Challenges to Growth
2004 Report

Challenges to Growth

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**EUROPEAN ORGANISATION
FOR THE SAFETY OF AIR NAVIGATION**

EUROCONTROL

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Abstract

The *Challenges to Growth 2004 Report* is the final deliverable of the CTG04 study, which updates the ECAC-EUROCONTROL Study on Constraints to Growth published in 2001. Extending the time horizon to 2025, the study is based, *inter alia*, on a new long-term demand forecast and updated airport capacity projections.

The study has been conducted to help clarify the future position of air transport in Europe via a network-wide analysis of:

- The long-term evolution of traffic demand
- The long-term potential for airport capacity enhancement
- The long-term network effect of airport capacity constraints
- Possibilities to mitigate these constraints
- A qualitative analysis of environmental challenges

Because the results of the study will also serve as an input to strategic planning in the context of the European ATM Master Plan, the focus of the analysis was on the interaction between traffic demand and airport capacity, without any *a priori* assumption of ATC capacity constraints.

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forecast	challenges	growth	environment
accommodated	unaccommodated	demand	

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CONTENTS

EXECUTIVE SUMMARY

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Future Traffic Demand

To study the long-term evolution of traffic demand, the Agency, in collaboration with Stakeholders, has developed four forecasting scenarios which together were judged to capture a range of possible futures for the air traffic industry that was wide enough to support the formulation of strategy:

- Scenario A — globalisation and rapid economic growth: flight demand (traffic without airport constraints) grows on average 4.3% p.a. By the year 2025, this scenario would result in a growth of 2.5 times the 2003 flight demand.
- Scenario B — business as usual (moderate economic growth and no significant change from the status quo and current trends). Results in an annual growth rate of 3.6%, which equates to a growth factor of 2.2 by 2025.
- Scenario C — strong economic growth with government regulation to address growing environmental issues: leads to 3.2% growth p.a. and a growth factor of 2.0.
- Scenario D — regionalisation and weak economies (increased tensions between regions with high security costs and high oil prices), resulting in 2.5% growth p.a. and a growth factor of 1.7.

In this study, most of the analysis is focused on scenario A, because its associated traffic demand forecast represents the highest challenges to growth.

<u>Future Airport Capacity</u>

While it addresses all served airports, the focus of the study is on the first 133 European airports which together handle 90% of the IFR traffic. The findings are based on the replies to a EUROCONTROL-ACI questionnaire sent to these airports (response rate 52%) complemented by data obtained from non-responding airports on earlier occasions.

It is estimated that the airport network has a long-term potential for 60% capacity growth, but only a small part of this extra capacity can be provided at the major airports and one third of it would in fact not be needed in 2025 due to insufficient demand at the concerned airports.

The potential is partly due to the fact that 25% of airports reported a possibility for building new runways in the next 20 years. However most of this reported growth potential is to take place under the condition that all airports manage to apply best practices as soon as possible.

Nevertheless, almost 80% of the airports indicate that without adding extra runways, they will be unable to achieve the same capacity as the best performing airport with comparable runway configuration. The most frequently cited reasons for this were physical site and infrastructure limits (two thirds of airports with constraints), followed by environmental issues (half of the airports), and physical constraints related to surrounding airspace and geography (one third).

Today, most airports have some spare capacity. In fact, for the first 133 airports, nearly 30% of existing capacity remains unused at 2003 typical busy hour traffic levels. In the scenario with the highest traffic growth (scenario A), even with maximum achievable capacity enhancements, this situation is expected to gradually deteriorate into *capacity imbalance*, i.e. capacity shortage in parts of the network with a remaining capacity surplus in other parts. Already in 2010, more than twenty airports are expected to have a capacity shortage if the demand evolution follows the high growth scenario. Ultimately, in 2025, with all new investments taken into account, more than 60 airports will be unable to handle the typical busy hour demand without generating delays or unaccommodated demand.

<u>Traffic Growth Potential</u>

With the highest growth scenario airports will severely constrain traffic growth in 2025. Annual demand will have increased to 21 million flights, a growth by a factor 2.5 compared to 2003. However, despite 60% potential capacity increase of the airport network, **only <u>twice</u> the volume of 2003 traffic can be accommodated**, and 17.6% of demand (i.e. 3.7 million flights per year) cannot take place. This is expected to have a significant impact on airport operations: more than 60 airports will be congested, and the top-20 airports will be saturated at least 8-10 hours per day.

The progressive occurrence of unaccommodated flight demand will cause pressure to change the traffic distribution pattern: growth will be limited to parts of the airport network which are not yet congested, meaning that extra flights will only be possible at secondary airports, generally at less favourable times. There will also be a strong pressure to accelerate the switchover to larger aircraft, in order to accommodate more passengers while keeping the number of flights constant.

The study has analysed the potential of mitigating unaccommodated demand if aircraft operators would be willing to adapt their demand distribution patterns:

- If unaccommodated flights would take place up to 3 hours earlier or later than desired, then the unaccommodated demand could be reduced from 17.6% to 11%, meaning that up to 1.6 million extra flights per year could be accommodated.
- In addition, if unaccommodated flights could be transferred to secondary airports in the same region, the unaccommodated demand would be brought down to 5%. In other words, it is possible to find capacity for up to 2.6 of the 3.7 million unaccommodated flights by accepting less ideal times and places for that traffic.

On the other hand, if the air transport market would require that demand distribution patterns need to remain as they are, and considering that the existing airports cannot expand as required, the only alternative way to handle the 3.7 million unaccommodated flights per year in 2025 would be the creation of reliever airports in the vicinity of their congested counterparts. The study concludes that there could be a market for up to 10 new major airports (capacity 70-140 mov/hr) and 15 medium sized airports (capacity 35-70 mov/hr).

Environmental Challenges

Environmental issues remain a major impediment to achieving maximum airport throughput. Without their successful resolution it will be impossible to deliver sufficient capacity. Given the political and institutional context on environmental matters, it was decided to conduct a qualitative assessment of environmental issues to identify any "pinch points" that could occur during the study period. It is clear that aircraft noise in the vicinity of airports is an issue that will not go away. The short-term noise outlook is somewhat positive. However, there is little prospect of new internationally agreed noise stringency standards for applicability before 2012. As traffic grows, therefore, the noise climate around airports will deteriorate from about 2010 onwards. At the same time, EU limits on local air quality will be introduced and these can also be expected to constrain airports' ability to grow. Indeed, recent planning decisions are already taking air quality into account, and its importance as a constraining factor on airport development is likely to be equal to that of noise.

Although the CTG04 study has concentrated on airports, there is an emerging view that aviation's single biggest environmental challenge is that of mitigating its effects on global warming. This is principally an en-route issue. Although scientific evidence would suggest that aviation's global warming impact is greater than previously thought, the case can not yet be made. Nevertheless, the risk remains that, at some point during the study period, there may be a shift in public perception of air transport that leads to a new set of constraints being imposed for new environmental reasons.

The Need to Plan for the Most Challenging Scenario

The highest growth is forecast to occur under conditions of globalisation and rapid economic growth. The other forecasting scenarios would lead to lower demand (hence less airport congestion), but possibly also to higher airport capacity constraints. In case of lower demand growth the constraining effects are smaller but they still present unaccommodated demand and simply push the same problem further in the future. In addition, it is easier to delay capacity development than to accelerate it at a later stage. The study, therefore, recommends to assume the highest growth scenario (but without constraint mitigation) as the reference on which to base the strategic discussions and decisions.

1. INTRODUCTION

1.1 Background

The first CTG study (then called: Constraints to Growth; in this report referred to as CTG01) was conducted in 2000-2001 in response to a request of the Transport Ministers at the MATSE/6 meeting in January 2000. The CTG01 report was developed by the ECAC Medium Term Objectives (EMTO) group and has been used as a basis for political discussion on constraints. The report was also used to derive strategic performance requirements. These requirements in turn were the performance driven basis for the update of the EUROCONTROL Air Traffic Management Strategy for the Years 2000+ (ATM 2000+ Strategy).

Since the publication of the CTG01 report early 2001, more than three years have passed. During that period, events took place such as September 11th, economic down turn but also the strong growth of the Low Cost Carriers. In addition airports have implemented and updated their capacity enhancement plans. It became clear that the CTG01 results were in need of an update to take account of the latest trends and forecasts.

In 2003, the EUROCONTROL Agency started a new strategic planning cycle in preparation for the development of the European ATM Master Plan. This plan will detail all the actions that have to be undertaken to change the European ATM system to cope with growing demand while meeting performance objectives. Hence an update of the CTG01 study is also necessary from a perspective of supporting that strategic planning process.

Environmental issues are playing an increasing role in the evolution of air traffic. Mitigating them takes long lead times. For these reasons, it was decided that the study should include a qualitative analysis of the environmental constraints to growth.

At the 27th triennial plenary session of the European Civil Aviation Conference (ECAC) held on 8 – 9 July 2003, the Agency's initiative to update the study was announced. Members of the Collaborative Forum of Air Transport Stakeholders (CFS) were invited to nominate representatives for the Steering Group for the update of the study.

The Steering Group met for the first time on 18th November 2003 to discuss the approach for the update of the study. At its 3rd meeting the group decided to change the name of the study to *Challenges to Growth Study 2004* (CTG04). The new name better matches the current objectives and needs of the study.

1.2 Acknowledgements

This study would not have been possible without the involvement of many people and organisations.

We thank the CTG04 Steering Group, with participation from the following organisations:

- European Civil Aviation Conference (ECAC)
- Airports Council International (ACI Europe)
- Civil Air Navigation Services Organisation (CANSO)
- Air Transport Action Group (ATAG)
- Association of European Airlines (AEA)
- International Air Transport organisation (IATA)
- European Commission, Directorate-General for Energy and Transport
- The EUROCONTROL Agency

Special thanks go to:

- ACI Europe for its endorsement of the questionnaire and its significant assistance in building the list of addressees for the mailing
- The many airports which took the time to respond to the questionnaire.

2. OBJECTIVES, SCOPE AND APPROACH

2.1 Objectives

The objective of the CTG04 study is twofold:

- To help clarify the future position of air transport in Europe via a network-wide analysis of:
    - The long-term evolution of traffic demand under different forecasting scenarios
    - The long-term potential for airport capacity enhancement
    - The long-term network effect of the corresponding airport capacity constraints
    - Possibilities to mitigate these constraints
    - A qualitative analysis of environmental challenges
- Support strategic planning of the European ATM system through the European ATM Master Plan.

From a technical point of view, the CTG04 modelling also fulfils a role in the production of the EUROCONTROL Long Term Forecast, by developing a realistic long-term capacity enhancement scenario for the airport network, and quantifying the network effect of the corresponding airport capacity constraints.

As part of the analysis work, detailed results have been developed at individual airport level. Such results are not published in this report, but can be provided to airport authorities upon request. Because the results are based on a coherent modelling of the complete European air traffic route network, they can provide individual airport authorities with a long term perspective about their position, in terms of traffic evolution, in the European network of airports.

2.2 Scope

2.2.1 Type of Air Traffic Demand

The focus of this study is on IFR traffic, measured in numbers of flights at airports and between airports. All IFR flights are included: not just scheduled and unscheduled airline traffic, but also military and general aviation flights operating under GAT IFR rules. No statements are made about VFR traffic.

The study is not publishing any demand projections in terms of numbers of passengers. However, it is useful to know that the forecasts have been developed using a model which internally works with numbers of passengers, which are then converted to numbers of flights using assumptions about load factors and evolution of fleet composition per aircraft size segment.

Therefore it should be kept in mind that the published numbers of flights include implicit assumptions about aircraft size mix and the evolution of fleet composition.

2.2.2 Geography (Airport Network)

The study analyses the evolution of air traffic demand within the ECAC area. The focus is on the demand in the airport network, not on the airspace demand. Therefore the geographical scope is defined as the set of

- traffic flows between airports within the area
- traffic flows between airports within the area and airports outside the area
- a limited number of traffic flows between airports outside the area (only those overflying the ECAC area).

2.2.3 Time Horizon

The study analyses the growth and constraints from 2010 until 2025, using five-year intervals. Results are published for the snapshot years 2010, 2015, 2020 and 2025.

The time horizon of the CTG01 Study ended in 2020; the CTG04 update is extending that time horizon by five years.

Results for the period prior to 2010 are not included in this strategic study. That period is covered by the STATFOR Medium Term Forecast (MTF) published early 2004 (see ref. [2]). The final year of the MTF (2010) is the starting point of the long-term analysis of the CTG04 Study. Note that for the year 2010 there can be slight differences between the CTG04 and MTF results, due to improvements in airport capacity information.

2.2.4 Time Granularity

The study analyses airport constraints expressed as hourly capacity in relation to hourly demand. Hence the modelling has taken place with a time granularity of one hour. Results are available at hourly level and all aggregates: daily, monthly and annual totals.

2.2.5 Type of Constraints

The study only analyses airport-related non-ATC constraints. This is a change from the CTG01 study that also analysed en-route ATC constraints. The CTG01 study included a what-if analysis for a scenario in which no further ATC capacity would be provided beyond a five year planning horizon.

Rather than assuming a priori ATC constraints, the CTG04 study serves as an instrument to derive strategic performance requirements for the European ATM system, beyond the traditional five-year planning horizon. Through the European ATM Master Plan the necessary enhancements will be planned to cope with the forecasted demand.

2.3 Overview of Study Approach

The approach for the CTG04 study builds on the experiences gained with the CTG01 study. Main enhancements are:

- New Long Term Forecast capability developed by STATFOR
- Improved approach for translating annual traffic growth to future hourly traffic samples
- Integration of constraints and constraints mitigation analysis
- Updated airport constraints data
- Assumption that corresponding ATM capacity can be developed in a timely manner.

Figure 1 illustrates the approach for the CTG04 study.

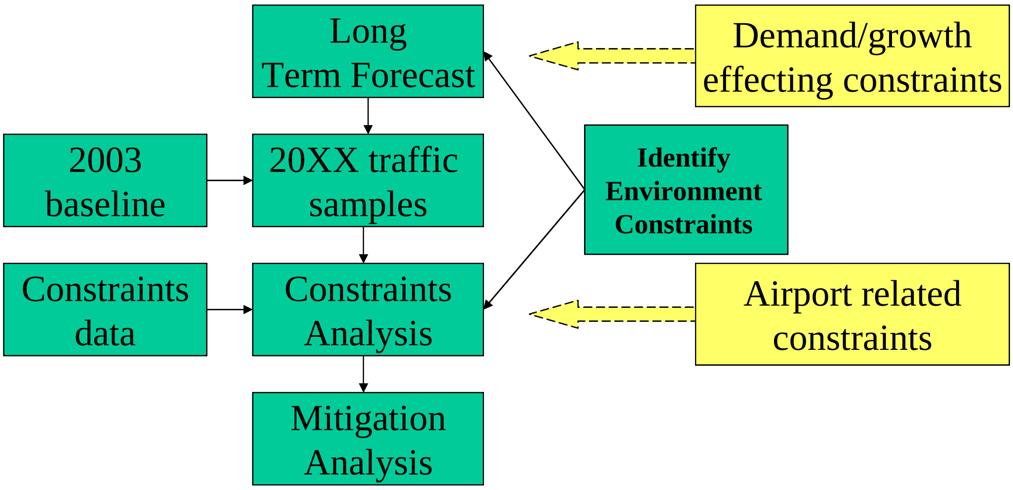

Figure 1 CTG04 study approach

2.3.1 Long Term Forecast

Starting point is the development of a long term forecast of flight demand (until 2025). Use is made of the new long term forecast capability of the EUROCONTROL Statistics and Forecast (STATFOR) Service. The long term forecast starts from the end of the Medium Term Forecast (i.e. 2010) and is driven by scenarios each representing a consistent assumption of the future. The scenarios include assumption on the factors affecting demand such as demographics, economic growth, de-regulation, price of travel, aircraft size etc. In total four scenarios have been developed in consultation with the STATFOR User Group and the CTG04 Steering Group. The output of the forecast process is annual growth rates of flight demand per traffic flow per scenario. Constraints that have an influence on flight demand like for example environmental regulation, are included in the scenarios via increased *travel cost* parameters. They affect flight demand prior to the application of airport capacity constraints.

2.3.2 2003 Baseline and 20XX Traffic Samples

The second step is to take a full year of traffic data (baseline year is 2003: a traffic pattern described by 8.5 million IFR flights) and grow that for each scenario with the forecast growth rates to obtain traffic samples for the snapshot years (2010, 2015, 2020, 2025). The traffic samples include the flows between more than 3000 airports on an hour by hour basis resulting in traffic flows over more than 155,000 airport pairs.

