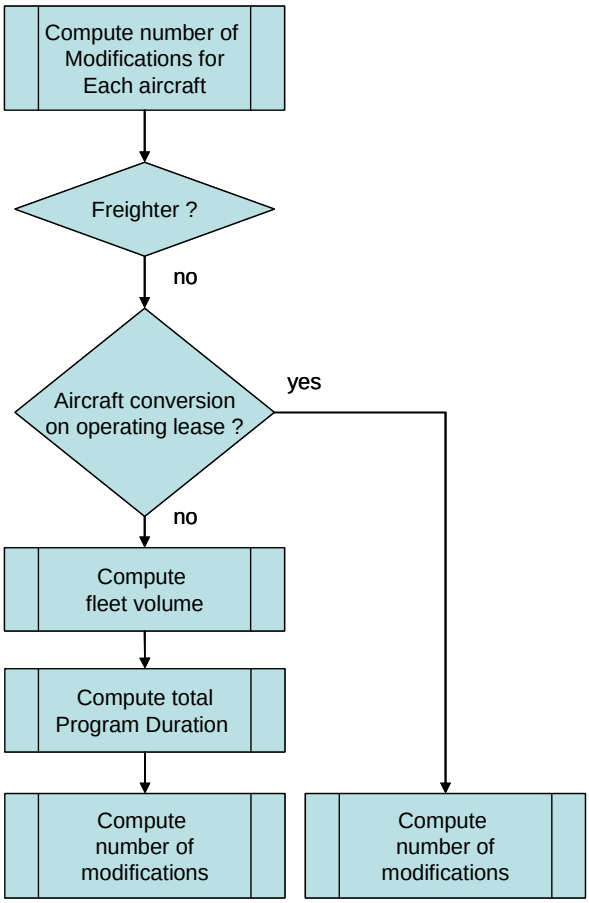


Figure 5.8b Database: computation method for aircrafts on commercial use

5.3.2 Method for freighter conversion

Existing freighters in the database are not considered in order to compute the number of freighter conversions. Indeed, only aircrafts on commercial use which have reached a specific age could be involved in a freighter conversion. Therefore the fleet forecast made by **Boeing 2009** is rather used,, wherein a specific percentage indicates the amount of freighter conversions for the future. Moreover, the figures put forward by *Boeing* are verified by *EADS* in **EADS 2009**.

The additionnal airplanes which are required in the future amounts to 3500. 75% of this demand will be met by freigther conversion. The following formula is therefore used to get the number of freighter conversion by 2029, where $n_{FreigtherConversion}$ is the amount of freighter conversion, $n_{AdditionnalAirplanes}$ the number of additionnal airplanes forecast by *Boeing* and $p_{FreighterConversion}$, the proportion of conversions in these additionnall airplanes.

$$n_{FreigtherConversion} = n_{AdditionnalAirplanes} \times p_{FreighterConversion} \quad (5.7)$$

However, the world distribution of this demand is not yet available. Therefore, the distribution of the current freighter fleet is computed and it is extrapolated to the number of freighter conversions. In order to get the amount of freighter conversions in a specific world region $n_{FreighterConversion}^{world\_region}$, the following formula is used, where $p_{FreighterFleet}^{world\_region}$ is the proportion of the freighter fleet in this specific region:

$$n_{FreighterConversion}^{world\_region} = n_{FreighterConversion} \times p_{FreighterFleet}^{world\_region} \quad (5.8)$$

5.3.3 Method for Executive Jets

No database with enough detailed information has been found about the fleet world distribution neither about the current fleet volume. Therefore only the fleet volume for the 2009-2029 period will be used, based on *Teal*'s 2009 forecast (see paragraph 4.3).

Each business aircraft will have the same modification scenario. It means that all of them will be involved in several VIP completions (as described in paragraph 2.3 and 3.4.) until they reach the limit at which VIP completions will not be undertaken anymore ($age_{scenario\_limit}$), with the same duration ($duration_{scenario}$) and the same frequency of occurrence ($frequency_{scenario}$).

All business aircrafts will have the same number of modifications. Of course some aircrafts will be delivered in 2028 and they will not have the same number of completions in one year time than others which have been in service for years. This hypothesis will therefore lead to an error regarding the VIP completions volume. However, this is about to compensate the VIP completions of business aircrafts which are already in service in the current fleet and which have not been taken into account because of a lack of information.

For each aircraft, the number of VIP completions will be computed in the following way. It will first be computed the duration of the period $duration_{scenario\_period}$ within which VIP completions should be undertaken.

$$duration_{scenario\_period} = age_{scenario\_limit} \quad (5.9)$$

Within that time, it will be computed the number of VIP completion $n_{aircraft}$ that could be undertaken for one aircraft.

$$n_{aircraft} = \text{int}\left\lfloor duration_{scenario\_period} / (duration_{scenario} + frequency_{scenario}) \right\rfloor \quad (5.10)$$

Finally, it will be computed the total number of VIP completions n for the entire business aircraft forecasted fleet.

$$n = n_{aircraft} \times volume_{fleet} \quad (5.11)$$

5.4 VBA Program

The VBA code, which executes the forecast computation, is seperated in 4 main functions which will be explained in the following paragraph:

- “Sub project_commercial_airplanes()”
- “Sub project_commercial_airplanes_total_modifications()”
- “Sub project_freighter_conversion()”
- “Sub project_VIP_modification()”

Access to the code itself is executed by the command “ALT+F11” in Excel and and can also be read in the appendix A.

The parameters of each scenario such as “frequency” or “duration” are modifiable in the sheet “Forecast”.

5.4.1 Aircrafts on commercial use

“Sub project_commercial_airplanes()”, which can be read under “Module3” is the part of the code which computes the cabin modification scenario and the cabin modification volume for each aircraft on commercial use. It writes the results in the database for each aircraft on commercial use. The computation can be executed with its linked command button available in the sheet “Forecast”.

Two important variables are used in this function, as shown in the Figure 5.9:

- Aircrafts
- Scenarios

These variables are filled each time another aircraft is considered (i.e. for each sheet and each row). The compact form of these variables helps for the computation and the understanding of the code. All the details about these variables are described on the figure.

```
Type aircrafts
    model As String 'model of the aircraft
    wide_body As Boolean 'indicates if the aircraft is a wide-body or not
    operator As String 'gives the airline name that operate this aircraft
    LCC As Boolean 'indicates if this operator is a LCC or not
    freighter As Boolean 'indicates if this aircraft is operated in the freighter configuration
    delivery_date As Date 'gives the delivery date of the aircraft to its first operator
    lease_termination As Date 'gives the date of the lease contract termination and indicates if the aircraft is on operating lease or not
    region As String
End Type

Type scenarios
    type As String 'gives the name of the scenario that affects this aircraft
    occurence As Integer 'time at which the conversion of leased aircraft is undertaken (useful just for aircrafts on operating lease)
    frequency As Integer 'time between two modification programs in the aircraft useful life
    duration As Integer 'duration of the cabin modification of one aircraft (useful just for aircrafts on operating lease)
    equ_duration As Integer 'equivalent duration of the modification program for one aircraft
    tot_duration As Integer 'duration of the modification program for an entire fleet (same aircraft model and type)
    age_limit As Integer 'aircraft age at which this modification scenario is no longer planned
    date_limit As Date 'date at which this modification scenario is no longer planned
End Type
```

Figure 5.9 Database: major variables of the VBA code

“Sub project_commercial_airplanes_total_modifications()”, which can be read under “Module2” is the part of the code which computes the total cabin modification volume of aircrafts on commercial use, and this for each scenario and each world region, by using the results fo the function “Sub project_commercial_airplanes()”. It writes the results in the sheet “Forecast”. The computation can be executed with its linked command button available in the sheet “Forecast”.

5.4.2 Freighter conversions

“Sub project_freighter_conversion()”, which can be read under “Module1” is the part of the code which computes the freighter conversion volume for each world region. It writes the results in the sheet “Forecast”. The computation can be executed with its linked command button available in the sheet “Forecast”.

5.4.3 VIP modifications

“Sub project_VIP_modification()”, which can be read under “Module5” is the part of the code which computes the VIP modification volume. It writes the results in the sheet “Forecast”. The computation can be executed with its linked command button available in the sheet “Forecast”.

5.5 Forecast Results

5.5.1 Cabin Modification Volume

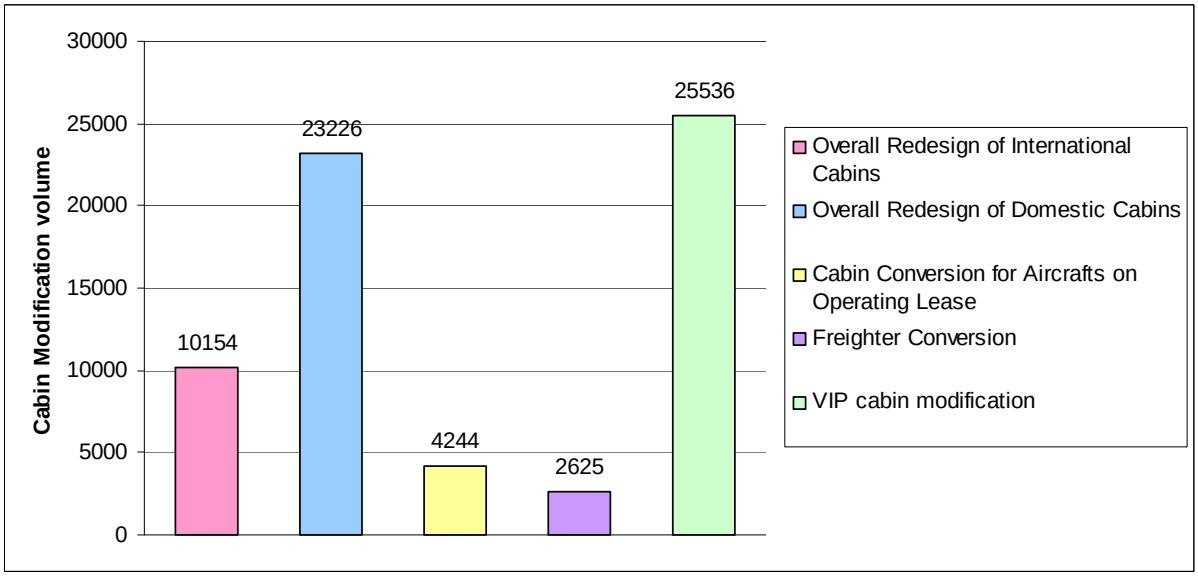


Figure 5.10: Cabin modification world volume 2009-2029

The results of the forecast applied on the several databases are presented in the Figure 5.10. Over the next twenty years, 10154 programs for the retrofit of international cabins and 23226 for domestic cabins will be undertaken. The demand for the cabin conversion of leased aircrafts will create 4244 additional cabin modifications on airliners. 2625 conversions from jetliners to freighters will be planned. Last but not least, the most important demand will come from 25536 modifications of executive aircraft cabins at VIP standards.

5.5.2 Demand for Overall Redesign of International Cabins

A big part of the 10100 wide-body cabin redesigns forecasted will come from Asia-Pacific (29%). Indeed, over 40 percent of twin aisles will be delivered to airlines in Asia-Pacific. So the Asia-Pacific market will have a big influence on this segment.

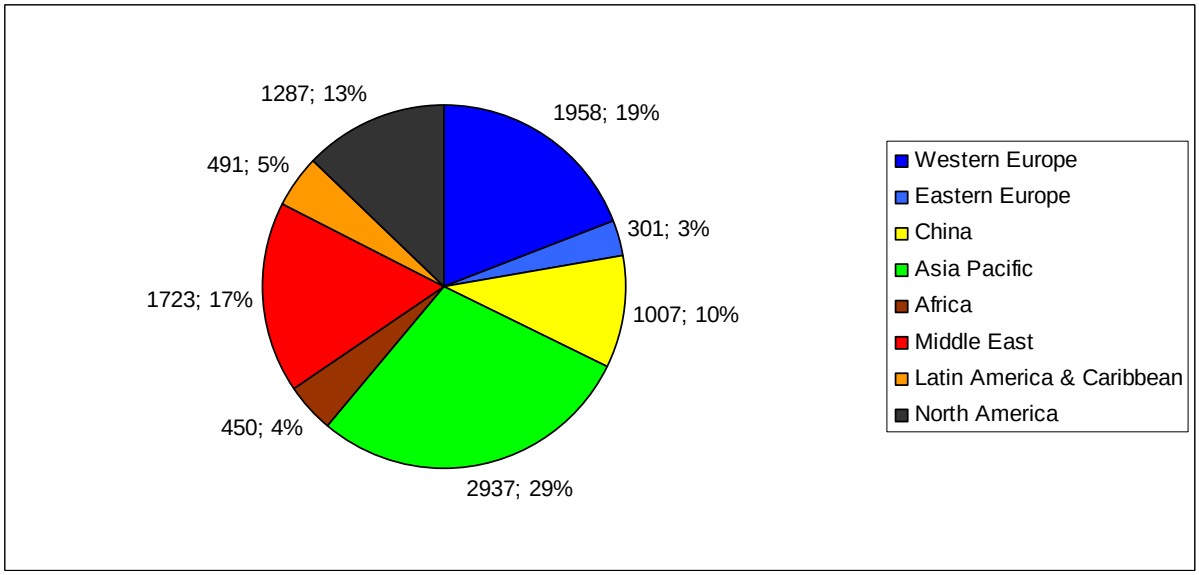


Figure 5.11 Overall Redesign of International Cabins: Cabin Retrofit World Distribution 2009-2029

If the market share of the Middle East and China are added to this consideration, more than 55% (6000 cabin retrofits) of the demand will be concentrated in a single world continent.

In following positions come Western Europe and North America with respectively 19% and 13% of the market share. These results were expected because of the relative small part of the wide-body deliveries in these two regions.

Moreover, as it has already been shown, the redesign of wide-body cabins is a tool for differentiation between airlines. That means, even if aircraft deliveries and orders could be postponed because of a possible economical downturn, airlines will continue to redesign their cabins in order to attract customers at minimal expenses (compared to the purchase of a brand new aircraft). Therefore, the demand for the redesign of international cabins will continue to grow at a quick pace.

Although premium cabins are considered by airlines as very large profit centers, some specialists believe the margins will start to erode as retrofit and innovation costs go up and fares go down from competition. As a result, it will be more difficult to recoup their investment. These specialists believe too that innovation on premium cabins has a limit because customers may not be able to afford it every time they travel **(ATW 2007b)**.

5.5.3 Demand for Overall Redesign of Domestic Cabins

The North American market will drive the global demand of 23200 domestic cabin retrofits along with the Western European market (respectively 28% and 23% of the market share).

This is due to the high number of existing narrow-bodies in these regions. But Asian markets (China, Middle East, Asia-Pacific) are still strong and approximately 60% of new narrow-bodies will be delivered in these regions.

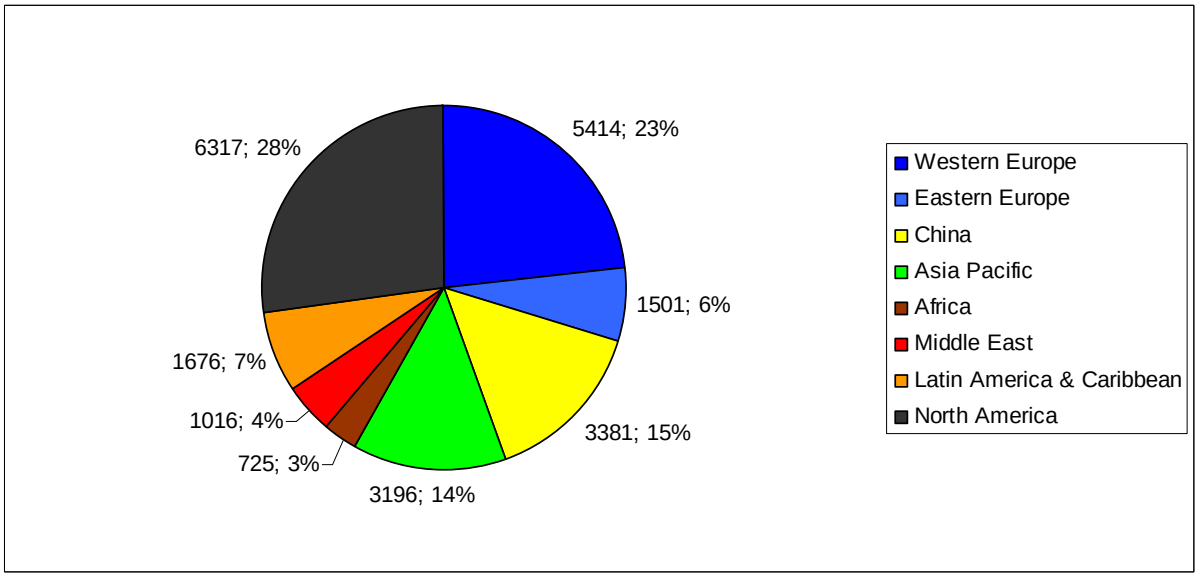


Figure 5.12 Overall Redesign of Domestic Cabins: Cabin Retrofit World Distribution 2009-2029

The world demand for Cabin Redesign of Narrow-bodies appears to be a lot stronger than the demand for International Cabin Redesign. It has to be reminded that the price of such a retrofit is a lot higher than the domestic cabin retrofit, and this is due to the expenses required by the innovation in premium cabins.

Although comfort and amenities on short-haul flights also drive the airlines reputation, most of them do not currently put the emphasis on it and focus on wide-bodies.

Moreover, the real advantage for the domestic cabin redesign is the reduction of fuel burn or the increase of seating capacity. However North American and Western European markets have to be investigated if this segment is suddenly growing because of a future trend.

5.5.4 Demand for Cabin Conversion of Aircrafts on Operating Lease

The chart below shows that most of the 4200 cabin conversions of leased aircrafts will be undertaken in Europe and in North Americа with respectively 41% and 17% of the market share. This world distribution of the demand is certainly due to the great proportion of Low Cost Carriers in Europe and in North America, which operate a lot of leased aircrafts. However, the Asian market follows the trend with 31% of the market share.