2.3.3 Constraints Analysis

The third step includes a questionnaire to airports to obtain their current capacity, growth potential (maximum achievable hourly capacity at the snapshot years) and the reasons for constraints when the maximum theoretical capacity can not be achieved. For airports not responding to the questionnaire, other available data is used, to ensure that the capacity enhancement scenario covers all airports.

The constraints analysis takes the airport capacity data and applies this on the traffic samples. When the aggregated traffic at an airport exceeds the hourly capacity, the traffic (departure and arrival movements) above the capacity limit is declared “un-accommodated demand”. This is done hour by hour for all the airport pairs. The result of this step is an overview per airport, per scenario of the accommodated and un-accommodated flight demand.

2.3.4 Mitigation Analysis

The fourth step analyses the sensitivity of the levels of un-accommodated demand to the way that the overall traffic pattern is organised. The traffic pattern is mostly determined by airline schedules. These so-called “mitigation scenarios” therefore represent potential ways in which airlines may attempt to grow their business in a heavily constrained environment. The analysis is done on a 28 day summer traffic sample. The scenarios include

- traffic smoothing (use of off-peak periods),
- use of secondary airports and
- limiting the daily number of flights on airport pairs.

All these measures are less optimum solutions from a current single airline business perspective. It will also be a sub-optimal situation for the whole air transport system as long as capacity is not increased to match demand. From a regulatory/infrastructure point of view however it can be argued that scarce resources can be used more effectively through means of “steering” demand for air services.

2.3.5 Analysis and Reporting

The final step is the analysis of the results and reporting. The analysis includes a qualitative analysis of the current and anticipated environmental challenges to growth.

2.4 Interpretation and Confidentiality of Results

This is a strategic study with a time horizon of twenty years. Its results have to be interpreted with caution: the aim is not, and cannot be to predict the future with absolute certainty, but rather to demonstrate what would be the outcome under different forecasting and airport capacity scenarios, each based on a large number of assumptions. Readers are invited not to quote any numbers from this report without specifying the associated assumptions.

Although the effect of several scenarios has been modelled, the analysis has focussed on the scenario with the highest flight demand growth, together with maximum achievable airport capacity. This combination leads to the highest long-term traffic forecast amongst all the scenarios. It may not be the most likely outcome, but it establishes a suitable upper bound of demand for strategic ATM planning purposes.

The results of this study are in the public domain, with the exception of individual results for airports which have responded to the questionnaire. They have cooperated under the condition that the data which they provide, as well as any directly associated results are treated confidential. Therefore the report publishes only aggregated airport data, or depersonalised results such as rankings without airport names. Detailed results for named airports will only be made public by EUROCONTROL after approval by the airports concerned. These confidentiality provisions do not preclude that the detailed results are used internally for strategic planning purposes.

2.5 Definitions

Certain terminology in this report is used with a specific meaning. Please refer to the following definitions (terminology is listed in order of appearance).

Movement Refers to **IFR movements** only.

IFR movement Within the context of an airport pair: an IFR flight. Within the context of an airport: an IFR departure or arrival. Each flight generates two airport movements.

Traffic flow A sequence of **movements** on a given **airport pair**.

Airport pair A departure plus destination airport between which there is at least one **IFR movement** per year. Airport pairs are directional: A-to-B and B-to-A are different pairs. Annual traffic is on 155,000+ airport-pairs.

Airport network The 3,000+ airports between which the **traffic flows** take place. Approximately 2,000 of those are within the ECAC area. The remaining 1,000 are non-ECAC airports which connect the ECAC area to the rest of the world.

Top-133 airports The airports which received a CTG04 questionnaire. The group contains all ECAC airports which in 2003 or 2002 had more than 20,000 **IFR movements** per year, plus the main airport of those countries which had no airport exceeding 20,000 movements. The top-133 airports carry 90% of the ECAC IFR traffic. In alphabetical order of ICAO code, they are:

ICAO CODE	IATA CODE	ICAO NAME
EBBR	BRU	BRUSSELS-NATIONAL
EBLG	LGG	LIEGE
EDDB	SXF	BERLIN-SCHONEFELD
EDDC	DRS	DRESDEN
EDDF	FRA	FRANKFURT/MAIN
EDDG	FMO	MUNSTER/OSNABRUCK
EDDH	HAM	HAMBURG
EDDI	THF	BERLIN-TEMPELHOF
EDDK	CGN	KOLN/BONN
EDDL	DUS	DUSSELDORF
EDDM	MUC	MUNCHEN
EDDN	NUE	NURNBERG
EDDP	LEJ	LEIPZIG/HALLE
EDDS	STR	STUTTGART
EDDT	TXL	BERLIN-TEGEL
EDDV	HAJ	HANNOVER
EDDW	BRE	BREMEN
EDLP	PAD	PADERBORN-LIPPSTADT
EDLW	DTM	DORTMUND-WICKEDE
EETN	TLL	TALLINN
EFHK	HEL	HELSINKI-VANTAA
EGAA	BFS	BELFAST/ALDERGROVE
EGAC	BHD	BELFAST CITY
EGBB	BHX	BIRMINGHAM
EGCC	MAN	MANCHESTER
EGGD	BRS	BRISTOL
EGGP	LPL	LIVERPOOL
EGGW	LTN	LONDON LUTON
EGHI	SOU	SOUTHAMPTON
EGJB	GCI	GUERNSEY
EGJJ	JER	JERSEY
EGKK	LGW	LONDON GATWICK
EGLC	LCY	LONDON CITY
EGLL	LHR	LONDON HEATHROW
EGNM	LBA	LEEDS/BRADFORD
EGNS	IOM	ISLE OF MAN

EGNT	NCL	NEWCASTLE
EGNX	EMA	EAST MIDLANDS
EGPD	ABZ	ABERDEEN
EGPF	GLA	GLASGOW
EGPH	EDI	EDINBURGH
EGSS	STN	LONDON STANSTED
EHAM	AMS	AMSTERDAM/SCHIPHOL
EHBK	MST	MAASTRICHT/MAASTRICHT AACHEN
EHRD	RTM	ROTTERDAM
EICK	ORK	CORK
EIDW	DUB	DUBLIN
EINN	SNN	SHANNON
EKBI	BLL	BILLUND
EKCH	CPH	KOBENHAVN/KASTRUP
ELLX	LUX	LUXEMBOURG
ENBO	BOO	BODO
ENBR	BGO	BERGEN/FLESLAND
ENGM	GEN	OSLO/GARDERMOEN
ENTC	TOS	TROMSO
ENVA	TRD	TRONDHEIM/VAERNES
ENZV	SVG	STAVANGER/SOLA
EPWA	WAW	WARSZAWA/OKECIE
ESGG	GOT	GOTEBORG/LANDVETTER
ESMS	MMX	MALMO/STURUP
ESSA	ARN	STOCKHOLM/ARLANDA
ESSB	BMA	STOCKHOLM/BROMMA
EVRA	RIX	RIGA (AIRPORT)
EYVI	VNO	VILNIUS INTL
GCFV	FUE	FUERTEVENTURA
GCLP	LPA	GRAN CANARIA
GCRR	ACE	LANZAROTE
GCTS	TFS	TENERIFE SUR/REINA SOFIA
LBSF	SOF	SOFIA
LCLK	LCA	LARNAKA/INTL
LDZA	ZAG	ZAGREB
LEAL	ALC	ALICANTE
LEBB	BIO	BILBAO
LEBL	BCN	BARCELONA
LEIB	IBZ	IBIZA
LEMD	MAD	MADRID/BARAJAS
LEMG	AGP	MALAGA
LEMH	MAH	MENORCA
LEPA	PMI	PALMA DE MALLORCA
LEVC	VLC	VALENCIA
LEZL	SVQ	SEVILLA
LFBD	BOD	BORDEAUX/MERIGNAC
LFBO	TLS	TOULOUSE/BLAGNAC
LFLC	CFE	CLERMONT-FERRAND-AUVERGNE
LFLL	LYS	LYON SAINT-EXUPERY
LFML	MRS	MARSEILLE-PROVENCE
LFMN	NCE	NICE-COTE D'AZUR
LFMT	MPL	MONTPELLIER-MEDITERRANNEE
LFPB	LBG	PARIS-LE BOURGET
LFPG	CDG	PARIS-CHARLES DE GAULLE
LFPO	ORY	PARIS/ORLY
LFQQ	LIL	LILLE-LESQUIN
LFRN	RNS	RENNES-ST-JACQUES
LFRS	NTE	NANTES ATLANTIQUE
LFSB	BSL	BALE-MULHOUSE
LFST	SXB	STRASBOURG-ENTZHEIM
LGAV	ATH	ATHINAI/ELEFTHERIOS VENIZELOS
LGIR	HER	IRAKLION/NIKOS KAZANTZAKIS
LGRP	RHO	RODOS/DIAGORAS
LGTS	SKG	THESSALONIKI/MAKEDONIA
LHBP	BUD	BUDAPEST/FERIHEGY
LICC	CTA	CATANIA/FONTANAROSSA
LICJ	PMO	PALERMO/PUNTA RAISI
LIEE	CAG	ELMAS
LIMC	MXP	MILANO/MALPENSA
LIME	BGY	BERGAMO/ORIO AL SERIO
LIMF	TRN	TORINO/CASELLE
LIML	LIN	MILANO/LINATE
LIPE	BLQ	BOLOGNA/BORGO PANIGALE
LIPX	VRN	VILLAFRANCA
LIPZ	VCE	VENEZIA/TESSERA
LIRA	CIA	CIAMPINO
LIRF	FCO	ROMA/FIUMICINO
LIRN	NAP	NAPOLI/CAPODICHINO
LIRP	PSA	PISA
LIRQ	FLR	FIRENZE
LJLJ	LJU	LJUBLJANA
LKPR	PRG	PRAHA/RUZYNE
LMML	MLA	LUQA
LOWS	SZG	SALZBURG
LOWW	VIE	WIEN-SCHWECHAT
LPFR	FAO	FARO
LPMA	FNC	AEROPORTO DA MADEIRA
LPPR	OPO	PORTO
LPPT	LIS	LISBOA
LROP	OTP	BUCURESTI/OTOPENI
LSGG	GVA	GENEVE
LSZH	ZRH	ZURICH FLUGHAFEN
LTAC	ESB	ANKARA/ESENBOGA
LTAI	AYT	ANTALYA
LTBA	IST	ISTANBUL/ATATURK
LYBE	BEG	BEOGRAD (AERODROM)
LZIB	BTS	BRATISLAVA/M.R.STEFANIK

Capacity	Refers to **hourly airport capacity**.
Hourly (airport) capacity	The sustainable number of **IFR movements** (departures + arrivals) per hour that can be handled by an airport during extended periods of time. Airport capacity is affected by infrastructure capacity (combined effect of rail/road access + terminal + apron + taxiway + runway), and by the local environmental and airspace (eg mountains) situation which may impose special constraints.
Network capacity	The sum of the **hourly capacities** of the top-133 airports in the network. Does not include the capacities of the other (smaller or non-ECAC) airports, because those are not known or used in the study.
Baseline year	The year 2003. Used as the reference for **demand**, **capacity** and **growth factors**.
Snapshot year	One of the forecast years for which the analysis has been performed. This study uses the snapshot years 2010, 2015, 2020 and 2025.
Base capacity	The **hourly capacity** of an airport as existing at the end of the **baseline year**.
Theoretical capacity	The **hourly airport capacity** that would be achieved if the airport would be able to reach the same capacity as the best-performing airport with a comparable runway configuration. The theoretical capacity is based on an airport's current runway configuration.
Max achievable capacity	Is equal to the **hourly airport capacity** that can be achieved if the airport applies best practices, ie any type of operational or infrastructure improvement except building new or extended runways. Max achievable capacity may be <u>lower</u> than the **theoretical capacity** due to infrastructure, environmental, airspace or other constraints which make this airport different from the best performing airport with a comparable runway configuration. Max achievable capacity can <u>exceed</u> the **theoretical capacity** in cases where the airport improves its runway infrastructure (new or extended runways to the extent that such plans or possibilities exist).
Typical busy hour	The 176th busiest hour of the year. This corresponds to the 2-percentile point, meaning that 2% of time (175 hours per year) **demand** is higher than during the typical

	busy hour. These 175 hours are considered a-typical, and it is acceptable to mitigate their excess demand through flow regulation.
Capacity need	The **hourly airport capacity** that is needed to satisfy **demand** 98% of the time. By definition, the capacity need is equal to the **demand** during the **typical busy hour**.
Used capacity	If the **capacity need** is lower than the **capacity**, then the used capacity is equal to the capacity need. Otherwise the used capacity equals the capacity.
Spare capacity	The difference between the **capacity** and the **used capacity**.
Capacity shortage	If the **capacity need** is higher than the **capacity**, then the capacity shortage is equal to the difference between the capacity need and the capacity. Otherwise the capacity shortage equals zero.
Demand	Refers to **flight demand**.
Flight demand	The IFR flights that would take place according to the forecast, if all airports had sufficient **capacity**.
Unaccommodated demand	That portion of flight demand which cannot take place due to demand exceeding airport **capacity**.
Network effect	Refers to the phenomenon that **demand** needs **hourly airport capacity** at both the departure and the destination airport, at the appropriate departure and arrival hour of each flight. If one of the airports on an **airport pair** is more congested than the other, the less congested (or uncongested) one will suffer from **unaccommodated demand**, even though it has sufficient **capacity** itself.
Accommodated demand	That portion of **flight demand** which does not exceed **airport capacity**, taking the **network effect** into account.
Flight forecast	The **accommodated demand** of a **forecast scenario** corresponding to the **max achievable capacity** scenario.
Growth factor	The comparison of a value (eg **demand** or **capacity**) for a particular **snapshot year** against the value in the **baseline year**. For example a growth factor of 2 represents a doubling of the value between the baseline

	year and the snapshot year.
Growth rate	Refers to **annual growth rate**.
Annual growth rate	The comparison of a value (eg **demand** or **capacity**) for a particular year against the value during the previous year. For example an annual growth rate of 5% implies an increase from 100 to 105 between two successive years.
Scenario	A consistent set of (quantified) assumptions, representing a particular possible future.
Forecast scenario	A set of **scenario** assumptions resulting in a **flight demand** forecast. There are 4 forecast scenarios, named A, B, C and D.
Mitigation scenario	A set of **scenario** assumptions modifying a **flight demand** forecast, with the aim to increase the amount of **accommodated demand** and reduce the **unaccommodated demand**. Three mitigation scenarios have been studied: traffic smoothing (use of off-peak periods), use of secondary airports, and limiting the daily number of flights on airport pairs, thereby forcing the use of larger aircraft.
Capacity scenario	A set of **scenario** assumptions describing how the **capacity** of each of the **top-133 airports** will evolve over time. The study uses three capacity scenarios: do-nothing (keep **baseline capacity**), **max achievable capacity** and **theoretical capacity**.
Analysis scenario	A combination of a particular **forecast scenario** and a particular **capacity scenario**.
Constraints analysis	The application of **analysis scenarios** to **flight demand** in order to determine **accommodated demand** and **unaccommodated demand**.
Mitigation analysis	The application of **mitigation scenarios** to investigate how much of the **unaccommodated demand** can be recovered by modifying the **flight demand**.

3. EVOLUTION OF FLIGHT DEMAND

3.1 Introduction

The starting point for the CTG04 study is the future flight demand, in other words the number of flights that would take place if all airports had sufficient capacity.

These flight demand projections are supplied by the EUROCONTROL Agency's Statistics and Forecast Service (STATFOR).

STATFOR produces 3 forecasts with different forecast horizons and time granularity:

- the short-term forecast (STF, 24 months);
- medium-term forecast (MTF, 7 years, in the current forecast extending to 2010); and
- long-term forecast (LTF, ~20 years, in the current forecast extending to 2025).

In earlier years, STATFOR published a long-term forecast which was really a long-term extrapolation of the medium-term forecast. This estimate extended the trends of the latter part of the medium-term forecast to 20 years, but did not consider new effects starting after the medium-term forecast horizon. The *ECAC Constraints to Growth Study* published in 2001 (CTG01) was based on a forecast using this approach. Starting with the LTF used in this study, the long-term extrapolation is replaced with explicit modelling of the long-term.

This data input for the study is not the long-term flight forecast as finally published by STATFOR, but an initial flight demand forecast on which the CTG04 study is to apply its constraint modelling. It is the output of the CTG04 study which is published by STATFOR as the long-term flight forecast or LTF in short. More information on the LTF can be found in [ref 1].

3.2 Four Long-Term Forecasting Scenarios

Both MTF and LTF have "scenarios", but they are used differently in the two forecasts:

- In the MTF, the scenarios typically are used to provide a range of likely values. Any point between the scenarios represents a possible out-turn having more, or less, growth.
- In the LTF, the scenarios represent different possible futures, with qualitative differences: for example, one representing a strongly globalised economy, another a fragmented world. Other futures near each scenario are quite possible, but it might not make sense to talk about a value half way, say, between two scenarios.

The LTF has a strict relationship with the MTF — each LTF scenario starts with the final year of one of the scenarios from the MTF. This means in particular that the 2010 forecast values are resulting from the MTF scenarios and that for the LTF scenarios, only events which happen after 2010 are of interest.

Following discussions with Stakeholders, and drawing on earlier work (including CONSAVE, ACARE, the EU "European Visions scenarios", Dutch Central Planning Bureau, and Shell), four LTF scenarios have been defined to capture different ways in which the air traffic industry might develop. Some of this development is for reasons within the Industry (eg aircraft size); other aspects of development (eg trading blocks) are external.

These four scenarios together were judged to capture a range of possible futures for the Industry that was wide enough to support the formulation of strategy.

The scenarios have been named A, B, C, and D. In summary, their storylines are:

3.2.1 Scenario A: Globalisation and Rapid Economic Growth

Scenario A is based on the *MTF High Growth* scenario until 2010. Thereafter, it involves strong economic growth in an increasingly globalised world. Economy, free trade, and Open Skies agreements encourage traffic growth at fastest rate. This scenario assumes use of bigger aircraft for airlines, but also increased use of small business jets.

This is the reference scenario, used for strategic planning (see chapter 9).

3.2.2 Scenario B: Business as Usual

Scenario B is based on the *MTF Medium Growth* scenario until 2010. Thereafter, it involves moderate economic growth and no significant change from the status quo and current trends. Economy grows at medium rate and EU expansion is fastest amongst the scenarios.

3.2.3 Scenario C: Strong Economies and Environmental Regulation

Scenario C is based on the *MTF Medium Growth* scenario until 2010. Thereafter, it involves strong economic growth, with government regulation to address growing environmental issues. As a result noise and emission costs are higher, which encourages a move to larger aircraft and more hub-and-spoke operations.

3.2.4 Scenario D: Regionalisation and Weak Economies

Scenario D is based on the *MTF Low Growth* scenario until 2010. Thereafter, it involves increased tensions between regions, with knock-on effects on economies, trade, and tourism shifting to short haul. Security costs increase further, and fuel price is highest amongst the scenarios, reaching nearly 40% of operating costs by 2025.

3.3 Demand not Constrained by Airport Capacity

3.3.1 Evolution of Total European Demand

In the past 20 years (between 1983 and 2003) traffic has grown by a factor 2.5, which corresponds to an average growth rate of 4.6% p.a.

The flight demand forecasts for 2025 range from 1.7 times the number of flights in 2003 to 2.5 times. The scenarios with higher economic growth and lower oil price largely give the higher growth, except in the case of scenario C (curtailed by additional environmental charges) which has lower growth than Scenario B (boosted by trans-Atlantic Open Skies and Free Trade agreements and by slow growth in seats per aircraft).

The long term flight demand forecast based on the four scenarios is summarised in the figure and table below.

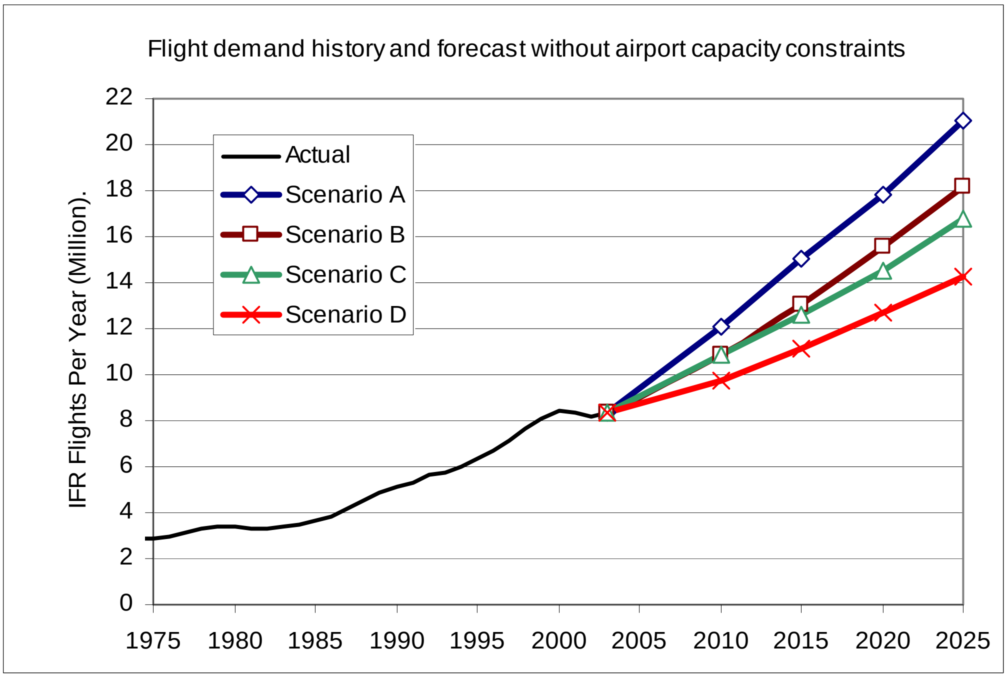

Figure 2 Flight demand history and forecast

Forecast scenario	**SC A**	**SC B**	**SC C**	**SC D**
Average annual growth 2010 to 2025	3.8%	3.5%	2.9%	2.6%
Average annual growth 2003 to 2025	4.3%	3.6%	3.2%	2.5%
Growth factor 2025 / 2003	2.5	2.2	2.0	1.7

Table 1 Key figures of the flight demand forecast

The table indicates that in all scenarios except scenario D, growth would slow down after 2010. Even in the highest-growth scenario, the post-2010 growth in number of flights would be less than 4% p.a.

3.3.2 Evolution of Unconstrained Demand on the Airport-Pair Network

Annual traffic is on 155,000 different airport pairs. But, as is illustrated in Figure 3, the first 1,000 airport pairs are good for 33% of the total traffic, the first 2,000 for nearly 50%, and the first 10,000 for approximately 90%. The top 40,000 airport pairs cover 98.6% of total traffic.

In the baseline year, the busiest airport pair has over 23,000 flights per year. But only 2,000 airport pairs carry more than 1,000 flights/year, which is about 3 flights/day. 5,000 airport pairs have a traffic density of at least 365 flights/year, which is at least 1 flight/day. These airport pairs carry 75% of the total traffic, meaning that 25% of the traffic occurs on airport pairs served less than once per day. Only 30,000 airport pairs have more than 12 flights/year. The remaining 125,000 airport pairs are served less than once per month.

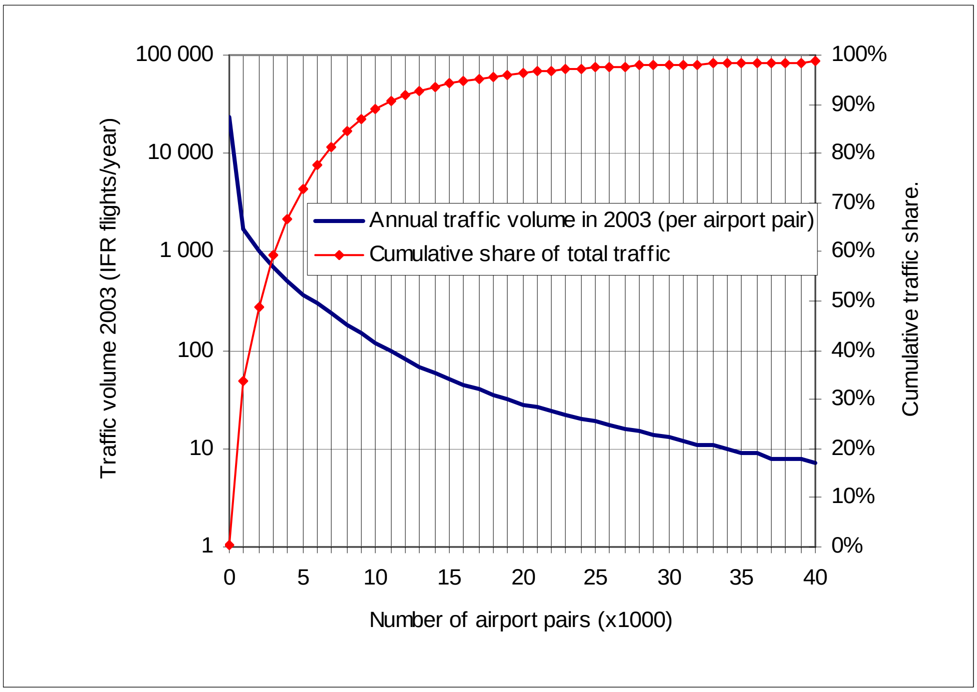

Figure 3 Traffic distribution over airport pairs

Figure 4 shows that flight demand does not grow at the same rate for all airport pairs:

- Flight demand on the busiest routes is expected to double between 2003 and 2025 (scenario A).
- When moving to airport pairs with lower baseline demand, growth rates initially increase. For example routes which are served 3 times per day in 2003, are forecast to have a demand of 8 flights per day in 2025.
- The fastest growing routes are those which in 2003 had a demand of 180 flights/year, or one every two days. The growth factor is more than 3. The result is that in 2025 those routes have a projected flight demand of approximately 2 flights per day.
- Thereafter, relative growth rapidly decreases. In combination with the low baseline demand, it follows that the low intensity routes do not significantly contribute to the total increase in flight demand.

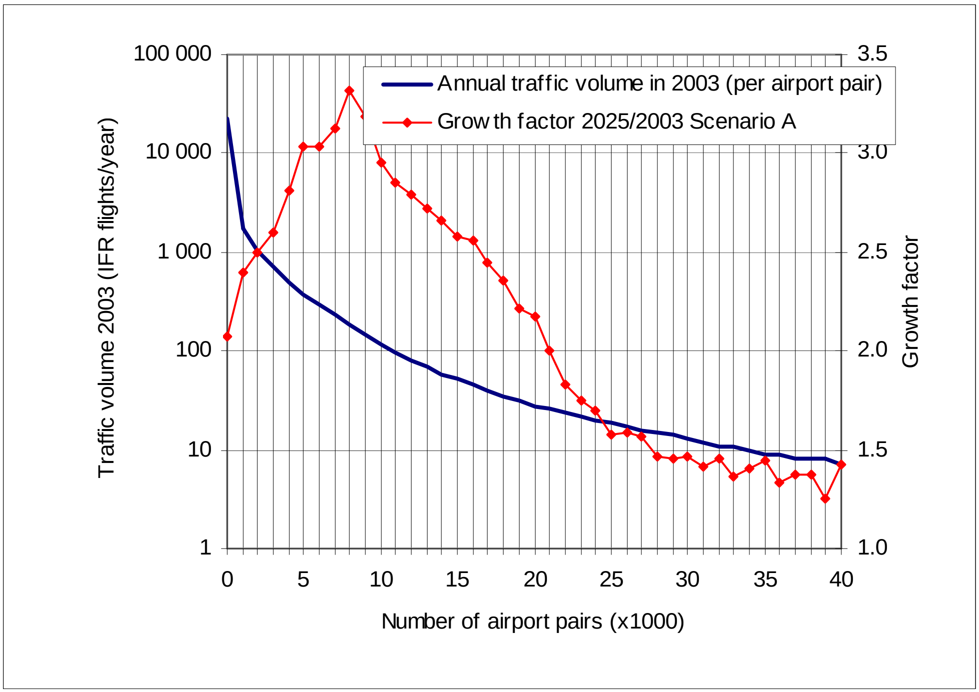

Figure 4 Flight demand growth factor of airport pairs

3.3.3 Evolution of Demand at the Main European Airports

The previous figures have illustrated the evolution of total demand in the ECAC area and as distributed over the airport pairs. This section gives an indication how this flight demand would be distributed over the airports.

Figure 5 shows the baseline annual demand for the top-133 airports, the projected demand in 2025 for scenario A (highest growth), as well as the growth factor between the two.

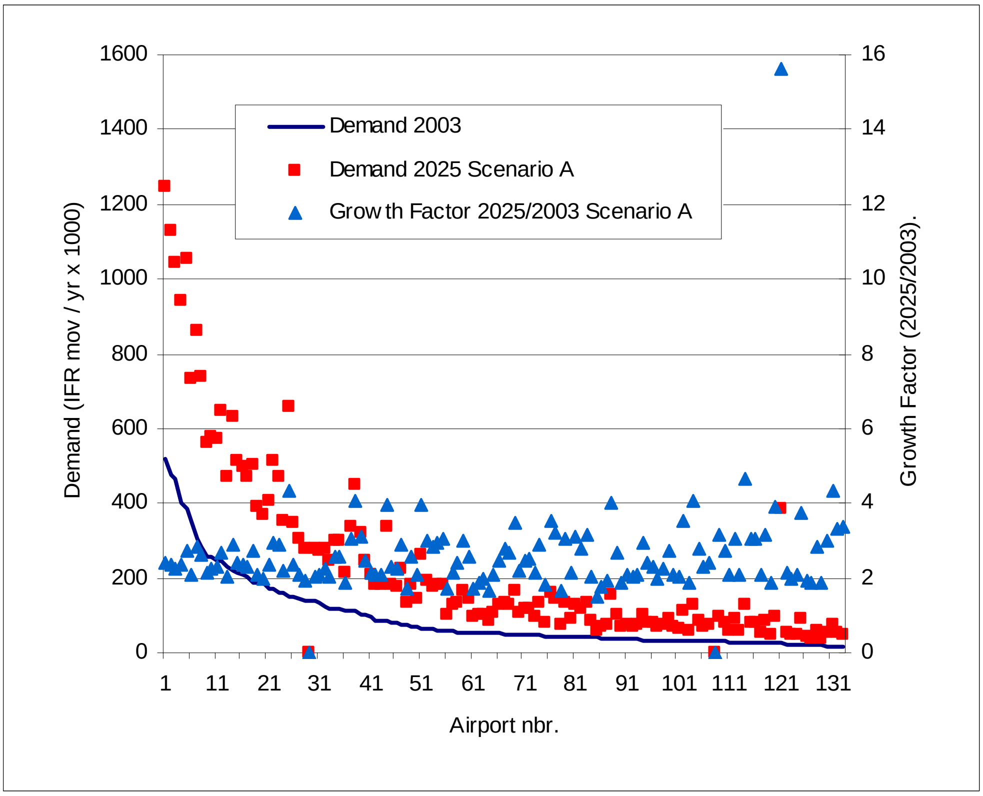

Figure 5 Current and projected annual demand at the top-133 airports

It can be seen that airport demand grows with a factor 2 to 4, with a slight tendency of small airports growing faster than the major ones. The trend is that demand at major airports would be somewhat more than doubling, and at the smaller airports it is expected to triple.

Today, only one European airport has more than 500,000 movements per year. In 2025, the scenario A forecast indicates that there would be 17 such airports in Europe if their capacity would allow it, with four airports having a demand which exceeds 1 million IFR movements per year.

4. ANALYSIS OF CURRENT AND FUTURE AIRPORT CAPACITY

4.1 Introduction

To asses the effect of airport capacity, the constraint analysis has used four different scenarios for the capacity of the airport network:

- Network with unlimited airport capacity
- Network with maximum theoretical airport capacity
- Network with maximum achievable airport capacity (the reference scenario)
- Network without capacity increases (do-nothing scenario)

The *network with unlimited airport capacity* leads to the flight demand forecast, in other words, demand patterns which can be expected to develop if neither the airspace nor any of the airports would have capacity constraints. These are clearly not realistic forecasts, because they would require a number of airports to accept traffic levels far exceeding their physical capacity limit. It would certainly not be worthwhile to plan airspace capacity to match such an unrealistic unconstrained demand. On the other hand, developing a forecast based on a scenario with only current airport capacity enhancement plans would also not lead to relevant results. The present absence of long-term plans for a number of airports would artificially constrain the accommodated demand calculated in this study.