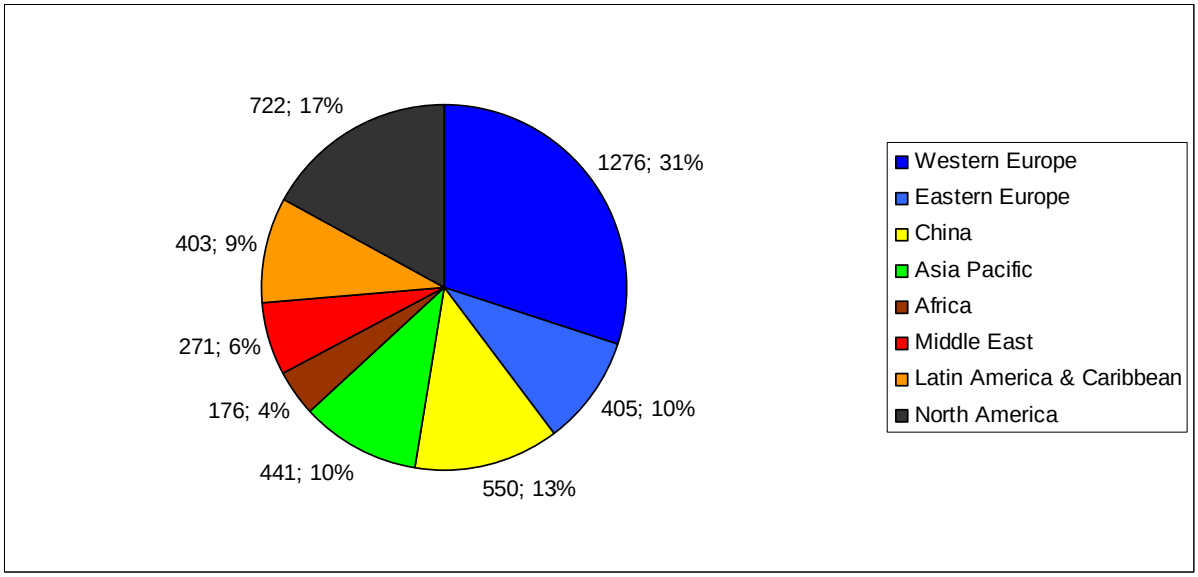


Figure 5.13 Cabin Conversion for Aircrafts on Operating Lease: Cabin Retrofit World Distribution 2009-2029

Let's not forget that the leasing of aircrafts allows carriers to be more flexible towards the market expectations: they can preserve their cash in time of economical downturn; they can meet the market change by remodelling quickly their fleet and they can always offer the passengers new aircrafts. For these reasons, the market of aircraft leasing is expected to grow as more and more full service carriers (along with LCC) decide on aircraft leasing because of its advantages.

Moreover, as it deals with short-term lease contracts, cabin retrofits occur in relative short cycles. As a result, the leasing of aircrafts generates an additional strong demand for cabin redesigns for narrow-bodies as well as wide-bodies.

5.5.5 Demand for Freighter Conversion

A strong demand for Freighter Conversions comes from North America with 55% of the market share. The second position is shared by Western Europe and Asia-Pacific. This is probably due to the high number of freighters operated in North America.

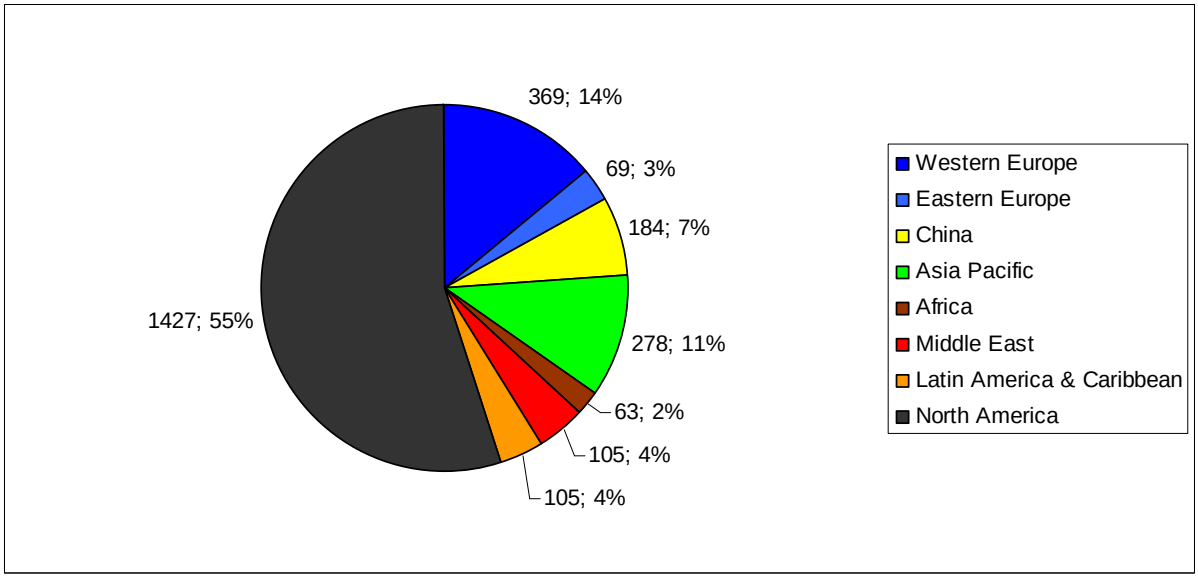


Figure 5.14 Freighter Conversion: Cabin Retrofit World Distribution 2009-2029

Let's not forget that a freighter conversion is an economical alternative to the purchase of a new aircraft. Moreover, it allows a carrier to keep a former airliner in service which is no longer suitable for passenger use. Therefore, this scenario also generates a strong demand for Cabin Modifications.

5.5.6 Demand for VIP Completion

Among the 25500 VIP modifications that are forecasted for the next twenty years, specialists currently see strong interest from India, Russia and the Middle East and they think China will also become a strong market. Traditionally, most VIP conversion business has been generated by the Middle East. Now really strong growth from Russia is seeing and these specialists think there is plenty of potential for further increases in business there. In fact, people from Russia can afford the best, and they're asking for everything: bathrooms, dining areas, bedrooms, libraries, children's rooms. Russia could dominate the sector within five years, exceeding even the Middle East in its demand for the ultimate in opulence. Growth is also coming from the South American market, especially in Brazil, and mainly in the business jet segment. India's fast-growing economy is fuelling demand, where a lot of interest in the Airbus ACJ and Boeing BBJ for both VIP and corporate transport is foreseen (**Aviation Today 2008**).

Then, the typical price of a VIP modification has to be considered because it put this scenario at the front rank of the market. The AeroStrategy company estimates that more than $3.3 billion was spent in 2007 on completing green VIP aircraft and upgrading in-service large executive airplanes. AeroStrategy forecasts that those expenditures could grow to more than $3.8

billion annually by 2015. Typically, VIP aircraft buyers spend up to $100 million for a top-of-the-range completion **(Aviation Week 2008b).**

6 Investigation of Modification Centers

Modification centers will be here investigated by identifying the type of aircrafts involved, the type of work (or scenario) they carry out on aircraft interiors and their location. This information has been collected in the following table shown in the Figure 6.1, 6.2 and 6.3. This table is included in the sheet “Modification Centers” of the enclosed *Excel* database.

Modification Center name	Type of work	In-house Interior Design	Aircraft types involved	Location
ADI Interiors	VIP cabin modification	yes		US
Aero Air, Inc.	Interior modification		Galaxy, Astra, Westwind and Twin Commander	US
Aero Industries / Richmond Jet Center	Interior modification	yes		US
Aerosmith Aviation, Inc.	VIP cabin modification	yes	Gulfstreams, Hawkers, Learjets, Challengers, Jet Stars, Diamonds, King Airs, Falcons, Citations and Westwinds	US
Airbus Corporate Jet Centre	VIP cabin modification		Airbus	
AirCraft Interiors Inc	VIP cabin modification	yes	Medium sized jet	Canada
Aircraft Interiors of Memphis, LLC	Interior modification	yes	piston and turbine aircraft	US
Air Hanson Engineering, Ltd	VIP cabin modification			England
AiROVATION Interior Restyling, Inc	Interior modification	yes		US
Akridge Aircraft Interiors, Inc.	VIP cabin modification	yes	Gulfstream	US
American Aircraft Interiors	VIP cabin modification		Citation, King Air, Conquest, Hawker, Lear, Falcon, Gulfstream, and Boeing.	US
Associated Air Center, Inc.	VIP cabin modification	yes	BBJ & ACJ	US
Austin Jet International	VIP cabin modification		Lears, Citations, King Airs, Hawkers, Gulfstream	US
AvCraft Support Services, Inc.	Airliner interior modification	yes	Dornier 328	US
AVMATS	Airliner interior modification	yes	Falcon, Hawker, and Sabreliner	US
Bizjet International Sales & Support	VIP cabin modification	yes	Citation, Learjet, Dassault Falcon Jet, Embraer, Gulfstream, BBJ	US
Bombardier Aerospace - Montreal	VIP cabin modification	yes	Bombardier Global Express, Bombardier Challenger	Canada
Bombardier Aerospace - Tucson	VIP cabin modification	yes	Challenger, Learjet and other aircraft	US
Bombardier Aerospace - West Virginia	Interior modification		commuter aircraft types	US
Bombardier Aerospace - Wichita	VIP cabin modification	yes	Learjet	US
Burnet Interiors sa	VIP cabin modification	yes		Switzerland
Cabin Crafters	upholstery and cabinetry	subcontract	up to Gulfstream V size aircraft	US
Capital Aviation, Inc.	VIP cabin modification	yes	up to Gulfstream IV size aircraft	US
Classic Interior Completions, Inc.	Interior modification	yes		US
Cypress Aviation, Inc.	Interior modification	no		US
Dassault Falcon Jet	VIP cabin modification	yes	Falcon Jet	US
Dassault Falcon Jet - ILG	VIP cabin modification	yes	Falcon, Challenger, Bae, Gulfstream. NDT and DAS	US
Dassault Falcon Service	VIP cabin modification	yes	Dassault Falcon Jet	France
Delta Interior srl	VIP cabin modification	yes		Italy
DO328 Support Services	Airliner interiors refurbishment		Dornier	Germany

Forecast / Aircrafts / Airlines / Executivejets / Freighters \ Modification Centers / SS1 /

Figure 6.1 Modification centers database (part 1)

Duncan Aviation Inc. - LNK	VIP cabin modification	yes	Citations, Learjets, Hawkers, Falcons, Gulfstreams, Challengers, Astras	US
EADS EFW	Freigher Conversion		Airbus	Germany
EADS Sogerma Services	VIP cabin modification		Airbus	France
Eagle Aviation, Inc.	Interior modification	yes		US
Elliott Aviation	VIP cabin modification	yes		US
Executive Aircraft Corp. - Newton	Interior modification			US
Executive Aircraft Corporation - Wichita	Interior modification	yes		US
Field Aviation East Ltd.	VIP cabin modification	yes		Canada
Field Aviation East Ltd.	VIP cabin modification	yes		Canada
Florida Aircraft Interiors	Interior modification		single engine to small jets	US
Fokker Services	VIP cabin modification	yes		Netherlands
	Airliner interior modification		Fokker	
Flying Colours Corp.	VIP cabin modification	yes	Gulfstream, Cessna, Falcon, Lear Jet, Challenger, Sikorsky, Hawker, Beechjet. Extensive experience with Citation Series.	Canada
Garrett Aviation Services - SPI	Interior modification	yes	Falcon Service Center	US
Garrett Aviation Services - VNY	VIP cabin modification	subcontract	Gulfstream, Challenger and Global Express	US
Goderich Aircraft, Inc	VIP cabin modification	yes	Bombardier	Canada
Goodner-Crider Aircraft Painting	Interior modification	yes		US
Gore Design Completions, Ltd	VIP cabin modification	yes	BBJ, A340, 767, executive jets	US
Greenpoint Technologies, Inc.	VIP cabin modification	yes	Boeing	US
Gulfstream Aerospace Corp. - Dallas	VIP cabin modification	yes	Gulfstream	US
Gulfstream Aerospace Corp. - Long Beach	VIP cabin modification	yes	Gulfstream	US
Gulfstream Aerospace Corp. - SAV	Interior modification	yes	Gulfstream jets	US
Hillaero Modification Center	VIP cabin modification	yes	King Air 200, Citation Bravo, Citation VII	US
Indianapolis Jet Center	VIP cabin modification	yes	Challenger & Learjet	US
Innotech - Execaire Aviation Group	VIP cabin modification	yes		Canada
International Jet Interiors	VIP cabin modification	yes	Gulfstreams, Challengers, Falcons, Hawkers, Jetstars, Citations and Learjets	US
Irkut	Freigher Conversion			Russia
Jet Aviation Basel	VIP cabin modification	yes	Gulfstream, Canadair for Challenger, Learjet, Dassault for the Falcon series	Switzerland
	Airliner interiors refurbishment		aircraft up to the size of a Boeing 747-400 and 767	
Jet Aviation West Palm Beach	VIP cabin modification	yes	Dassault Falcon Jets, Gulfstreams, Challengers and Hawkers	US
JetCorp	VIP cabin modification	yes	Falcon, Learjet, Gulfstream, Jetstar, Sabreliner, HS125	US

Figure 6.2 Modification centers database (part 2)

Jet Source, Inc.	VIP cabin modification			US
Jet Works Air Center	VIP cabin modification	yes	up to large cabin jets such as Gulfstreams and Challengers.	US
KD Aviation Inc. / Reese	Interior modification	yes		US
L-3 Communications Integrated Systems	VIP cabin modification	yes	narrow and wide-body aircraft.	US
Lufthansa Technik AG	VIP cabin modification	yes		Germany
	Airliner interior modification			
Marshall Aerospace	VIP cabin modification	yes		England
	Airliner interior modification			
MAV Aircraft Services	Interior modification	yes		US
McKinney Aerospace	VIP cabin modification	yes	Gulfstreams, Challengers,Falcons, Hawkers, Jetstars, Citations and Learjets	US
Mena Aircraft Interiors	Interior modification	yes	from Cessna 150 to Gulfstream II	US
Midcoast Aviation Inc.	VIP cabin modification	yes	Challenger, Embraer, Falcon, Global, Gulfstream, Hawker, Learjet	US
MJET	VIP cabin modification	yes		Canada
	Airliner interior modification		Bombardier CRJ100/200	
Mobarak Aircraft, LLC	Interior modification	yes	from a Cessna 150 to a Gulfstream GIII	US
Ozark Aircraft Systems	Interior modification	yes		US
Phazar Aerocorp Inc.	VIP cabin modification	yes		US
PrivateSky® Aviation Services, Inc.	VIP cabin modification	yes	Gulfstream GII, GIII, GIV, and GV	US
Ranger Aviation Enterprises, Inc.	VIP cabin modification	no	turboprops through midsize corporate	US
Raytheon Aircraft Services - Little Rock	VIP cabin modification	yes	Raytheon aircrafts	US
Raytheon Aircraft Services - San Antonio	Interior modification		Raytheon	US
Raytheon Aircraft Services - Tampa	VIP cabin modification	yes	Raytheon aircrafts	US
Raytheon Aircraft Services - Wichita	VIP cabin modification		Raytheon	US
Savannah Air Center	VIP cabin modification	yes	Bombardier Challenger and Global Express aircraft, Gulfstream II's through Vs, Raytheon Hawker series, and Falcon 50 aircraft.	US
Sierra Industries Inc.	VIP cabin modification		Cessna Citation	US
Sky Harbour Aircraft	VIP cabin modification	yes		Canada
	Airliner interior modification			
Stevens Aviation Inc. - Dayton	Interior modification	yes		US
Stevens Aviation Inc. - Greenville	Interior modification	yes		US
The Aircraft Completion Centre	VIP cabin modification			Australia
Trace Aircraft Completions	VIP cabin modification	yes		UK
	Airliner interior modification			
UAC	Freigher Conversion			
West Star Aviation, Inc.	VIP cabin modification	yes	Challenger, Citation, Conquest, Lear, Falcon and Hawker.	US

Figure 6.3 Modification centers database (part 3)

Conclusions

The demand for the 10100 International Cabin retrofits is a major segment of the cabin modification global market even if the total amount of modifications is lower than the demand for the 23200 Domestic Cabin redesigns. It is driven by markets with a high growth rate, concentrated in a single world region that is to say Asia-Pacific, the Middle East and China. Nevertheless, this demand is expected to be stable even in economical downturn. The high price of a retrofit program of a wide-body fleet, compared to narrow-bodies, indicates that this scenario will have a big influence on the global market. Therefore it has to be considered with the biggest attention.

Although comfort and amenities on short-haul flights also drive the airlines reputation, most of them do not currently put the emphasis on domestic cabins. Moreover, the real advantages of Domestic Cabin Redesigns are the reduction of fuel burn and the increase of seating capacity and do not involve high expenses. Thus, this scenario is less interesting than International Cabin Redesigns. However, as innovation on International Premium Cabins has a limit and should not always generate high margins for airlines, North American and Western European markets have to be investigated if this segment will suddenly grow.

Aircrafts on operating lease creates an additionnal strong market of 4200 Cabin Conversions for Wide-bodies as well as Narrow-bodies. Moreover, this segment is expected to grow in the future because of the real advantages of operating such aircrafts even for full service carriers. Therefore, European and Asian markets should be anew considered with attention as this demand will concentrate in those regions.

The market segment of Freighter Conversions remains still interesting with 2600 cabin conversions, which most of them will take place in North America.

Last but not least, the 25500 VIP modifications will perhaps be the strongest segment of the Cabin Modifications market for the next twenty years. The high prices of VIP cabin completions, along with the strong need for business aircrafts to be refurbished as soon as possible, makes this segment very interesting. Therefore, North America and European markets should have the biggest influence on the Cabin Modifications market. However, an emerging and growing demand for next years should call attention to Russian and Asian markets.

Acknowledgments

First of all, I want to thank Prof. Dr. Scholz who encouraged me to realize this project and who was always present to advise me. He helped me to enjoy my semester in Hamburg. He motivated me in my researches, and finally made me discover the most interesting aspect of aeronautics.

The next person I want to salute is Mrs. Mihaela Nita who supported me in my work. She was always patient with me and helped me to keep up my project in the right direction. I’m fully aware that without her advices I would never complete this paper.

Last but not least, I really thank my relatives in which I keep finding my courage and who gave me an objective point of view about my work.