For the *maximum achievable airport capacity* scenario it was decided to model accommodated demand resulting from significant but feasible airport capacity enhancement, even if such enhancements were not yet included in today's plans. The *maximum achievable airport capacity* scenario was developed using the following principles:

- The focus is on hourly IFR capacity only (max number of IFR mov/hr). VFR traffic is not included in the analysis. Today, some airports operate with imposed annual capacity limitations which have the potential of reducing the volume of accommodated demand below the levels resulting from hourly capacity constraints. By definition, the *maximum achievable capacity* scenario does not take such annual constraints into account. Also, the main focus is on daytime traffic, so no attempt is made to model the effect of night curfews. Hence a very simple capacity model is considered suitable for this strategic study: constant hourly capacity, 24 hours per day, 365 days per year. For the modelling of the constrained scenarios, this means that night time traffic (at most airports very low compared to daytime traffic) grows in accordance with the flight demand forecast.

- The scenario assumes no closure of airports or building of extra runways except where already included in today's plans.

- For the purpose of determining *maximum achievable capacity*, the scenario assumes that all airports have maximized hourly capacity in 2010 by implementing best practices.

- From 2011 onwards, capacity increases occur only via construction of new runways (only those which are already planned today).

- No further airport capacity enhancement is assumed beyond 2020.

- Through a direct dialogue (questionnaire), the most important European airports (ie the top 133, which carry 90 % of the ECAC IFR traffic) have been provided with the opportunity to retain control over the current and maximum achievable capacity used in the study.

- Maximum achievable capacity may be lower than best-in-class (BIC) capacity of airports with a comparable runway configuration, for example due to physical capacity limitations. Airports did get the opportunity to indicate the reasons for this.

- In the absence of actual fresh data (due to airports not responding to the questionnaire), the scenario makes use of older available data first, and if nothing is available, then reasonable default values are applied

- For the 2900 other airports and airfields which did not receive a questionnaire, a default capacity of 50 IFR mov/hr is used. This ensures that these airports behave as unconstrained, except in those rare cases where demand is extremely high.

For comparison purposes, two additional capacity scenarios have been defined as follows:

- The *maximum theoretical capacity* scenario is a theoretical model which assumes that physical constraints do not exist and all airports reach the best-in-class capacity corresponding to their present runway configuration

- The *do-nothing* scenario is also theoretical, in that it assumes that today's capacities are maintained throughout 2025, regardless of existing capacity enhancement plans and projects

To build the airport capacity scenarios, a data acquisition process was conducted consisting of the following steps:

- Select the top 133 airports

- Analyse their runway layout, and assign each airport to one of the following classes:

- Complex 1 (the most complex airports in Europe)
- Complex 2 (all other airports with more than 2 runways)
- Parallel independent runways
- Parallel dependent runways
- Crossing runways
- Converging runways
- Single runway

- Determine the current best-in-class capacity for each class. This is assumed to be the maximum achievable capacity that can be reached by applying best practices.
- Send a joint ACI/EUROCONTROL questionnaire to the top 133 airports (those with more than 20,000 IFR movements per year). The cover letter promises that replies provided by the airports are treated as strictly confidential. This implies that analysis data associated with named airports will not be made publicly available.
- 69 completed questionnaires were received (52%). This is a very high response rate. Certain airports did not answer all the questions. There was a need to interpret, structure and complete some of the replies.
- For 64 airports (48%) which did not reply: make a selection of data from other sources. In descending order of preference: EUROCONTROL/ACI airport questionnaire 2003, CTG01 study, APATSI database 1998.

4.2 Current Capacity

Looking at the top-133 airports in Figure 6, the following can be observed. Current airport capacity ranges from less than 10 mov/hr to more than 110 mov/hr. The top-35 airports represent 50% of the total available hourly capacity. Only 20 airports have a capacity greater or equal to 59 mov/hr. The top-10 has a capacity better than 75 mov/hr.

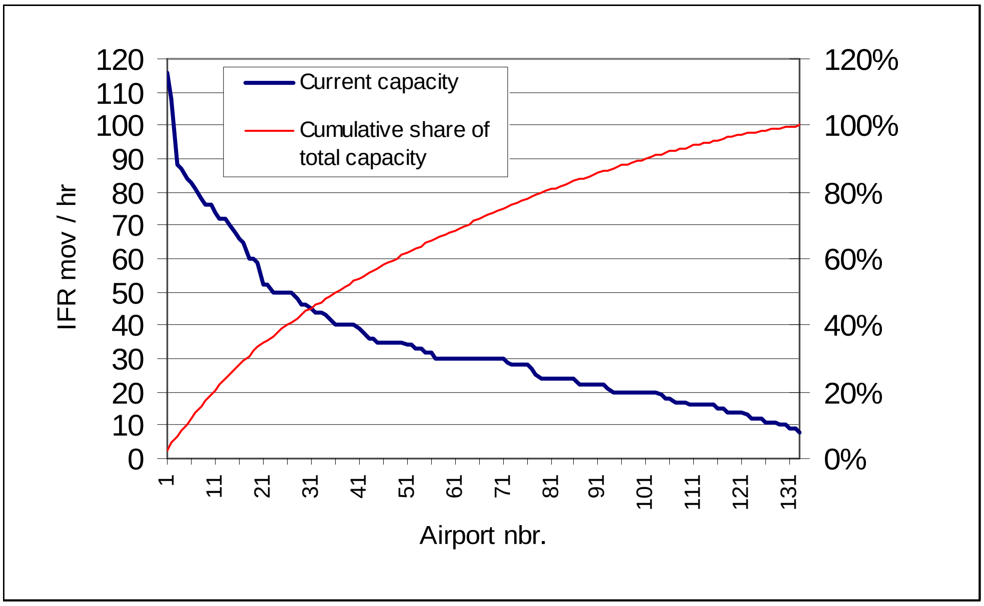

Figure 6 Current airport capacity

4.3 Maximum Theoretical Capacity

For each airport group with comparable runway configuration, the airport with the highest capacity today has been identified. Its current capacity is called the best-in-class (BIC) capacity, which is used to set the maximum theoretical capacity for all airports in the group.

Airport group	Size of Group	BIC capacity
Complex 1	2	125
Complex 2	12	100
Parallel independent runways	6	90
Parallel dependent runways	15	90
Crossing runways	19	76
Converging runways	3	50
Single runway	76	50

Table 2 Best-in class airport capacity

The airport groups “parallel dependent” and “parallel independent runways” have the same BIC capacity because the best-performing airports in both classes reported nearly the same current capacity.

Two groups are very small (only 2 or 3 airports) and received special treatment:

- Group *Complex 1* was given a BIC capacity slightly higher than today’s value, to allow for some efficiency improvement.
- All airports in the group *Converging Runways* have a current capacity lower than the best-in-class of the group *Single Runway*. None of them

can be considered as having reached the maximum possible capacity. Therefore the class has been given the same BIC capacity as the group *Single Runway*.

4.4 Airports' Inability to Achieve the Maximum Theoretical Capacity

For 74 airports a capacity ceiling is known, which cannot be exceeded without building extra runways. Only 16 of those (22%) believe that they can reach the maximum theoretical capacity. The 58 others (78%) say they are limited to a lower *maximum achievable capacity*.

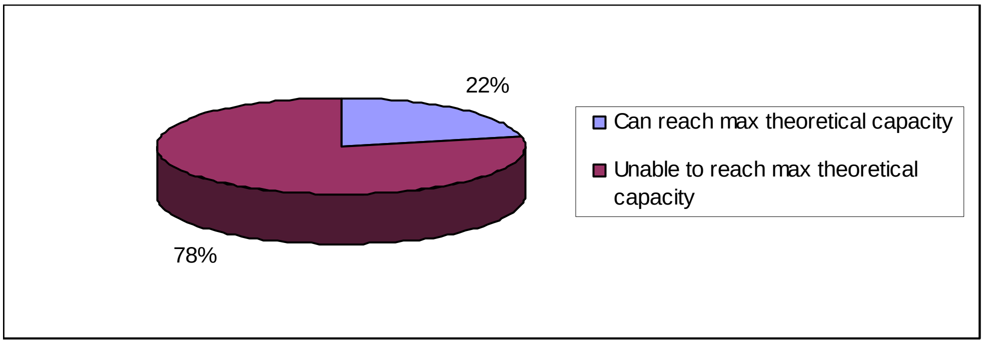

Figure 7 Airports' inability to reach maximum theoretical capacity

When asked for the reasons, the following responses were given (multiple reasons were permitted):

Reasons for not being able to reach the maximum theoretical capacity	Nbr of airports answering 'yes'	Percentage answering 'yes'
Physical site & infrastructure limits	38 out of 58	66%
Environmental issues	29 out of 58	50%
Surrounding airspace & geography	18 out of 58	31%
Other constraints	5 out of 58	9%

Table 3 Nature of airport constraints

In most cases the main reason determining the maximum capacity is found to be in the physical characteristics of the airport site and its infrastructure. In addition, half of the airports see environmental issues limiting their expansion, and slightly less than one third cites surrounding airspace (vicinity of other airports, military activity etc.) and geography (mountains) as a constraint to handling more movements with the existing runways.

These results indicate that the concept of maximum theoretical capacity based on *best-in-class performance* has limited value in the European airport network.

4.5 Infrastructure Changes

This section reports on how infrastructure changes affecting the capacity of the European airport network have been dealt with in this study.

4.5.1 Closure of Airports

Two airports are planned to be closed (Berlin Tempelhof before 2010 and Berlin Tegel between 2011 and 2014). At the appropriate years, their traffic has been transferred to Berlin Schönefeld (the future Berlin Brandenburg) as part of the modelling. This traffic transfer is the only one not considered as a *mitigation strategy* in this study.

4.5.2 Plans and Possibilities for New or Extended Runways at Existing Airports

With regards to the construction of new runways, airports reported the following:

Question	Nbr of airports answering 'yes'
Are there new runways planned or under construction which are anticipated to be operational by the year 2010?	9
Do you believe additional runways will be constructed between 2011 and 2015?	11
Are there any long term runway possibilities for the period 2016-2025?	13

Table 4 Projected new runways

For the total period from 2005 to 2025, 33 airports or 25% of the top-133 have plans or see possibilities for new or extended runways, should the need arise.

4.5.3 Construction of New Airports

This study has not included an analysis of new greenfield airport development projects which may be in the planning pipeline in Europe[1]. Such airports have not been included in the modelling, mainly because of the way the long-term forecasting model works: it grows existing traffic flows between existing airports. Even if a complete list of projects would have been established, it would have been difficult to obtain the type of information asked for in the airport questionnaire.

In practice, it makes more sense to look at new airports *a posteriori*: the unaccommodated demand at existing airports determines what the "market" is for new airport development projects in certain regions (see section 5.4).

[1] For example Don Quijote Airport near Ciudad Real (200 km south of Madrid), currently under construction and due to open in 2006.

4.5.4 Other Infrastructure Changes

Other capacity enhancing infrastructure changes at an airport may include

- Rail/road access improvements
- Expansion or construction of terminals
- New aprons, taxiways, high-speed runway exits etc.

There was no need to model these changes explicitly, because their effect is implicitly included in the maximum achievable capacity as reported by the airports.

4.6 Maximum Achievable Capacity

The maximum achievable capacity of an airport is equal to the hourly capacity[1] that can be achieved if the airport applies best practices, ie any type of operational or infrastructure improvement except building new or extended runways.

Maximum achievable capacity may be lower than the theoretical capacity due to infrastructure, environmental, airspace or other constraints which make this airport different from the best performing airport with a comparable runway configuration.

Maximum achievable capacity can exceed the theoretical capacity in cases where the airport improves its runway infrastructure (new or extended runways to the extent that such plans or possibilities exist).

The origin of the values used in this study is the following:

- In those cases where the airport did reply to the questionnaire, the values supplied by the airport have been used.
- Else, if other sources did report future capacity values, the highest available value was chosen
- In case no data at all was available, a default value was used equal to the best-in-class airport with comparable runway configuration
- For all airports not receiving a questionnaire (those not part of the top-133), a default value of 50 mov/hr was used, corresponding to the best-in-class single runway airport.

Figure 8 below depicts the present and the maximum achievable capacity. For each curve representing a year, airports have been ranked in descending order of capacity. Because the ranking of airports varies over time, a given

[1] Sustainable number of IFR movements (departures + arrivals) per hour that can be handled during extended periods of time.

position on the x-axis does not represent the same airport on the different curves.

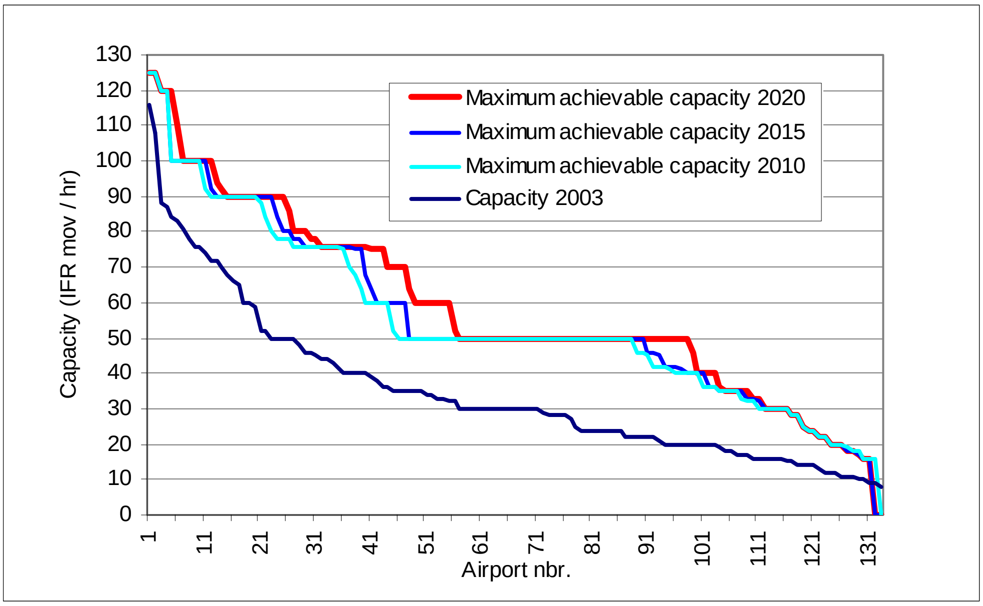

Figure 8 Evolution of maximum achievable capacity

By 2020 for instance, the number of airports with a capacity of 100 IFR mov/hr or better can increase from 2 to 12. The number of airports with a capacity of 50 IFR mov/hr or better could increase from 27 to 98.

The area below the curves represents the collective capacity of the top 133 airports in Europe. Today this amounts to 4616 mov/hr.

The maximum achievable capacity in 2010 is 7306 mov/hr, which is approximately 60% higher than today's value. Since only 9 airports foresee new runways by that time (see 4.5.2), it is clear that this has mainly to be achieved by applying best practices.

By 2020 the maximum achievable capacity is expected to rise to 7754 mov/hr, which is 68% higher than today's value, and 6% higher than the 2010 value. This extra capacity in the post-2010 time frame originates exclusively from anticipated or potential runway construction projects.

For 2025, the study assumes the same maximum achievable capacity as in 2020. This is because of the large uncertainties associated with such a long time horizon.

5. IMPACT OF DEMAND ON AIRPORT CAPACITY UTILISATION

5.1 Introduction

5.1.1 Relationship between Demand and Capacity

There is no straightforward relationship between the projected flight demand increase and the required extra capacity in the airport network. The reason for this is that today there is significant spare capacity in the network. In the future, such spare capacity might still exist in parts of the network, while at the same time other parts suffer from a capacity shortage. In addition, it is not because a certain amount of extra capacity could be made available by a certain year (see the analysis of maximum achievable capacity in the previous chapter), that all of this is actually needed. Airports will first "consume" the existing spare capacity, and then start implementing the maximum achievable capacity in phases, keeping pace with traffic growth. It is assumed that unaccommodated demand will start to develop only after all of the maximum achievable capacity has been exhausted.

This chapter clarifies these issues by analysing the impact of demand growth on airport capacity utilisation.

5.1.2 Capacity Needed to Cope with the Typical Busy Hour

The CTG04 study does not assume that airports should provide capacity to meet demand all the time. Investing in capacity to meet exceptional peaks in demand does not make sense from an economical point of view. Therefore the capacity need is defined as the hourly airport capacity that is required to satisfy demand 98% of the time. By definition, the capacity need is equal to the demand during the typical busy hour.