References

Achorizons 2008
ACHORIZONS.CA
URL:http://www.achorizons.ca/en/issues/2006/april/extreme.htm (accessed 2009-05-14)

ACW 2003
AIR CARGO WORLD ONLINE: *Holding Pattern for Freighters*, 2003
URL: http://www.aircargoworld.com/features/1103_1.htm (accessed 2009-06-01)

Aeroconseil 2009
AEROCONSEIL.COM: *Reconfiguration Cabine* -
URL:http://www.atsaeroconseil.com/fr/pagesEditos.asp?IDPAGE=454&sX_Menu_selectedID=m2_DA7EC8DD (accessed 2009-04-15)

Aeroweb 2009
AEROWEB-FR.NET: *Air New Zealand Doubles Premium Economy Offerings*, 2009-04-17
URL: http://www.aeroweb-fr.net/depeches/2009/04/air-new-zealand-irdoubles-premium economy-offerings (accessed 2009-05-27)

Airbus 2009
AIRBUS: *Technical definition of the A320P2F cargo conversion is completed*
URL:http://www.afc.aero/index.php?ILNK=news_20090205&iL=2&PHPSESSID=82fcdacd962a0da4a1e9503d512aae2d (accessed 2009-06-01)

Air Canada 2004
AIR CANADA
URL:http://www.aircanada.com/en/about/media/facts/products/factsheetlivery.html (accessed 2009-05-27)

Air France 2009a
AIR FRANCE: Glossary
URL:http://corporate.airfrance.com/no_cache/en/utiles/glossary/index.html#L (accessed 2009-05-19)

Air France 2009b
AIR FRANCE: *La nouvelle cabine « Premium Voyageur » sur les vols long-courriers d'Air France*, 2009-03-20
URL:http://corporate.airfrance.com/index.php?id=communiques_detail&tx_ttnews[tt_news]=4395 (accessed 2009-05-27)

Airliners 2009a
AIRLINERS
URL: http://www.airliners.net/photo/Jazeera-Airways/Airbus-A320 214/1341026/&sid=b8ebd10f937f423fd58f1d524a9cbfd9 (accessed 2009-05-29)

Airliners 2009b
AIRLINERS
URL: http://www.airliners.net/photo/Air-Canada/Airbus-A320-211/1483899/&sid=b8ebd10f937f423fd58f1d524a9cbfd9 (accessed 2009-05-29)

Airliners 2009c
AIRLINERS
URL: http://cdn-www.airliners.net/aviation-photos/middle/3/2/4/1506423.jpg (accessed 2009-05-29)

Airliners 2009d
AIRLINERS
URL: http://cdn-www.airliners.net/aviation-photos/middle/2/5/1/1342152.jpg (accessed 2009-05-29)

Airliners 2009e
AIRLINERS
URL: http://cdn-www.airliners.net/aviation-photos/middle/3/8/0/0768083.jpg (accessed 2009-05-29)

Airliners 2009f
AIRLINERS
URL: http://cdn-www.airliners.net/aviation-photos/middle/9/8/0/1168089.jpg (accessed 2009-05-29)

Airliners 2009g
AIRLINERS
URL: http://cdn-www.airliners.net/aviation-photos/middle/4/7/6/0252674.jpg (accessed 2009-05-29)

Air Pacific 2008
AIR PACIFIC: *Air Pacific's 747 Aircraft To Be Upgraded*, 2008-09-25
URL:http://www.airpacific.com/default.aspx?sid=AP_AboutAirPacific&pid=AP_MediaCentre&MediaCentreID=0fe21ffb-bb76-4613-9d62-fe345a1149b3 (accessed 2009-05-27)

All Experts 2006
ALLEXPERTS.COM: *Shelf life of an aircraft*, 2006-09-27
URL: http://en.allexperts.com/q/Aviation-Flying-1651/shelf-life-aircraft.htm (accessed 2009-06-01)

Arzenheimer 2009
ARZENHEIMER, Adree; Airplane Equipment & Services GmbH; Cabin modification. Interview. Hamburg, Aircraft Interiors Expo, 2009-04-01

ATA 2009
AIR TRANSPORT ASSOCIATION: Glossary
URL: http://www.avjobs.com/history/airline-glossary.asp (accessed 2009-05-09)

ATI 2009
AEROSPACETESTINGINTERNATIONAL.COM : *BizJet begins A318 Elite completion*, 2009-05-17
http://www.aerospacetestinginternational.com/news.php?NewsID=12274 (accessed 2009-06-10)

ATT 2004
ASIA TRAVEL TIPS: *Massive overhaul for Malaysia Airlines' IFE systems*, 2004-10-20
URL:http://www.asiatraveltips.com/travelnews04/2010-Entertainment.shtml (accessed 2009-05-19)

ATT 2005
ASIA TRAVEL TIPS: *Air Canada unveils all new seating featuring industry-leading lie flat suites*, 2005-11-10
URL: http://www.asiatraveltips.com/news05/1011-AirCanada.shtml (accessed 2009-06-01)

ATW 2007a
AIR TRANSPORT WORLD: *Take a Seat*, 2009-03-01
URL: http://www.atwonline.com/magazine/article.html?articleID=2696(accessed 2009-05-01)

ATW 2007b
AIR TRANSPORT WORLD: *Cabin Fever*, 2007-04
URL: http://www.atwonline.com/magazine/article.html?articleID=1898 (accessed 2009-05-01)

Aviation 2009
AVIATION.COM: *Navigation Errors a Key Business Jet Safety Concern,* 2008-05-29
URL: http://www.aviation.com/safety/080529-business-aviation-safety-concerns.html (accessed 2009-06-10)

Aviation Today 2008
AVIATION TODAY: *Incredible Interiors: Modern VIP Cabins,* 2008-11-01
URL: http://www.aviationtoday.com/am/categories/bga/Incredible-Interiors-Modern-VIP Cabins_27215.html (accessed 2009-06-15)

Aviation Week 2008a
AVIATION WEEK: *Cabin Fever*, 2008-10-23
URL:http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=om&id=news/om1008cab.xml (accessed 2009-04-19)

Aviation Week 2008b
AVIATION WEEK: *Demand For Executive/VIP Completions On The Rise, 2008-04 -21*
URL:http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=om&id=news/om408vip.xml (accessed 2009-05-01)

Aviation Week 2008c
AVIATION WEEK: *MRO Prospector. Aircraft and Engines by Aircraft Model. Web Intelligence Document,* last update *:* 2008-11-20
URL: http://mrop.aviationweek.com/(accessed 2008-12-09)

BA 2009
BRITISH AIRWAYS
URL: http://www.britishairways.com/travel/cwexp/public/en_gb (accessed 2009-05-27)

BJII 2009
BUSINESSJETINTERIORSINTERNATIONAL.COM: *328 Support Services announces contract for two Dornier 328 Jet 10-seat VIP conversions, 2009-05-17*
URL: http://www.businessjetinteriorsinternational.com/news.php?NewsID=12358 (accessed 2009-06-10)

BNet 2004
BNET: *China Southern Continues Modernizing Fleet With Major Retrofit*, 2004-11-1
URL:http://findarticles.com/p/articles/mi_m0EIN/is_2004_Nov_1/ai_n6278264/ (accessed 2009-05-19)

BNet 2007
BNET: *Finnair to fit new seats on its Airbus A320 aircraft*, 2007-01-19
URL:http://findarticles.com/p/articles/mi_m0CWU/is_2007_Jan_19/ai_n17135087/ (accessed 2009-05-26)

Boeing 2003
BOEING: *Boeing Offers New 747-400 Freighter Conversion Program*, 2003-10-14 –
URL:http://www.boeing.com/news/releases/2003/q4/nr_031014h.html (accessed 2009-06-01)

Boeing 2009
BOEING: *Current Market Outlook*
URL: http://www.boeing.com/commercial/cmo/ (accessed 2009-04-10)

Business 2008
BUSINESS TRAVELLER: *Exclusive: Air France announces premium economy class*, 2008-04-30
URL: http://www.businesstraveller.com/news/air-france-announces-premium-economy-class (accessed 2009-05-27)

Captain Chris 2000
CAPTAIN CHRIS, 2000-09
URL: http://users.otenet.gr/~cpnchris/airtravelgr.html (accessed 2009-06-01)

Cathay 2007
AVIATION TODAY: *Cathay Pacific Airways Brings Luxurious New Seats and Cabin 'Look and Feel' to Major Cities*, 2007-10-08
URL: http://www.aviationtoday.com/pressreleases/16374.html (accessed 2009-05-27)

Cathay 2009
CATHAY PACIFIC
URL:http://www.cathaypacific.com/cpa/en_INTL/whatonboard/ourfleet/b_747_400 (accessed 2009-05-27)

Cheap Flights 2006
CHEAPFLIGHTS.COM, 2006-09-11
URL:http://news.cheapflights.com/airlines/2006/09/deltas_md88_mak.html (accessed 2009-06-01)

Company 2009
COMPANYSEEK.COM
URL: http://www.company-seek.ceo-recruiters.com/britishairways-BAB.htm (accessed 2009-06-01)

Dallas News 2007
DALLASNEWS.COM: *AA's Mitchell talks customer service,* 2007-09-25 (accessed 2009-05-27)

Dragonair 2003
DRAGONAIR: *Dragonair unveils HDK195-Million Redesign of Aircraft Cabins, Service Enhancements,* 2003-01-20
URL:http://www.dragonair.com/da/en_INTL/aboutus/pressroomdetails?refID=2d457b7f88410110VgnVCM10000021d21c39 (accessed 2009-05-27)