The typical busy hour is chosen as the 176th busiest hour of the year. This corresponds to the 2-percentile point, meaning that 2% of time (175 hours per year, or more than 3 hours per week) demand is higher than during the typical busy hour. These 175 hours are considered a-typical peaks, and it is acceptable to mitigate their excess demand through flow regulation.

5.1.3 Segmentation of the Airport Network

To facilitate the presentation of capacity utilisation results, the top-133 airports have been grouped in function of their capacity in 2003. Five capacity segments are distinguished: 80-120 IFR mov/hr (7 airports), 60-79 IFR mov/hr (12 airports), 40-59 IFR mov/hr (21 airports), 20-39 IFR mov/hr (63 airports), and 0-19 IFR mov/hr (30 airports).

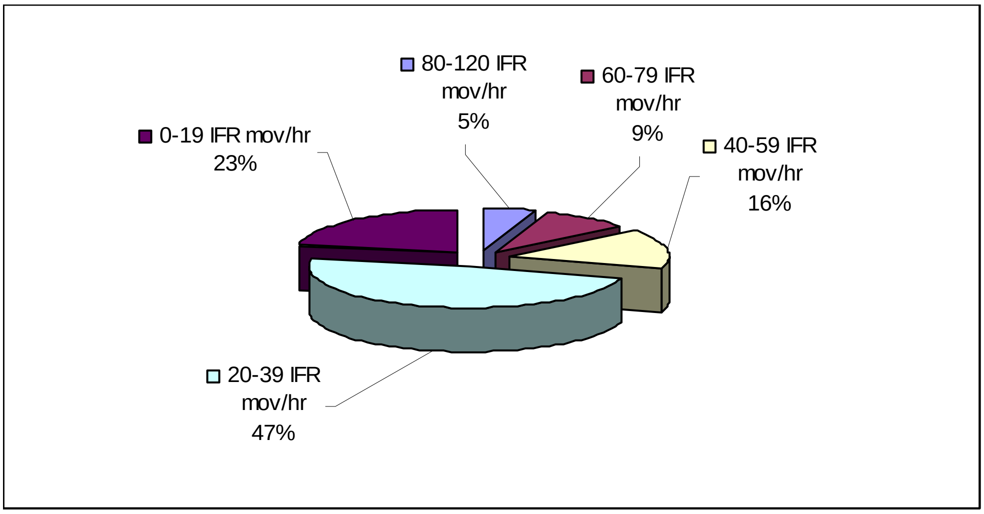

Figure 9 Capacity segments within the top-133 airports

5.2 Spare Capacity in the Current Airport Network

The base capacity of the top-133 airports is 4616 IFR mov/hr. Of this, no more than 3334 mov/hr (72% or less than three quarters) was effectively needed in 2003. As can be seen in Figure 10, half of the spare base capacity is in the small airport segment (20-39 IFR mov/hr). The three bigger segments have a comparable used capacity, but less spare capacity — in particular for the segments with the larger airports.

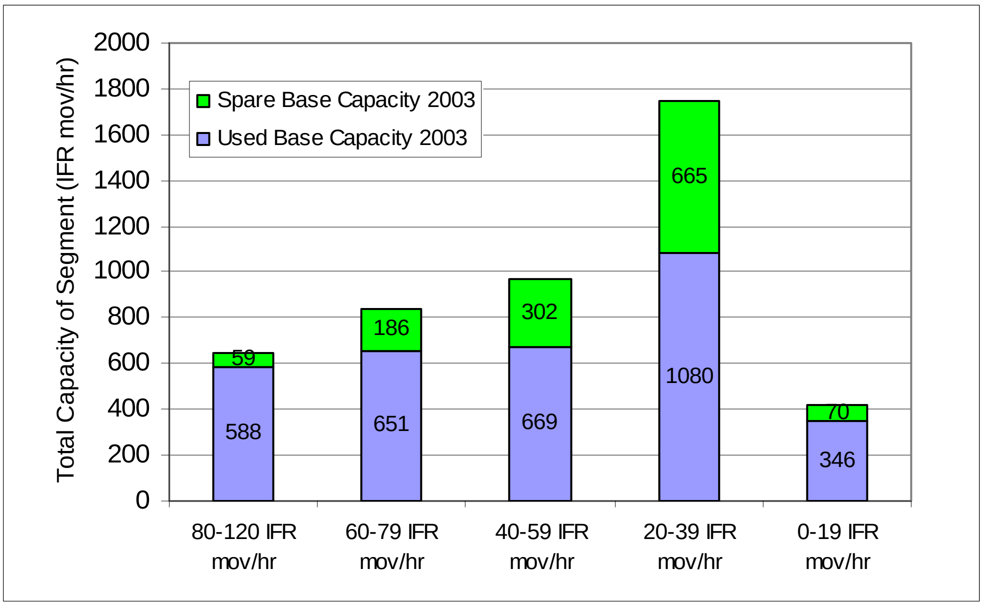

Figure 10 Spare airport capacity (per segment in 2003)

Looking at averages per airport within each segment (see Figure 11), airports with a capacity between 40 and 79 mov/hr have a spare base capacity of approximately 15 mov/hr, with the top-7 major airports averaging out on a spare base capacity of 8 mov/hr and the small airports 11 mov/hr.

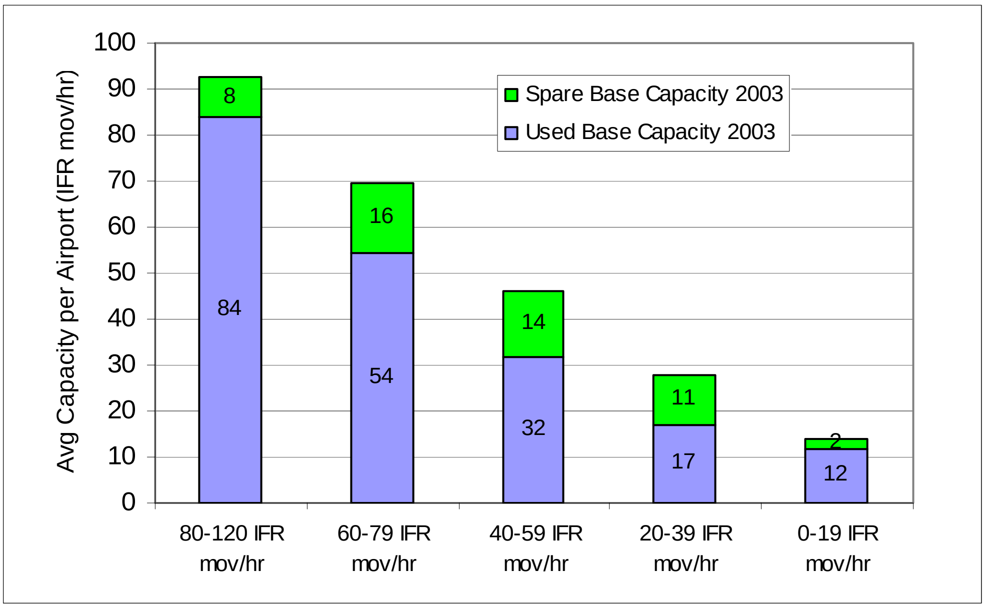

Figure 11 Spare airport capacity (average per airport in 2003)

5.3 Utilisation of the Maximum Achievable Capacity

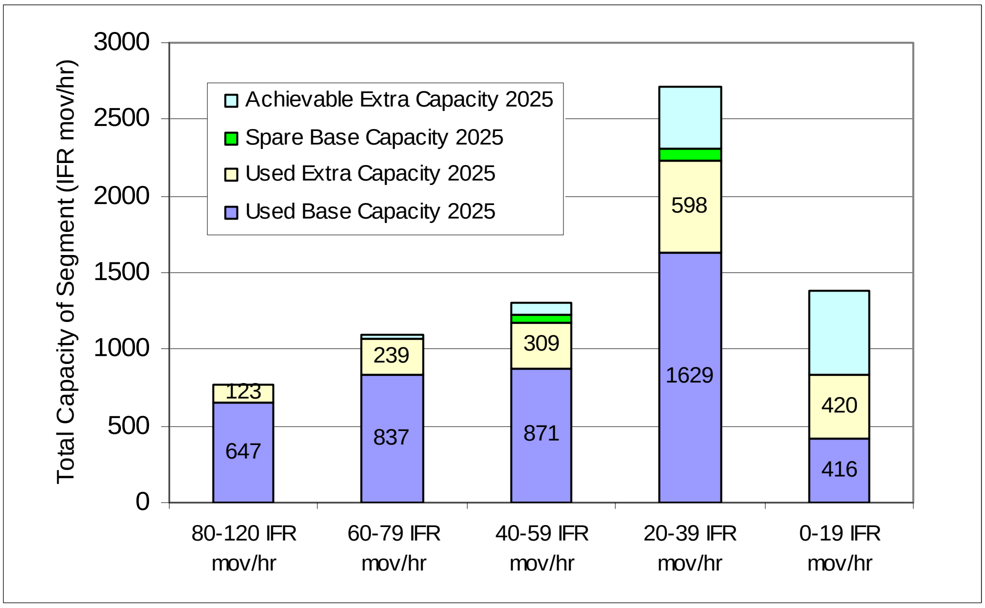

Figure 12 Utilisation of maximum achievable airport capacity (per segment, scenario A, in 2025)

In the year 2025 of forecast scenario A, most of the spare base capacity is “consumed” (Figure 12). Limited amounts of spare base capacity remain in the segments from 20 to 59 mov/hr.

Nearly all airports in the segments above 60 mov/hr need to implement the maximum achievable capacity. The same is true for most of those in the segment 40-59 mov/hr. Airports with unused expansion possibilities are primarily found in the segments below 40 mov/hr.

Figure 13 illustrates that on average, airports are able to increase their capacity by 15 to 20 IFR mov/hr to meet rising demand. Whether or not that is sufficient, is analysed in the next section.

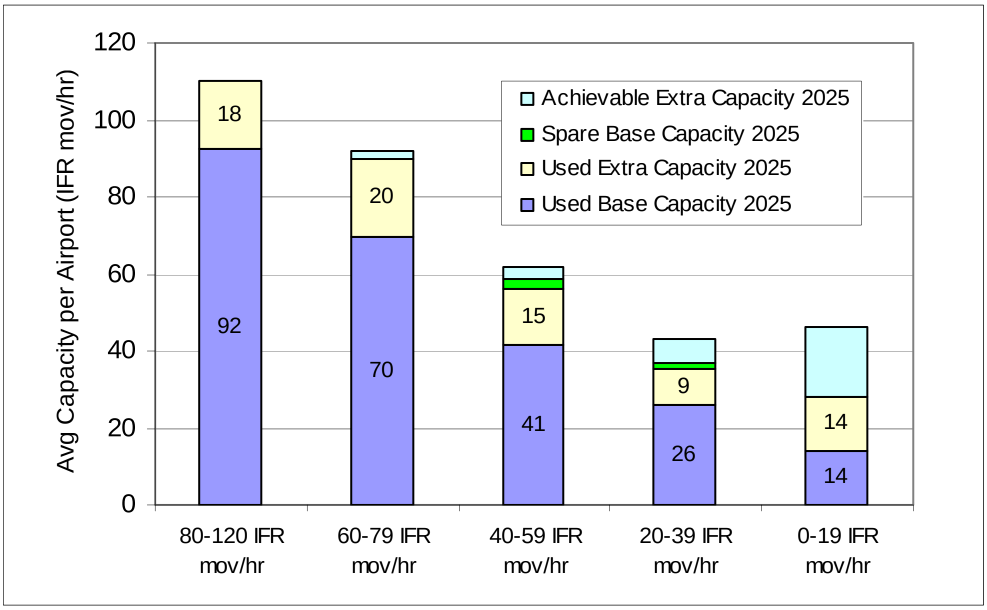

Figure 13 Utilisation of maximum achievable airport capacity (average per airport, scenario A, in 2025)

5.4 Capacity Needs beyond the Maximum Achievable Capacity

Figure 14 repeats the used base and extra capacity from Figure 12, but in stead of showing remaining spare capacity on top of that, it adds a display of the total capacity shortage in each segment.

The total shortage across all segments amounts to 2327 mov/hr, or somewhat less than 20 mov/hr per airport. The average capacity shortage (see Figure 15) is somewhat less at the small segments (base capacity less than 40 mov/hr), and significantly larger for the major airports (base capacity 60 mov/hr and up).

For airports with a base capacity of 60-79 mov/hr, the average shortage is 43 mov/hr, meaning that the required capacity is 50% above what is achievable.

For the top-7 airports, the situation is even worse: on average 91 needed IFR mov/hr cannot be provided. According to the scenario A forecast, the required capacity for those airports is nearly twice of what can be achieved.

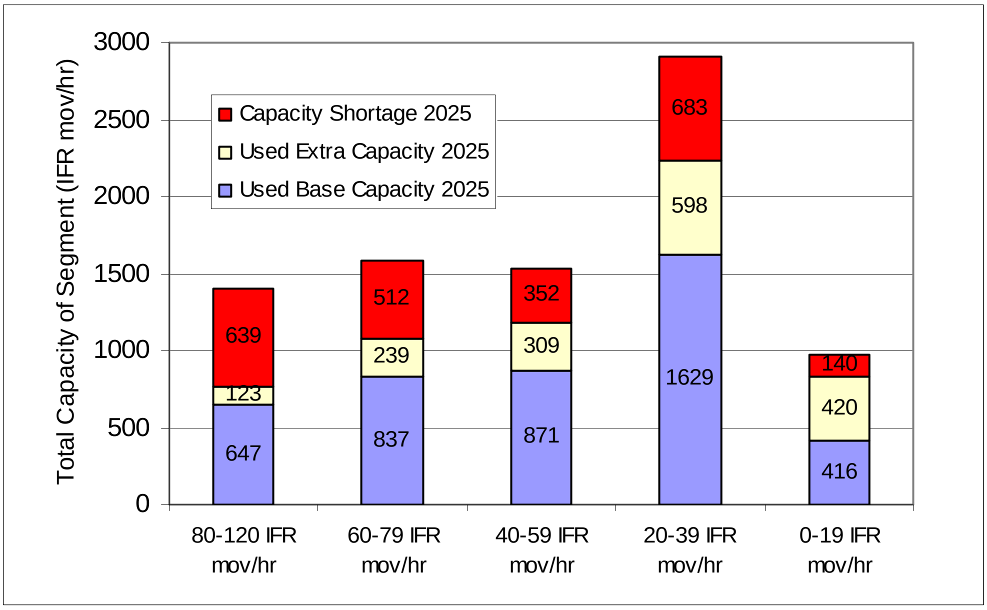

Figure 14 Airport capacity shortage (per segment, scenario A, in 2025)

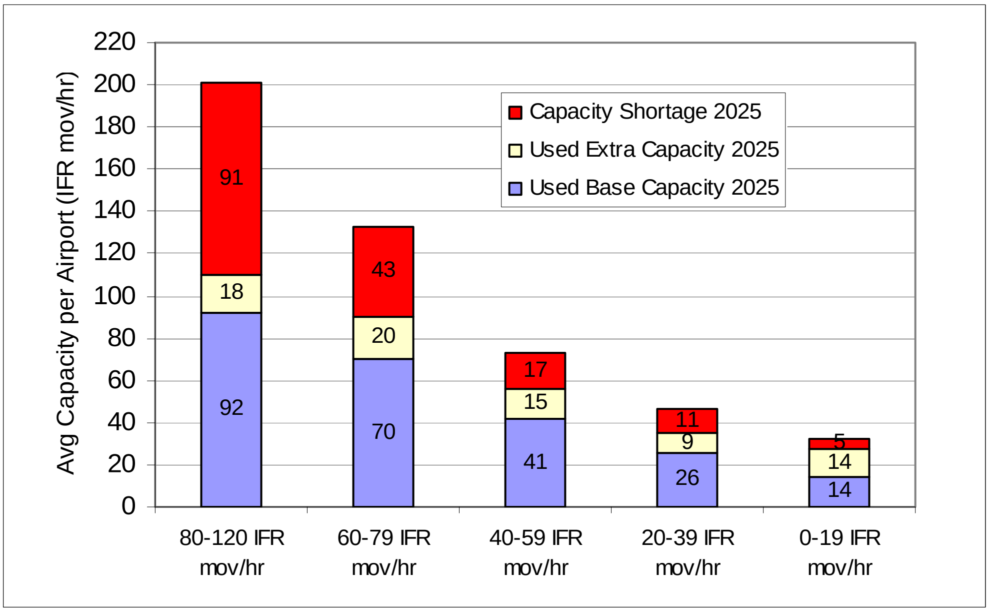

Figure 15 Airport capacity shortage (average per airport, scenario A, in 2025)

Figure 16 shows the evolution of capacity shortage per individual airport, through time. For each year, airports are ranked in descending order of capacity shortage. Negative values represent capacity surplus (i.e. spare base capacity). The diagram is based on the assumption that maximum achievable capacity is implemented in a timely manner, but only to the extent actually needed (unused extra capacity is not counted as spare capacity).

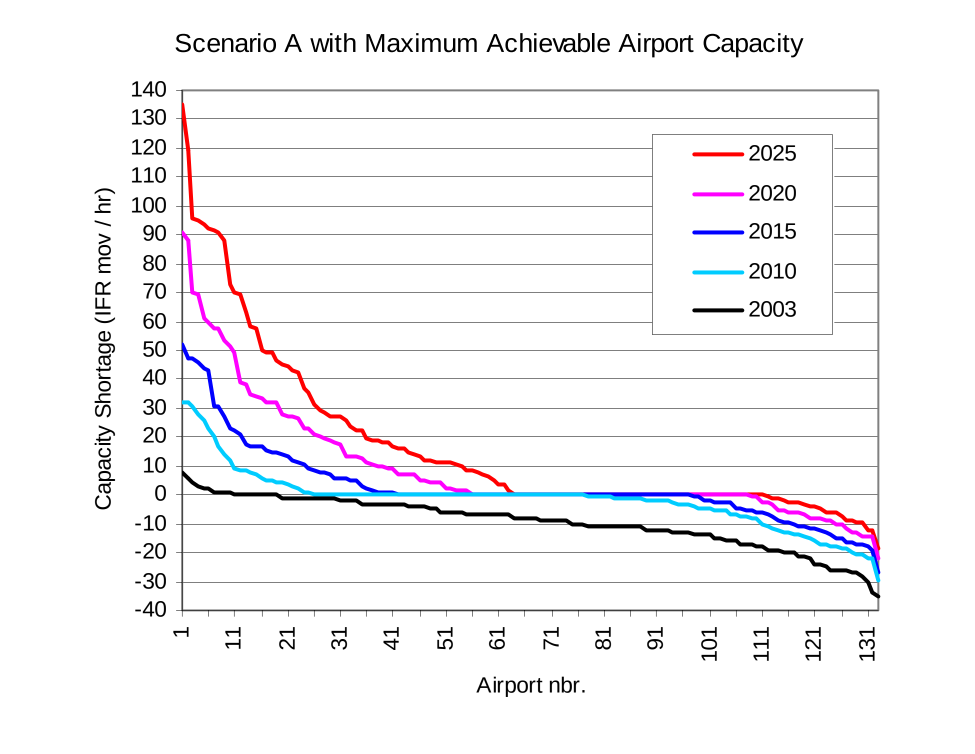

Figure 16 Evolution of spare base capacity and capacity shortage (per individual airport, scenario A)

Today, most airports have some spare capacity (see the black line in Figure 16). As mentioned in section 5.2, for the first 133 airports, nearly 30% of existing capacity remains unused at 2003 typical busy hour traffic levels. In the scenario with the highest traffic growth, even with maximum achievable capacity enhancements, this situation is expected to gradually deteriorate into *capacity imbalance*, i.e. capacity shortage in parts of the network with a remaining capacity surplus in other parts. Already in 2010, more than twenty airports are expected to have a capacity shortage if the demand evolution follows the high growth scenario. Ultimately, in 2025, more than 60 airports will be unable to handle the typical busy hour demand without generating delays or unaccommodated demand.

The capacity shortage values in the diagram also illustrate that — assuming that the air transport market would require that demand distribution patterns need to remain as they are, and considering that the existing airports cannot expand as required — the only way in a “perfect market system” to handle unaccommodated flight demand in 2025 would be the creation of 10 new major airports (capacity in the range 70-140 mov/hr) and 15 medium sized airports (capacity in the range 35-70 mov/hr) in the vicinity of their congested counterparts (see also para. 4.5.3 Construction of New Airports).

5.5 Amount of Time that Demand Exceeds Capacity

The previous sections have analysed the magnitude of the capacity shortage. Another relevant indicator is the amount of time that a given number of airports is saturated, without considering the extent to which demand exceeds capacity during these saturation periods (see however section 6.4 for more information on the relationship between the two parameters).

The next figure shows this type of information for scenario A.

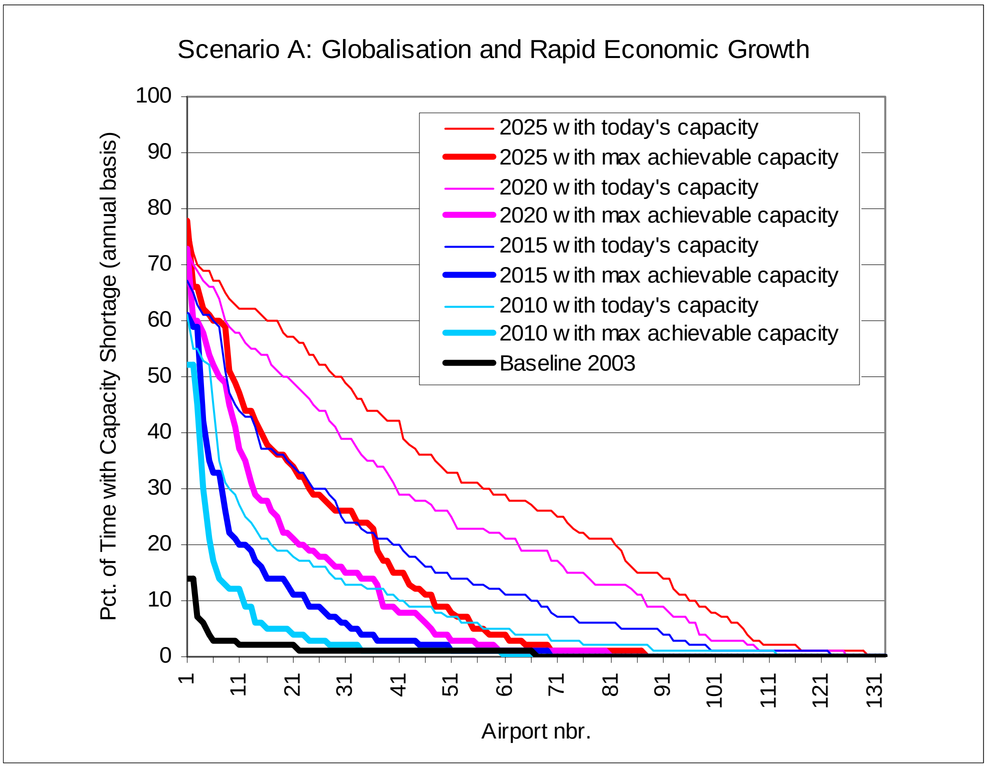

Figure 17 Duration of capacity shortage at airports

The y-axis represents the number of hours per year (expressed a percentage of 8760 hours) that flight demand exceeds capacity at a given airport. Since all saturation occurs during daytime (because the modelling has used constant capacity 24 hours/day, 365 days/year), it is fair to say that an airport reaching the 70% value is saturated during all daytime hours of the year.

On the x-axis, airports are ranked in descending order of saturation duration. Because the ranking of airports varies over time, a given position on the x-axis does not represent the same airport on the different curves.

As was explained in section 5.1.2, it is acceptable that flight demand exceeds capacity 2% of the time (176 hours/year, which is ~15 hours/month). Such demand can easily be accommodated by shifting (eg delaying) it a little bit. Ideally, airport capacity should be such that flight demand can be handled at least 98% of the time.

Airports which are saturated 10% of the time clearly have a capacity problem. Looking at the graph, it can be seen that in 2003 a few airports are in that situation (in reality more, because the baseline traffic sample certainly includes some degree of congestion). Even with maximum achievable capacity (but taking the highest growth scenario), that number of airports grows to 12 by the year 2010 (light blue line). By 2015 (dark blue line) there are more than 20 such airports; in 2020 (pink line) the number grows to almost 40; and in in 2025 (red line) to almost 50. If airports would not increase capacity, we would be faced in 2025 with the situation that nearly 100 airports are saturated more than 10% of the time.

Looking at the red line, we can see that by 2025 the top 20 airports are operating at their maximum achievable capacity at least 35% of the time. This means on average 8.5 hours/day; more during the summer, less during the winter.

6. ANALYSIS OF THE NETWORK EFFECT: ACCOMMODATED AND UNACCOMMODATED DEMAND

6.1 Introduction

6.1.1 Network Effect

The previous chapter focused on the airport capacity that would be needed to satisfy a given projected flight demand. This chapter takes existing and achievable future airport capacity as a given, to determine the accommodated demand, ie the portion of flight demand which does not exceed hourly airport capacity, taking the network effect into account.

The term *network effect* refers to the phenomenon that demand needs hourly airport capacity at both the departure and the destination airport, at the appropriate departure and arrival hour of each flight. If one of the airports on an airport pair is more congested than the other, the less congested (or uncongested) one will suffer from unaccommodated demand, even though it has sufficient capacity itself.

6.1.2 Assumptions Used to Determine Hourly Demand

The flight demand forecast provides annual traffic demand on routes, ie the future number of flights per year on individual airport pair flows. Growth rates may be different on each airport pair.

The forecast does not make any statements as to *when* during the year these flights will take place. Because the study is analysing the effect of *hourly* airport capacity constraints, there was a need to specify a time distribution scenario at the level of hourly demand. The following assumptions were made in the CTG04 study:

- Although demand may grow, the time distribution of airport-pair demand will not be different from the one observed during the baseline year (2003). This corresponds to simple proportional up-scaling of airport-pair demand, ie the annual growth rates remain valid at all levels: monthly, weekly, daily, hourly. This is not true for airports, because they are connected to airport pairs with different growth rates.

- Because demand is modelled in one-hour steps, the exact departure and arrival time of a flight is not relevant, as long as it stays within the same one-hour time slot. In other words, the flight demand time distribution allows for a departure/arrival uncertainty of 1 hour. This deliberate uncertainty is one of the reasons why the study does not attempt to quantify the effect of capacity shortage in terms of delays.

6.1.3 Analysis Scenarios

An analysis scenario is defined as a combination of a long term forecast scenario and an airport capacity scenario. 10 different combinations have been analysed. These are depicted in the following table.

Airport Capacity Scenario	Long Term Forecast Scenario			
	A **(reference)**	B	C	D
Network with unlimited airport capacity (unconstrained scenario)	X	X	X	X
Network with maximum theoretical airport capacity	X			
Network with maximum achievable airport capacity **(reference scenario)**	**X**	X	X	X
Network without capacity increases (do-nothing scenario)	X			

Table 5 Analysis scenarios

For each analysis scenario, the whole year was modelled in steps of 1 hour (one year consists of 8760 hours). This was necessary to publish annual totals, monthly totals, and ranking of hours (used to publish hourly values for the n-th busiest hour of the year or to determine the number of hours per year that demand exceeds capacity).

The modelling has produced 425 million data points (8.5 million baseline flights x 10 analysis scenarios x 5 snapshot years). This volume of data is presented below in the form of graphs and highly aggregated numbers.

6.2 Annual Demand

During 2003, the total annual demand was 8.5 million IFR flights.

In the highest growth scenario (LTF scenario A, the reference scenario), annual unconstrained demand would grow with a factor 2.49 by the year 2025, whereas the airport network could only accommodate growth by a factor 2.05 despite maximum possible airport capacity increase. This would leave an annual un-accommodated demand of 17.6% in terms of the unconstrained demand, or 3.7 million flights in absolute terms.

If all airports would be able to reach maximum theoretical capacity, the unaccommodated demand of scenario A in 2025 would go down from 17.6% to 14.2%, meaning that another 700,000 flights could be accommodated. This is not as much as one could expect.

In the do-nothing scenario (LTF scenario A without any airport capacity increase), 31.6% of demand would be unaccommodated in 2025, corresponding to 6.6 million flights.

In the lowest growth scenario (LTF scenario D), unconstrained demand would only grow by a factor 1.71 by the year 2025. Assuming that airports would still implement the same maximum achievable capacity, most of this demand (95.7%) could be accommodated, leaving "only" 600,000 flights un-accommodated.

Comparing the four LTF scenarios in 2025 in the context of maximum achievable airport capacity, we see that accommodated/constrained demand will grow with a factor in the range 1.7 - 2.0. We can conclude that in the coming 20 years, the volume of IFR traffic will probably less than double, due to airport capacity constraints.

Looking at the year 2010 (the dividing line between the Medium Term and the Long Term Forecast), there is very little un-accommodated demand in any of the four scenarios (from 0.5% in scenario D to 2.6% in scenario A). This is for two reasons: (1) initially there was a significant amount of spare capacity the airport network, and (2) the study assumes that capacity increases will take place in a timely manner (as early as 2010), up to the maximum achievable capacity reported by the airports. If capacity would not be increased and the airport network would only rely on spare capacity, unaccommodated demand in 2010 would be 6.9% in scenario A.

More details can be obtained from Table 6. Some of those numbers are also visualised in the figures on the following pages.

Year	Analysis Scenario	Unconstrained (million IFR flights	Accommodated (million IFR flights)	Percentage Accommodated	Percentage Unaccommodated	Constrained Growth w.r.t. 2003	Unconstrained Growth w.r.t 2003
2010	SC A with today's capacity	12.4	11.5	93.1%	6.9%	1.36	1.46
	SC A with max achievable capacity	12.4	12.1	97.4%	2.6%	1.42	1.46
	SC A with max theoretical capacity	12.4	12.2	98.3%	1.7%	1.43	1.46
	SC B with max achievable capacity	11.1	10.9	98.8%	1.2%	1.29	1.30
	SC C with max achievable capacity	11.1	10.9	98.8%	1.2%	1.29	1.30
	SC D with max achievable capacity	10.0	9.9	99.5%	0.5%	1.17	1.17
2015	SC A with today's capacity	14.6	12.5	85.6%	14.4%	1.48	1.73
	SC A with max achievable capacity	14.6	13.8	94.4%	5.6%	1.63	1.73
	SC A with max theoretical capacity	14.6	14.1	96.1%	3.9%	1.66	1.73
	SC B with max achievable capacity	12.7	12.4	97.1%	2.9%	1.46	1.50
	SC C with max achievable capacity	12.4	12.1	97.5%	2.5%	1.43	1.46
	SC D with max achievable capacity	11.1	10.7	98.7%	1.3%	1.29	1.31
2020	SC A with today's capacity	18.0	13.7	76.0%	24.0%	1.61	2.12
	SC A with max achievable capacity	18.0	16.0	89.1%	10.9%	1.89	2.12
	SC A with max theoretical capacity	18.0	16.5	91.6%	8.4%	1.94	2.12
	SC B with max achievable capacity	15.6	14.7	93.7%	6.3%	1.73	1.84
	SC C with max achievable capacity	14.7	14.0	95.3%	4.7%	1.65	1.73
	SC D with max achievable capacity	12.9	12.6	98.0%	2.0%	1.49	1.52
2025	SC A with today's capacity	21.1	14.5	68.4%	31.6%	1.70	2.49
	SC A with max achievable capacity	21.1	17.4	82.4%	17.6%	2.05	2.49
	SC A with max theoretical capacity	21.1	18.1	85.8%	14.2%	2.14	2.49
	SC B with max achievable capacity	18.3	16.1	88.1%	11.9%	1.90	2.15
	SC C with max achievable capacity	16.7	15.3	90.6%	9.4%	1.80	1.99
	SC D with max achievable capacity	14.5	13.9	95.7%	4.3%	1.64	1.71