EADS 2009
EADS: *EADS EFW - The Airbus Freighter Conversion Experts,* 2009-03-09

ExecutiveTravel 2009
URL:http://www.executivetravelmagazine.com/page/Design+flaws%3A+Aircraft (accessed 2009-05-19)

Feir 2001
FEIR, Jack; Jack B Feir & Associates, - Speednews Aviation Industry Suppliers Conference: *Aircraft Useful Lives, Retirements and Freighter Conversions,* 2001-03-26
URL:http://www.jackfeir.com/JackFeirPresentation.pdf (accessed 2009-05-09)

FFL 2008
FLYFORLESS.CA, 2008-02-18
URL: http://www.flyforless.ca/news-aircanada/aircanada-news26.html (accessed 2009-06-01)

Financial 2009
FINANCIAL POST: *Air Canada, Bombardier may rekindle once cozy ties,* 2009-03-13
URL: http://www.financialpost.com/story.html?id=1386999 (accessed 2009-06-01)

Finnair 2009
FINNAIR
URL: http://blogs.finnair.com/2009/04/06/interior/ (accessed 2009-06-01)

Flight Global 2006
FLIGHT GLOBAL: *Delta Air Lines to lose 14% seat capacity in Boeing 777 fleet after retrofits,* 2006-10-11
URL: http://www.flightglobal.com/articles/2006/10/11/209911/delta-air-lines-to-lose-14-seat-capacity-in-boeing-777-fleet-after.html (accessed 2009-05-27)

Flight Global 2009
FLIGHTGLOBAL.COM: *EBACE: Business jet deliveries hit by economic meltdown,* 2009-05-12
URL: http://www.flightglobal.com/articles/2009/05/12/326321/ebace-business-jet-deliveries-hit-by-economic-meltdown.html (accessed 2009-06-10)

GECAS 2009
GECAS.COM: *Operating leases*
URL: http://www.gecas.com/op_lease.asp (accessed 2009-06-01)

JAL 2007
JAPAN AIRLINES: *JAL to Introduce Domestic First Class for the First Time & Introduce New International JAL Premium Economy in FY2007*, 2007-01-17 –
URL: http://press.jal.co.jp/en/release/200701/000661.html (accessed 2009-05-26)

JAL 2007
JAPAN AIRLINES: *JAL to Introduce Domestic First Class for the First Time & Introduce New International JAL Premium Economy in FY2007*, 2007-01-17
URL: http://press.jal.co.jp/en/release/200701/000661.html (accessed 2009-05-19)

Lufthansa 2009a
LUFTHANSA TECHNIK, *Cabin Modification: A market grows in importance* –
URL:http://www.lufthansa-technik.com/applications/portal/lhtportal/lhtportal.portal?_nfpb=true&_pageLabel=Template5_6&requestednode=137&node=137&action=initial (accessed 2009-05-09)

Luxist 2007
LUXIST: *United Announces New Seats for International Business Class,* 2007-07-23
URL: http://www.luxist.com/2007/07/23/united-announces-new-seats-for-international-business-class/ (accessed 2009-05-26)

NYT 2008
NEW YORK TIMES: *On some airlines, business class goes first,* 2008-03-10

NYT 2009
NEW YORK TIMES: *For Some Airlines, Recession Doubts Are Taking a Back Seat,* 2009-05-26
URL:http://www.nytimes.com/2009/05/27/business/global/27first.html?pagewanted=1&_r=1&sq=On%20some%20airlines,%20business%20class%20goes%20first&st=cse&scp=1 (accessed 2009-06-01)

Pakistan 2000
PAKISTAN ECONOMIST: *Well done PIA, 2000-10*
URL: http://www.pakistaneconomist.com/issue2000/issue43/i&e5.htm (accessed 2009-05-01)

PAL 2009
PHILIPPINE AIRLINES: *PAL refurbishes B747 with world-class amenities*, 2009-05-14
URL:http://www.philippineairlines.com/news/may_14_pal_refurbishes_b747_with_world_class_amenities.jsp (accessed 2009-05-26)

PSFK 2009
PSFK: *Swiss Air Redesigns Their First Class Suites*, 2009-02-19
URL: http://www.psfk.com/2009/02/swiss-air-redesigns-their-first-class-suites.html (accessed 2009-05-21)

Punch 2009
PUNCH: *Why airlines are redesigning cabins*, 2009-04-15

RedOrbit 2005
REDORBIT.COM: *Delta Resumes Full Flight Schedule*, 2005-10-07
URL:http://www.redorbit.com/news/technology/264242/delta_resumes_full_flight_schedule/ (accessed 2009-06-01)
URL:http://www.eads.net/1024/en/businet/aeronaut/efw/fields/freighter.html (accessed 2009-06-01)

SAS 1998
SCANDINAVIAN AIRLINES
URL: http://www.sasflightops.com/latest/latest_98.htm (accessed 2009-06-01)

Scholz 1999
SCHOLZ, Dieter: *Flugzeugentwurf*. Hamburg, HAW Hamburg, Dep. F&F, Lecture, 1999

SeatGuru 2009
URL: http://www.seatguru.com/ (accessed 2009-05-19)

SEM 2009
SEM AEROSPACE: *Business airplanes: cabin upgrades*
URL: http://semproducts.com/Images/PressReleasePDF5.pdf (accessed 2009-05-05)

Swiss 2008a
SWISS AIRLINES: *Première mondiale : les sièges SWISS Business annoncent une nouvelle ère du confort*, 2008-05-21
URL:http://www.swiss.com/web/FR/about_swiss/media/press_releases/2008/Pages/pr_20080521.aspx (accessed 2009-05-27)

Swiss 2008b
SWISS AIRLINES: *New seats now installed throughout SWISS's European fleet*, 2008-04-10
URL:http://www.swiss.com/web/EN/about_swiss/media/press_releases/2008/Pages/pr_20080410.aspx?1243855120183&Country=US (accessed 2009-06-01)

TOM 2007
TIMESOFMALTA.COM: *Lufthansa breaks new ground*, 2007-06-28
URL:http://www.timesofmalta.com/business/view/20070628/interview/lufthansa-breaks-new-ground (accessed 2009-05-01)

Wikipedia 2009a
WIKIPEDIA: *Economy Class*, 2009-05-18
URL: http://en.wikipedia.org/wiki/Economy_class (accessed 2009-05-26)

Wikipedia 2009b
WIKIPEDIA: *Business Class*, 2009-05-29
URL: http://en.wikipedia.org/wiki/Business_class (accessed 2009-05-29)

Wikipedia 2009c
WIKIPEDIA: *Airline Seat*, 2009-05-12
URL: http://en.wikipedia.org/wiki/Airline_seat (accessed 2009-05-29)

Wikipedia 2009d
WIKIPEDIA: *Premium Economy*, 2009-05-16
URL:http://en.wikipedia.org/wiki/Premium_Economy (accessed 2009-05-29)

Wikipedia 2009e
WIKIPEDIA: *Cargo Aircraft*, 2009-05-30
URL: http://en.wikipedia.org/wiki/Cargo_aircraft (accessed 2009-06-01)

Wikipedia 2009f
WIKIPEDIA.COM: *Aircraft finance*
URL: http://en.wikipedia.org/wiki/Aircraft_finance (accessed 2009-06-01)

Wikipedia 2009g
WIKIPEDIA.COM: *Aircraft maintenance checks*
URL: http://en.wikipedia.org/wiki/Aircraft_maintenance_checks (accessed 2009-06-01)

Appendix

In this appendix, there is the whole VBA code used in *Excel* to forecast the cabin modification volume. The commentaries linked to each row are written in green colour.

Sub project_commercial_airplanes()

```
Dim aircraft As aircrafts 'contains all the characteristics of the aircraft we work on
Dim scenario As scenarios 'contains all the characteristics of the cabin modification scenario related to this aircraft
Dim sheet As Worksheet 'describes the worksheet we work on
Dim row As Integer 'describes the row of this worksheet we work on
row = 18 'row gives the number of the current row. Information begins at row number 18.
Dim number_modifications As Integer 'gives the number of modifications for one aircraft either until 01/07/2009 or before the aircraft end of life

For Each sheet In Worksheets
   If ((sheet.Name = "Forecast") Or (sheet.Name = "Aircrafts") Or (sheet.Name = "Airlines") Or (sheet.Name = "Executive-Jets") Or (sheet.Name = "Freighters") Or (sheet.Name = "B737-BBJ")) Then
   Else 'scan only the worksheets about commercial airplanes
      row = 18
      Do While sheet.Cells(row, 3) <> "" 'scan all the rows until the end of the sheet(we consider only one aircraft each time
         number_modifications = 0 'before the computation there is no modification for this aircraft
         Call read_aircraft_properties(aircraft, ByVal row, ByVal sheet) 'scan all the characteritics of this aircraft from the database
         Call determine_body_type(aircraft) 'determine if this aircraft is a wide-body or a narrow-body
         Call determine_operator_type(aircraft) ' determine if the aircraft operator is a LCC or not
         Call determine_scenario(aircraft, scenario) 'determine, with all these information, the cabin modification scenario related to this aircraft
         Call write_scenario(scenario, ByVal row, ByVal sheet) 'write the type of scenario of this aircraft in a specific column of the database
         Call read_scenario_parameters(scenario, aircraft) 'read the parameters of the scenario required for the computation
         Call compute_modifications(aircraft, scenario, number_modifications, ByVal sheet) 'compute the number of cabin modifications for this aircraft either until 01/07/2029 or until the aircraft end of life.
         Call write_number_modifications(number_modifications, ByVal row, ByVal sheet) 'write the number of modification for this aircraft in a specific column of the database
         row = row + 1 'goes to the next row
      Loop
   End If
Next sheet
End Sub
```

Sub read_aircraft_properties(aircraft As aircrafts, ByVal row, ByVal sheet)

```
aircraft.model = sheet.Cells(row, 3).Value
aircraft.operator = sheet.Cells(row, 6).Value
aircraft.freighter = sheet.Cells(row, 5).Value
aircraft.delivery_date = sheet.Cells(row, 21).Value
aircraft.lease_termination = sheet.Cells(row, 29).Value
End Sub
```

```
Sub determine_body_type(aircraft As aircrafts)
Dim row As Integer
row = 8 'row gives the number of the current row. Information begins at row number 8.

Do While Worksheets("Aircrafts").Cells(row, 3).Value <> "" 'scan all the rows until the end of the sheet
   If Worksheets("Aircrafts").Cells(row, 3).Value = aircraft.model Then ' if the aircraft model is found
      aircraft.wide_body = Worksheets("Aircrafts").Cells(row, 4).Value ' the type of body is saved in the variable aircraft
   End If
   row = row + 1 'goes to the next row
Loop
End Sub

Sub determine_operator_type(aircraft As aircrafts)
Dim row As Integer
row = 8 'row gives the number of the current row. Information begins at row number 8.
aircraft.LCC = False

Do While Worksheets("Airlines").Cells(row, 2).Value <> "" 'scan all the rows until the end of the sheet
   If Worksheets("Airlines").Cells(row, 2).Value = aircraft.operator Then ' if the aircraft operator is found
      aircraft.LCC = True ' the type of operator is saved in the variable aircraft
   End If
   row = row + 1 'goes to the next row
Loop
End Sub

Sub determine_scenario(aircraft As aircrafts, scenario As scenarios)
If aircraft.freighter = False Then 'if the aircraft is not a freighter
   If aircraft.lease_termination = "00:00:00" Then 'if the aircraft is not on operating lease
      If aircraft.wide_body = True Then 'if it is a wide-body
         If aircraft.LCC = False Then 'if it is a Full service carrier
            scenario.type = "Overall Redesign of International Cabins"
         Else  'if it is a LCC
            scenario.type = "No Modification Scenario"
         End If
      Else 'if it is a narrow-body
         scenario.type = "Overall Redesign of Domestic Cabins" 'no differentiation here between LCC and Full service carrier
      End If
   Else 'if the aircraft is on operating lease
      If aircraft.wide_body = False Then 'if it is a narrow-body
         scenario.type = "Cabin Conversion for Narrow-bodies on Operating Lease" 'no differentiation here between LCC and
Full service carrier
      Else 'if it is a wide-body
         scenario.type = "Cabin Conversion for Wide-bodies on Operating Lease" 'no differentiation here between LCC and
Full service carrier
      End If
   End If
Else 'if the aircraft is a freighter
   scenario.type = "No Modification Scenario"
End If
End Sub


Sub write_scenario(scenario As scenarios, ByVal row, ByVal sheet)
sheet.Cells(row, 30).Value = scenario.type
End Sub
```

```
Sub read_scenario_parameters(scenario As scenarios, aircraft As aircrafts)
If scenario.type = "Overall Redesign of Domestic Cabins" Then
   scenario.frequency = Worksheets("Forecast").Cells(13, 5).Value
   scenario.equ_duration = Worksheets("Forecast").Cells(13, 7).Value
   scenario.duration = 0 'duration is not useful for this scenario
   scenario.age_limit = Worksheets("Forecast").Cells(13, 9).Value
End If

If scenario.type = "Overall Redesign of International Cabins" Then
   scenario.frequency = Worksheets("Forecast").Cells(12, 5).Value
   scenario.equ_duration = Worksheets("Forecast").Cells(12, 7).Value
   scenario.duration = 0 'duration is not useful for this scenario
   scenario.age_limit = Worksheets("Forecast").Cells(12, 9).Value
End If
(….)
If aircraft.delivery_date + scenario.age_limit * 365 < "1 / 7 / 2029" Then 'if the date at which there is no more modification do not exceed the date 1/7/2029
   scenario.date_limit = aircraft.delivery_date + scenario.age_limit * 365 'then we take this date as upper limit for the computation
Else
   scenario.date_limit = "1 / 7 / 2029" 'else we take the date 1/07/2029 as upper limit for the computation
End If
End Sub

Sub compute_modifications(aircraft As aircrafts, scenario As scenarios, number_modifications As Integer, ByVal sheet)
Dim fleet_volume As Integer 'counts the number of aircrafts of the same model and affected by the same scenario

   If scenario.type = "Cabin Conversion for Narrow-bodies on Operating Lease" Or scenario.type = "Cabin Conversion for Wide-bodies on Operating Lease" Then
      Call compute_modification_lease(aircraft, scenario, number_modifications) ' compute the number of modification for aircrafts on operating lease
   End If
   If scenario.type = "Overall Redesign of Domestic Cabins" Or scenario.type = "Overall Redesign of International Cabins" Then
      Call compute_fleet_volume(ByVal sheet, aircraft, fleet_volume) 'compute the number of aircrafts of the same operator
      Call compute_total_duration(scenario, ByVal fleet_volume) 'compute the program duration for the entire fleet
      Call compute_modification_normal(aircraft, scenario, number_modifications) ' compute the number of modification for the other aircrafts
      'MsgBox ("aircraft: " & aircraft.model & Chr(13) & "fleet volume: " & fleet_volume & Chr(13) & "number modif: " & number_modifications)
   End If
   If scenario.type = "No Modification Scenario" Then
      number_modifications = 0
   End If
End Sub

Sub compute_modification_lease(aircraft As aircrafts, scenario As scenarios, number_modifications As Integer)
Dim end_computation As Boolean
Dim date_modification As Date 'indicates the date of the current forecast modification
end_computation = False 'command the exit of the loop
date_modification = aircraft.lease_termination 'the first modification will happen at the date of lease termination

If scenario.date_limit > Date Then 'if aircraft is not yet phased-out then modifications should be planned
```

```
   number_modifications = 0
   Do While (end_computation = False)
      number_modifications = number_modifications + 1
      date_modification = date_modification + scenario.frequency * 31 + scenario.duration 'computation of the date of the next modification
      If date_modification > scenario.date_limit Then 'if the date of the next modification exceed the upper limit, no more modification will be planned
         end_computation = True
      End If
   Loop
Else 'if the aircraft is already phased-out, no more modification will be planned
   number_modifications = 0
End If
End Sub

Sub compute_fleet_volume(ByVal sheet, aircraft As aircrafts, fleet_volume)
Dim row As Integer
row = 18
fleet_volume = 0

      Do While sheet.Cells(row, 3) <> "" 'scan all the rows until the end of the sheet
         If aircraft.lease_termination = "00:00:00" Then 'if the aircraft is not on operating lease
            If aircraft.freighter = False Then 'if the aircraft is not a freighter
               If aircraft.operator = sheet.Cells(row, 6) Then 'if the aircraft belongs to the same operator
                  fleet_volume = fleet_volume + 1 'count the fleet volume
               End If
            End If
         End If
         row = row + 1
      Loop
End Sub

Sub compute_total_duration(scenario As scenarios, ByVal fleet_volume)
scenario.tot_duration = scenario.equ_duration * fleet_volume 'compute the duration of the whole program (in days)
End Sub

Sub compute_modification_normal(aircraft As aircrafts, scenario As scenarios, number_modifications)
Dim end_computation As Boolean
Dim date_modification As Date 'indicates the date of the current forecast modification
end_computation = False 'command the exit of the loop
date_modification = Date 'the first modification will happen at the date of today

If scenario.date_limit > Date Then 'if aircraft is not yet phased-out then modifications should be planned
   number_modifications = 0
   Do While (end_computation = False)
      number_modifications = number_modifications + 1
      date_modification = date_modification + scenario.frequency * 31 + scenario.tot_duration 'computation of the date of the next modification
      If date_modification > scenario.date_limit Then 'if the date of the next modification exceed the upper limit, no more modification will be planned
         end_computation = True
      End If
   Loop
Else 'if the aircraft is already phased-out, no more modification will be planned
   number_modifications = 0
```

```
End If
End Sub

Sub write_number_modifications(ByVal number_modifications, ByVal row, ByVal sheet)
sheet.Cells(row, 31).Value = number_modifications
End Sub
```