Table 6 Summary of annual demand

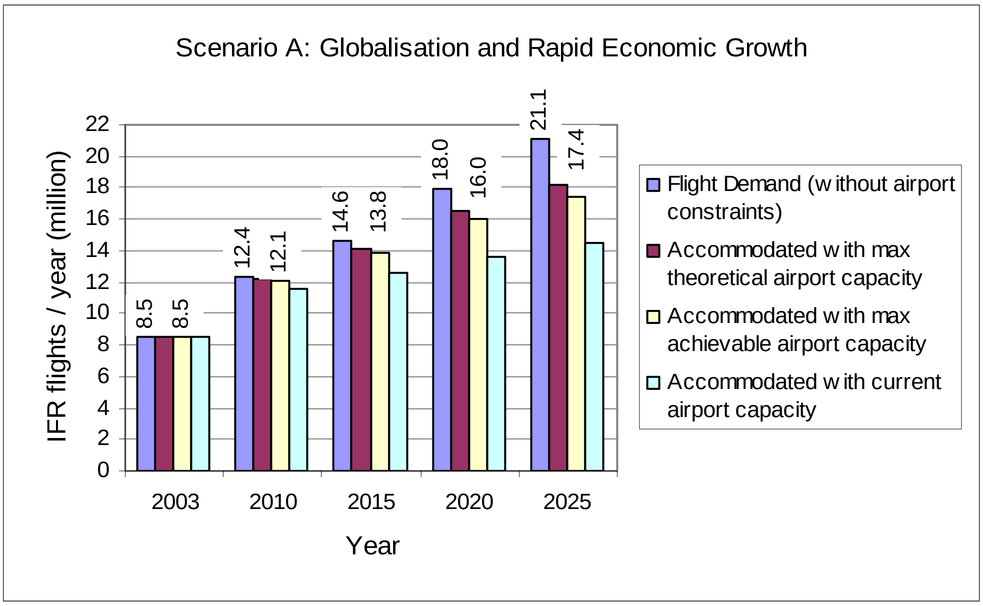

Table 7 Annual demand for scenario A

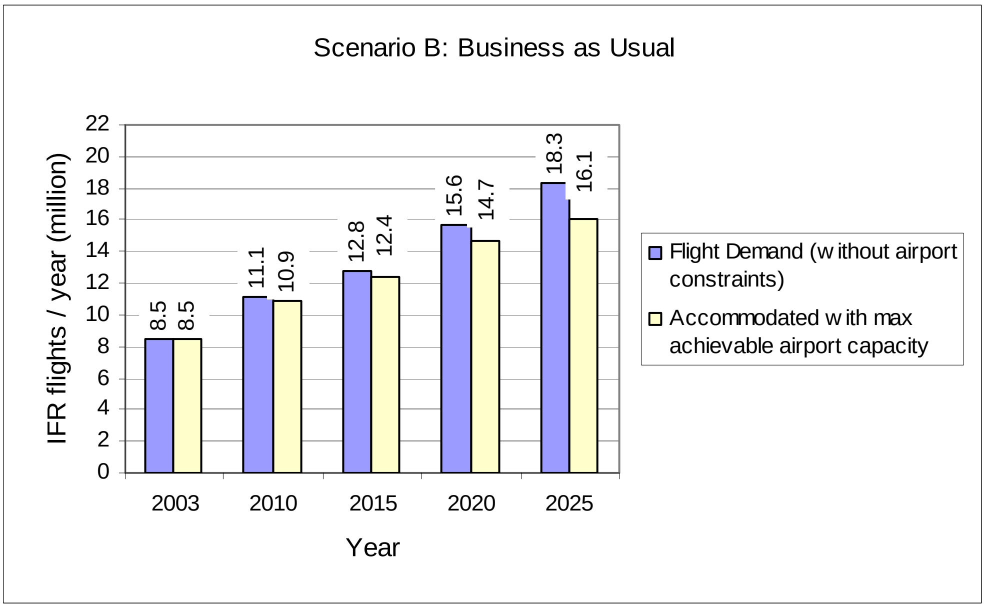

Table 8 Annual demand for scenario B

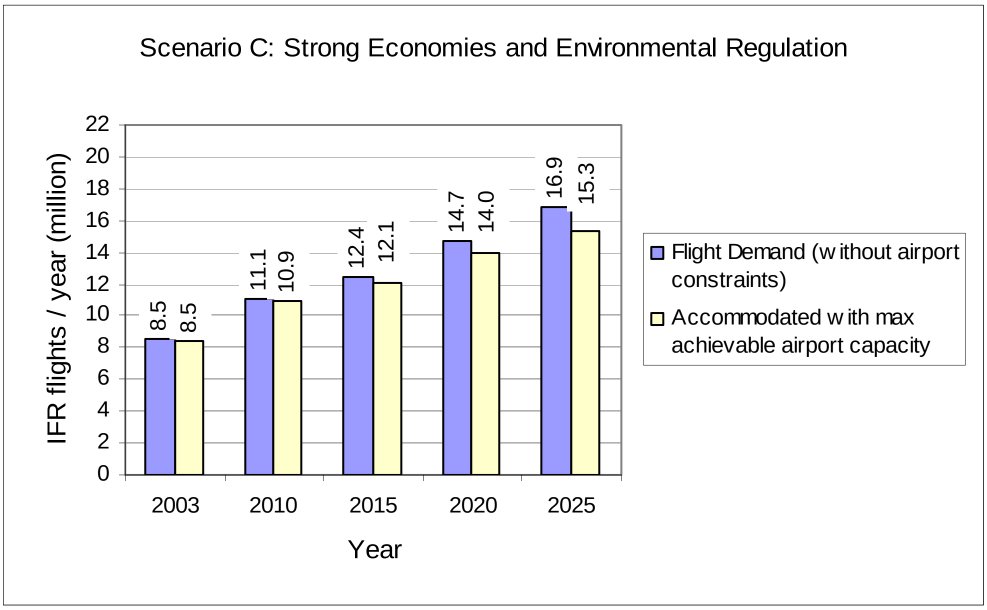

Table 9 Annual demand for scenario C

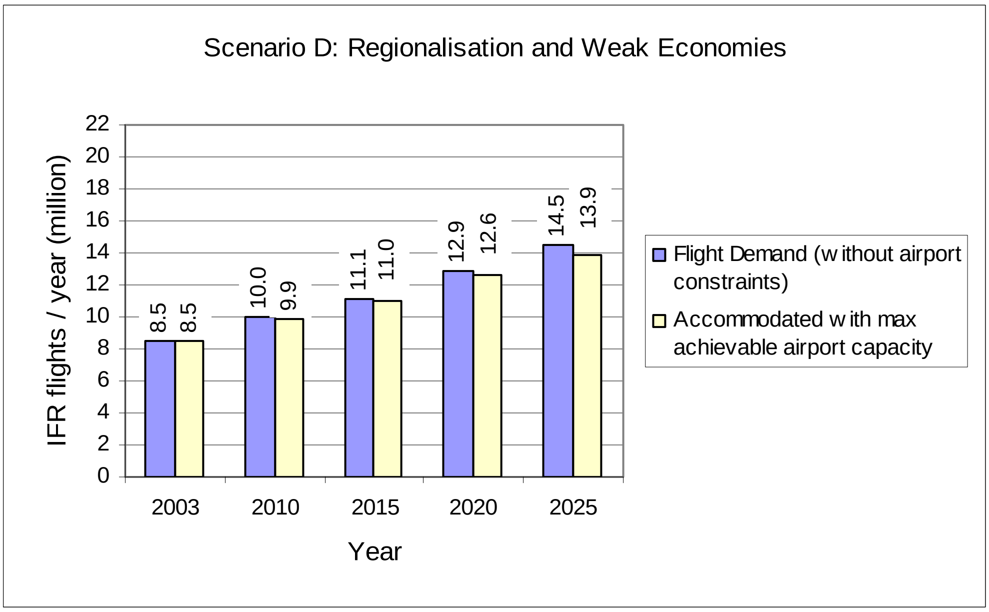

Table 10 Annual demand for scenario D

6.3 Daily Demand

Figure 18 in this section show the average daily demand per month (number of IFR flights per month, divided by the number of days in the month).

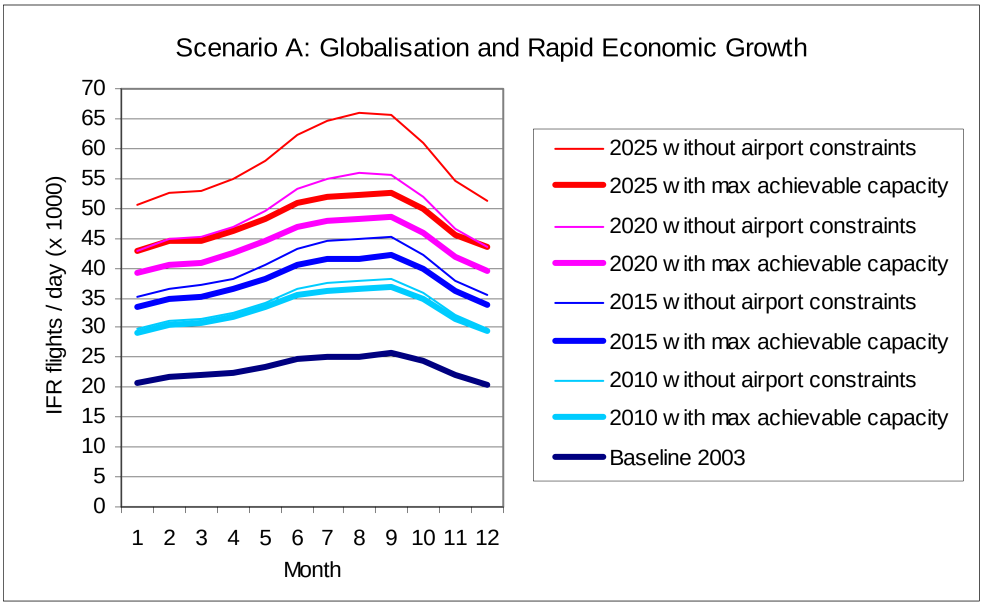

Figure 18 Average daily number of flights per month

September 2003 — busiest month of the year — saw an average daily demand of 25,900 IFR flights. For the busiest month in 2025, using scenario A, the unconstrained demand would be 65,900 flights/day. With implementation of maximum achievable airport capacity, 52,500 flights/day can be accommodated. In other words, during the busy summer months, approximately 20% of demand remains unaccommodated. During the winter months this is 15%. The annual average is 17.6% (see Table 6).

If airport capacity would stay at today's levels, demand would be constrained to 43,100 flights/day (not shown on the diagram).

6.4 Detailed Airport Results Examples

Due to confidentiality issues, the detailed airport results cannot be made available. However it is useful to illustrate the modelling results by presenting two unnamed airport examples.

6.4.1 Airport Example 1

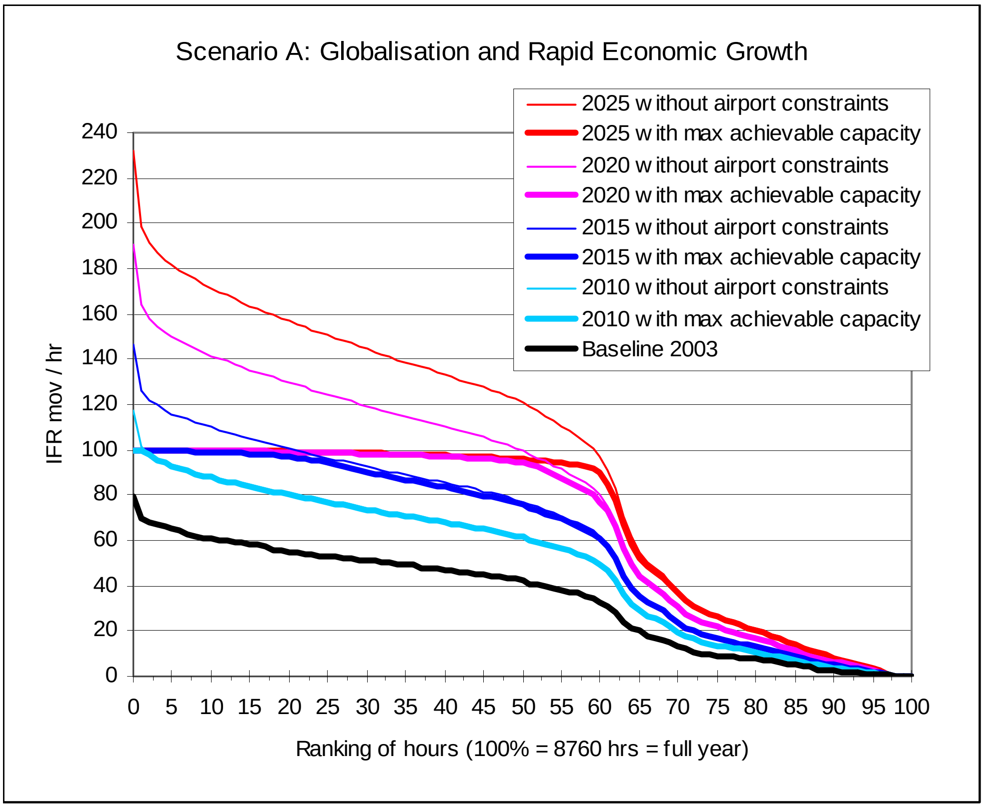

Figure 19 Hourly demand distribution at an airport (example 1)

With a capacity of more than 80 mov/hr, this airport can handle even the busiest hour in 2003. By 2010 it will have increased its capacity to 100 mov/hr, and this is sufficient to handle the 2010 demand (light blue line) 98% of the time. However no further capacity increases are possible and we see the following evolution:

- In 2015 the typical busy hour demand (2 percentile point) has gone up to 120 mov/hr, and demand is exceeding capacity 20% of the time
- In the year 2020 the typical busy hour demand is 160 mov/hr, and demand is exceeding capacity 50% of the time
- Finally, in 2025 the typical busy hour demand is 190 mov/hr, and demand is exceeding capacity 60% of the time, which is most of daytime hours during the year.

6.4.2 Airport Example 2

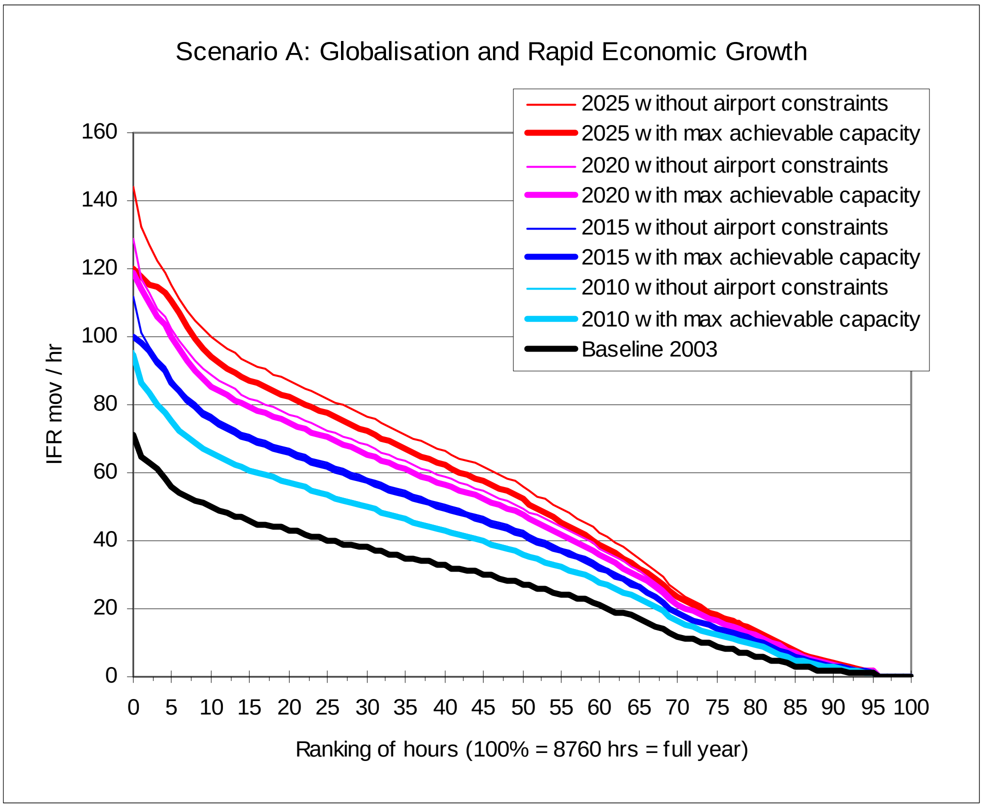

Figure 20 Hourly demand distribution at an airport (example 2)

With a capacity of more than 70 mov/hr, this airport can handle even the busiest hour in 2003. By 2010 it will have increased its capacity to 100 mov/hr, and this is sufficient to handle the 2010 demand (light blue line) 100% of the time. From there on we see the following evolution:

- In 2015 the capacity is still 100 mov/hr. The typical busy hour demand (2 percentile point) has gone up to 100 mov/hr, so this airport is still in good shape.
- By 2020 the airport has increased its capacity to 120 mov/hr. Typical busy hour demand has become 115 mov/hr, so there is some spare capacity.
- Finally, in 2025 the typical busy hour demand is 130 mov/hr, and with a capacity of 120 mov/hr, demand is exceeding capacity 5% of the time, which is not yet a serious problem.