Sub project_commercial_airplanes_total_modifications() 'compute and write the number of modifications for each region and each scenario

```
Dim region As String
Dim scenario_type As String
Dim sheet As Worksheet 'describes the worksheet we work on
Dim row As Integer 'describes the row of this worksheet we work on
row = 18 'row gives the number of the current row. Information begins at row number 18.
Dim number_modifications As Integer 'gives the number of modifications of a specific aircraft
Worksheets("Forecast").Range("D32:U34").ClearContents

For Each sheet In Worksheets
   If ((sheet.Name = "Forecast") Or (sheet.Name = "Aircrafts") Or (sheet.Name = "Airlines") Or (sheet.Name = "Executive-Jets") Or (sheet.Name = "Freighters")) Then
   Else 'scan only the worksheets about commercial airplanes
      row = 18
      Do While sheet.Cells(row, 3) <> "" 'scan all the rows until the end of the sheet(we consider only one aircraft each time)
         number_modifications = 0 'before the computation there is no modification for this aircraft
         Call read_region(region, ByVal row, ByVal sheet) 'scan the world region where this aircraft is based
         Call read_scenario(scenario_type, ByVal row, ByVal sheet) 'scan the modification scenario of this aircraft
         Call read_number_modifications(number_modifications, ByVal row, ByVal sheet) 'scan the number of modifications for this aircraft
         Call compute_detailed_modifications(ByVal number_modifications, ByVal scenario_type, ByVal region) 'compute and write the number of modifications for each region and each scenario
         row = row + 1 'goes to the next row
      Loop
   End If
Next sheet
Call compute_total_modifications   ' compute and write the total amount of modifications for each scenario
End Sub

Sub read_region(region As String, ByVal row, ByVal sheet)
region = sheet.Cells(row, 7)
End Sub

Sub read_scenario(scenario_type As String, ByVal row, ByVal sheet)
scenario_type = sheet.Cells(row, 30)
End Sub

Sub read_number_modifications(number_modifications As Integer, ByVal row, ByVal sheet)
number_modifications = sheet.Cells(row, 31)
End Sub

Sub compute_detailed_modifications(ByVal number_modifications As Integer, ByVal scenario_type As String, ByVal region As String)
If scenario_type = "Overall Redesign of International Cabins" Then
      If region = "Western Europe" Then
         Worksheets("Forecast").Cells(32, 5) = Worksheets("Forecast").Cells(32, 5) + number_modifications
      End If
      If region = "Eastern Europe" Then
         Worksheets("Forecast").Cells(32, 6) = Worksheets("Forecast").Cells(32, 6) + number_modifications
      End If
      If region = "China" Then
         Worksheets("Forecast").Cells(32, 7) = Worksheets("Forecast").Cells(32, 7) + number_modifications
```

```
        End If
        If region = "Asia Pacific" Then
           Worksheets("Forecast").Cells(32, 8) = Worksheets("Forecast").Cells(32, 8) + number_modifications
        End If
        If region = "Africa" Then
           Worksheets("Forecast").Cells(32, 9) = Worksheets("Forecast").Cells(32, 9) + number_modifications
        End If
        If region = "Middle East" Then
           Worksheets("Forecast").Cells(32, 19) = Worksheets("Forecast").Cells(32, 19) + number_modifications
        End If
        If region = "Latin America & Caribbean" Then
           Worksheets("Forecast").Cells(32, 20) = Worksheets("Forecast").Cells(32, 20) + number_modifications
        End If
        If region = "North America" Then
           Worksheets("Forecast").Cells(32, 21) = Worksheets("Forecast").Cells(32, 21) + number_modifications
        End If
End If

If scenario_type = "Overall Redesign of Domestic Cabins" Then
        If region = "Western Europe" Then
           Worksheets("Forecast").Cells(33, 5) = Worksheets("Forecast").Cells(33, 5) + number_modifications
        End If
        If region = "Eastern Europe" Then
           Worksheets("Forecast").Cells(33, 6) = Worksheets("Forecast").Cells(33, 6) + number_modifications
        End If
        If region = "China" Then
           Worksheets("Forecast").Cells(33, 7) = Worksheets("Forecast").Cells(33, 7) + number_modifications
        End If
        If region = "Asia Pacific" Then
           Worksheets("Forecast").Cells(33, 8) = Worksheets("Forecast").Cells(33, 8) + number_modifications
        End If
        If region = "Africa" Then
           Worksheets("Forecast").Cells(33, 9) = Worksheets("Forecast").Cells(33, 9) + number_modifications
        End If
        If region = "Middle East" Then
           Worksheets("Forecast").Cells(33, 19) = Worksheets("Forecast").Cells(33, 19) + number_modifications
        End If
        If region = "Latin America & Caribbean" Then
           Worksheets("Forecast").Cells(33, 20) = Worksheets("Forecast").Cells(33, 20) + number_modifications
        End If
        If region = "North America" Then
           Worksheets("Forecast").Cells(33, 21) = Worksheets("Forecast").Cells(33, 21) + number_modifications
        End If

End If
(….)
End Sub

Sub compute_total_modifications()
Dim index As Integer

   For index = 5 To 21
   Worksheets("Forecast").Cells(32, 4) = Worksheets("Forecast").Cells(32, index) + Worksheets("Forecast").Cells(32, 4)
   Next index
   For index = 5 To 21
```

```
    Worksheets("Forecast").Cells(33, 4) = Worksheets("Forecast").Cells(33, index) + Worksheets("Forecast").Cells(33, 4)
    Next index
    For index = 5 To 21
    Worksheets("Forecast").Cells(34, 4) = Worksheets("Forecast").Cells(34, index) + Worksheets("Forecast").Cells(34, 4)
    Next index
End Sub
```

Sub project_freighter_conversion()

```
 Call compute_fleet_distribution 'compute and write the freighter world fleet
 Call compute_conversion_volume 'compute and write the total volume of freighter conversion
 Call write_conversion_distribution 'compute and write the world distribution of freighter conversions
End Sub
```

Sub compute_conversion_volume()

```
Dim index As Integer
   Worksheets("Freighters").Cells(13, 5).Value = Worksheets("Freighters").Cells(13, 3) * Worksheets("Freighters").Cells(13, 4).Value 'multiplies the freighter fleet forecast with the freighter conversion proportion
   Worksheets("Forecast").Cells(35, 4) = Worksheets("Freighters").Cells(13, 5).Value 'write the total amount of conversions
End Sub
```

Sub compute_fleet_distribution()

```
Dim region As String
Dim sheet As Worksheet 'describes the worksheet we work on
Dim row As Integer 'describes the row of this worksheet we work on
Dim index As Integer 'useful for the distribution of the fleer (at the end)
row = 18 'row gives the number of the current row. Information begins at row number 18.
Dim fleet_volume As Integer 'counts the freighter world fleet volume
fleet_volume = 0
Worksheets("Freighters").Range("C18:J18").ClearContents

For Each sheet In Worksheets
   If ((sheet.Name = "Forecast") Or (sheet.Name = "Aircrafts") Or (sheet.Name = "Airlines") Or (sheet.Name = "Executive-Jets") Or (sheet.Name = "Freighters")) Then
   Else 'scan only the worksheets about commercial airplanes
      row = 18
      Do While sheet.Cells(row, 3) <> "" 'scan all the rows until the end of the sheet(we consider only one aircraft each time)
         If sheet.Cells(row, 5) = 1 Then 'considers only freighters
            fleet_volume = fleet_volume + 1 'counts the freighter fleet
            region = sheet.Cells(row, 7) 'scans the world region where this aircraft is based
            If region = "Western Europe" Then
               Worksheets("Freighters").Cells(18, 3) = Worksheets("Freighters").Cells(18, 3) + 1 'counts and write the freighter fleet of Western Europe
            End If
            If region = "Eastern Europe" Then
               Worksheets("Freighters").Cells(18, 4) = Worksheets("Freighters").Cells(18, 4) + 1
            End If
         (……)
         End If
         row = row + 1 'goes to the next row
      Loop
   End If
Next sheet
Worksheets("Freighters").Cells(18, 2) = fleet_volume ' write the freighter fleet volume
For index = 3 To 10
   Worksheets("Freighters").Cells(18, index) = Worksheets("Freighters").Cells(18, index) / fleet_volume ' compute and write the distribution of the fleet
Next
End Sub
```

```
Sub write_conversion_distribution()
Worksheets("Forecast").Cells(35, 5) = CInt(Worksheets("Freighters").Cells(18, 3) * Worksheets("Freighters").Cells(13, 5))
'multiplies the total number of conversion by the fleer proportion of that region and converts the result into an integer.
Worksheets("Forecast").Cells(35, 6) = CInt(Worksheets("Freighters").Cells(18, 4) * Worksheets("Freighters").Cells(13, 5))
(…)
End Sub
```

Sub project_VIP_modification()

```
Dim duration As Integer 'contains the duration of a VIP modification
Dim frequency As Integer 'contains the time between two modifications
Dim time_available As Integer 'contains the the period within which VIP modifications will be undertaken
Dim number_modification_aircraft As Long 'contains the amount of VIP modifications for one business aircraft
Dim total_modifications As Long 'contains the total amount of VIP modifications in the world
Dim aircraft_volume As Long 'contains the amount of business aircraft deliveries

duration = Worksheets("Forecast").Cells(17, 6) 'read the duration of a VIP modification in days
frequency = Worksheets("Forecast").Cells(17, 5) * 31 'read the frequency of VIP modifications in months and convert it in days
time_available = Worksheets("Forecast").Cells(17, 9) * 365 'read the time available for VIP modifications during the aircraft useful life (in years) and convert it in days
number_modification_aircraft = time_available / (duration + frequency) 'compute the number of modifications for one aircraft during its useful life
aircraft_volume = Worksheets("ExecutiveJets").Cells(13, 2) 'read the business aircraft fleet in the sheet ExecutiveJets
total_modifications = number_modification_aircraft * aircraft_volume 'compute the total amount of VIP modifications
Worksheets("Forecast").Cells(36, 4).Value = total_modifications 'write this result in the sheet Forecast
End Sub
```