7. ANALYSIS OF THE POSSIBILITIES FOR MITIGATING AIRPORT CAPACITY CONSTRAINTS

7.1 Introduction

The previous chapters have described in considerable detail the impact of airport constraints on the potential growth in aircraft movements at a number of different time horizons and for the different Long Term Forecast scenarios, assuming unchanged flight demand distribution patterns.

The aim behind the so-called "mitigation analysis" is to explore the sensitivity of the network, in terms of un-accommodated demand, to the way that the overall airline schedule is organised. The "mitigation scenarios" represent various options and not suggestions on how the traffic increase could be accommodated. The scenarios include

- schedule smoothing (use of off-peak periods),
- schedule smoothing in combination with use of secondary airports and
- limiting the daily number of flights on airport pairs, thereby forcing the use of larger aircraft.

Some of these measures may be considered as less optimum from the perspective of a single airline but for the air transport sector as a whole they might result in significant savings. Furthermore, the scenarios have been assessed and modelled purely from the standpoint of the relationship between potential traffic distribution and airport capacity constraints. An analysis of the extent to which the market supports such changes, or the impact on airline operations efficiency were not within the scope of this study.

Because of the calculation intensive nature of mitigation analysis, the modelling has been conducted for a limited traffic sample in the summer period. The unaccommodated demand without mitigation was calculated as being 17%, a result which is compatible with those from the previous chapter. The results of the mitigation analysis are to be seen as characterising the busy summer period, rather than providing averages or totals for the whole year.

7.2 The Impact of Schedule Smoothing

This scenario simulates the use by airlines of slots in those time periods where demand is below available capacity. In a number of 'schedules facilitated' airports, growth is no longer possible at certain periods of the day and airlines are obliged to choose slots in perhaps less favourable time periods if they wish to expand their services. Similarly, at a number of hub airports, peaks and troughs in the demand profile are visible and again, any overall growth will result in the daily demand profile becoming more "smooth" in nature.

Under this scenario, if a flight cannot be accommodated at a certain time of the day, we look in an adjacent time slot to see if there is a nearby period where demand is below capacity to enable the flight to be accommodated. The following figure compares the level of un-accommodated demand (expressed as a percentage of the unconstrained demand) in the absence of smoothing and also for the case where flights were accommodated at up to 1 or 3 hours from their original slot. Under this scenario, the level of un-accommodated demand at 2025 is approximately 11% compared with 17% in the reference case. Over the time horizon of the study, the major hubs will become congested throughout the entirety of each day but this result clearly indicates that there is some growth potential within the currently existing airport pairs, albeit with the necessity of moving away from a strict respect of the current daily traffic pattern.

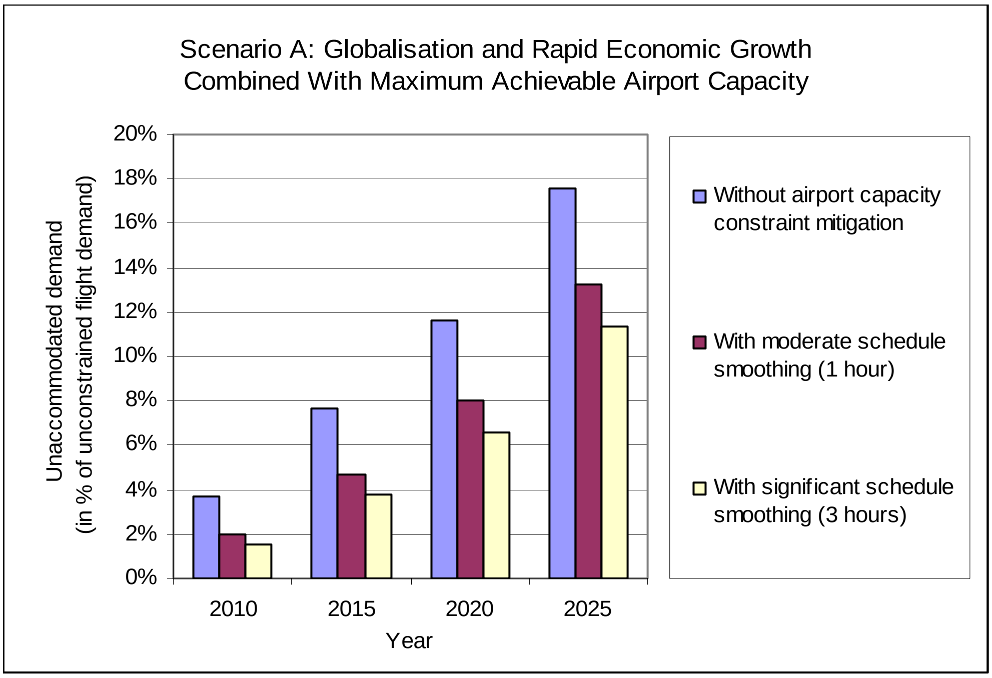

Figure 21 Impact of schedule smoothing

7.3 Increased Use of Secondary Airports

This scenario simulates the increased use of less capacity constrained airports in the areas surrounding more major, capacity constrained airports – the incidences of which are already being observed in today's demand characteristics notably with a number of low-cost carriers.

Under this scenario, the smoothing is augmented by also looking at airports in the same Origin and Destination Zone group to see if a "slot" can be found. Clearly this represents the most "ambitious" mitigation strategy and the one for which one would expect that un-accommodated demand would be the most reduced. The following figure indicates the levels of un-accommodated demand expressed as a percentage of the unconstrained demand in the absence of any mitigation strategies and then with the addition of use of off-peak slots (smoothing) and also the use of secondary airports.

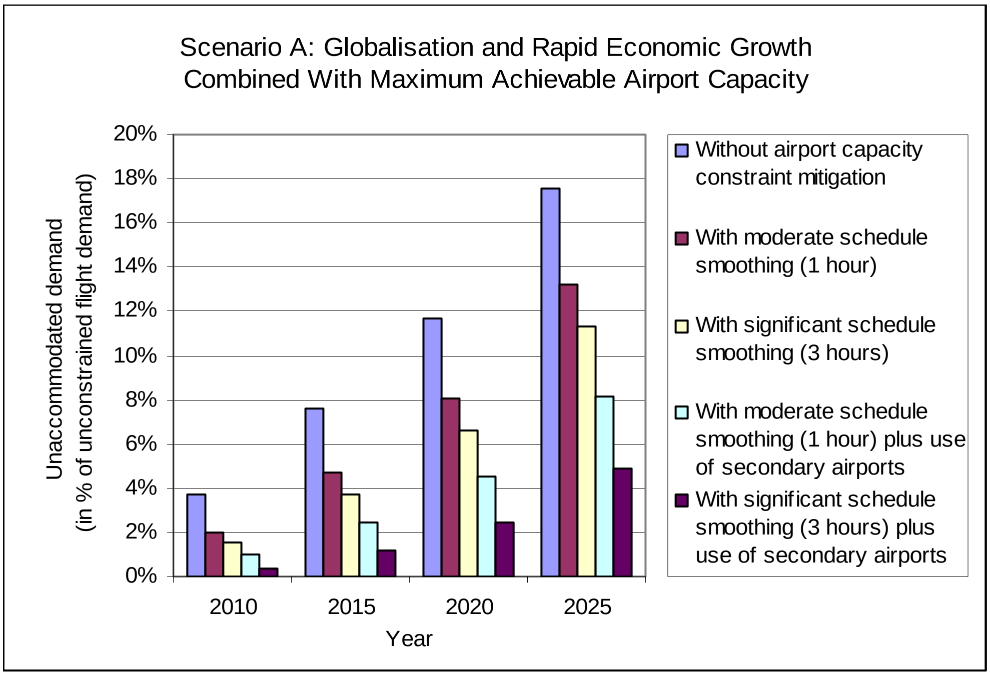

Figure 22 Impact of schedule smoothing plus use of secondary airports

Initial results indicate that the level of un-accommodated demand could be reduced to a value as low as 5% at 2025. The real effect would probably be less, because it remains to be seen to what extent the market (i.e. the passengers) would be willing to follow this mitigation strategy. On the other hand, part of the effect could be reached if airlines would decide to split or move some of their hubs to secondary airports.

It is important to note that the process of assigning flights to secondary airports takes into account the traffic distribution in 2003. That is to say flights will be assigned to secondary airports as a means of supporting traffic growth if (and only if) there is at least one flight operating on the airport pair in summer 2003. This process ensures that unrealistic airport pairs are not “invented”.

7.4 The Effect of Limiting the Daily Number of Flights on Airport-Pairs

It has been stated that the tendency of air traffic demand to require increased frequency rather than maximising the number of passengers per movement on certain high yield city pairs is a contributing factor to airport congestion. Earlier in this report, section 3.3.2 illustrated the often made assertion that the European airport-pair network is somewhat fragmented in nature: the high concentration of traffic on a small number of airport pairs but also the high number of airport pairs for which there is little traffic.

Any eventual limitation on daily flight frequency will therefore impact only a fraction of the totality of airport pairs. The aim of this analysis has therefore been to explore whether a constraint imposed on certain airport pairs may liberate sufficient slots in order to have an impact on overall levels of un-accommodated demand. It should be borne in mind that aircraft size per segment is already one of the scenario inputs for the unconstrained forecast. Scenario A, for example, assumes increased aircraft size on the big-aircraft end of the spectrum, combined with increased use of small business jets on the other side of the size spectrum. This creates two opposite forces: one tends to lower the number of flights, the other increases it. From the perspective of a forecasting scenario, the imposition of a “cap” on the number of daily flights will essentially have two effects on busy routes:

- Air carriers are assumed to move to even bigger aircraft than specified in the scenario.

- The use of business jets on busy routes will be constrained, leading to un-accommodated business jet demand rather than bigger aircraft.

The resulting unconstrained demand (ie without airport capacity limitations) is about 20% lower than for scenario A, thereby producing a demand comparable to scenario C. Let’s call this scenario X.

In order to simulate this scenario, any airport pair in summer 2003 which had more than 10 flights per day was not allowed to grow and the volume of traffic was forced to ‘stagnate’ at 2003 levels. Any airport pair which was considered to grow beyond 10 flights during the time horizon of the study had a similar limit imposed. Whilst this limit has been chosen ‘arbitrarily’ for the purposes of assessment of the scenario, it could reasonably be argued that a limit of ten daily flights on any airport pair presents the customer with a sufficient choice of travel options.

Comparing the generated traffic characteristics for the reference scenario A and the new scenario X at 2025 gives the following results:

Scenario	Average daily flights
Baseline 2003	26,400
Scenario A unconstrained 2025	67,100
Scenario A constrained 2025	56,100
Scenario X unconstrained 2025	54,800
Scenario X constrained 2025	52,200

Table 11 The effect of limiting the daily number of flights on airport-pairs

It is to be noted that capping of flight frequencies without airport constraints (scenario X unconstrained in the above table) leads to lower traffic than uncapped demand with airport constraints (scenario A constrained). Based on these numbers, the following conclusions can be drawn:

- uniform capping of demand on routes would not just affect airport pairs serving congested airports, but also airport pairs serving uncongested airports, therefore limiting traffic where it is not necessary;

- this regulatory measure would lead to sub-optimum use of the airport network, and is therefore not recommended.

8. QUALITATIVE ANALYSIS OF ENVIRONMENTAL CONSTRAINTS

8.1 Introduction

This chapter summarises the possible impact and mitigation of actual and potential environmental constraints to growth in the near to mid term (2005 to 2010) and in the mid to long term (2011 to 2025). These environmental constraints are related essentially to patterns of aviation operational activity (both civil and military) and build on the present airspace and airport congestion features of the European airspace system.

Community noise and its associated quality of life, health, congestion and environmental effects, as well as local (air) pollution can act to constrain the growth of aviation in the near future as well as over the long term. Their specific impact depends primarily on three factors: the patterns of aviation operational activity; the size, dimension and placement of airport facilities; and public and policy acceptance of aviation as a generator of economic and social wealth (i.e. public willingness to accept the environmental consequences of aviation activity. These impacts have become important in Europe and currently occur for the most part, but not exclusively, at the major airport hubs.

Aviation’s atmospheric and climate impacts are considered a major issue for the future of aviation because of the projected effects of global greenhouse gas emissions on the natural environment resulting from increasing air traffic volume. These impacts derive from primary emissions that are present in the aircraft engine exhaust as it leaves the aircraft and secondary emissions that are produced in the atmosphere by chemical reactions that use the primary emissions either as a reactant or a catalyst.

Aviation emissions impacts are distinct from noise impacts for a variety of reasons. These include a broader range of time scales over which the effects can occur (from a day to 1000 years) and a broader range of scales over which the effects are felt (local, regional and global). As a whole, emissions are expected to increase in relation to traffic growth, and to constitute a greater proportion of both the global man-made climate impact and local contributions to regional emissions around airports.

8.2 Community Noise

Community noise and other environmental capacity impacts are already influencing the growth and development of certain European airports and therefore limiting the capacity of the entire air traffic system (see also 4.4). At some key EU airports, notably those sited in close proximity to high-density population areas, noise constraints have become as important as ATC and runway capacity constraints. Some EU airports declare noise as one of the factors dictating capacity limits generally.

In the near term, to 2006 or thereabouts, it is expected that fleet renewal will help to reduce or stabilize the effects of aircraft noise impacts, but it would seem that noise constraints will increase steadily thereafter, over the next twenty years, driven by the congestion related effects of air traffic growth and the increasing urbanisation of Europe's population. Although this trend will not be the same for all airports, significant increases in aviation-related noise impacts are predicted on a European scale. In the absence of further technological progress and change or regulatory action, noise will remain an indelible feature of air traffic activity out to 2025 and beyond.

Although manufacturers have set stretching noise reduction research targets for 2010 and 2020, technological improvements are likely to be incremental, as no step changes in technology are perceived. For the foreseeable future, regulatory focus is on compliance with ICAO's Chapter 4 noise certification standard (to take effect on 1 January 2006) coupled with application of a uniform process, based on *ICAO's Balanced Approach to the Management of Aircraft Noise*, through which airports must go before being able to impose one or a variety of noise mitigation measures. The ICAO process alone suggests that further reduction of noise at source would not happen before 2010 at the very earliest, and probably not until 2015 or later, depending on whether work on new noise stringency standards and / or the development of environmental goals is undertaken.

It is likely that new approaches to limit the number of people affected by noise will be need to developed over the near to mid term. Technology alone will not be sufficient. For example noise charges (or noise surcharge to landing fees) are increasingly used to offset noise impacts. Charges can be used for instance for insulation schemes or relocation of people from high noise areas by covering relocation expenses. As a matter of fact, most airports in densely populated areas apply noise charges and operational restrictions during night hours. This means that more emphasis is being given to land use measures, including the possibility of assisted removal of those subjected to increased noise as a result of the growing air traffic activity, as well as to extended use of operational measures to reduce or limit approach noise, all of which require further evaluation in particular by air navigation service providers.

8.3 Air Quality

With airport operations and infrastructure expansion now critical issues, and as European air quality standards generally become more stringent in response to the adverse effects of local air pollution on human health, local air quality (LAQ) is re-emerging as an increasingly important environmental issue at airports. The contribution from aircraft engines in particular to nitrogen oxide (NO_x) is increasing again, so that air quality, particularly where related to potential health effects, is becoming another factor that limits airport capacity expansion and the ability to meet future traffic growth in the near future and over the longer term.

It would seem that already, additional runway capacity is contingent upon consistently containing all relevant pollutants within the EU regulatory limits. It is also clear that under some growth scenarios a number of European airports may have air quality problems over the long term, at 2030.

For the foreseeable future, the aviation-specific regulatory focus is on the progressive strengthening of international (ICAO) emissions standards (the latest revision of which takes effect in 2008) together with the prospect of a further review in principle (subject to specific conditions) of these standards in 2010. However, it has become apparent that other measures, such as the accelerated implementation of CNS/ATM on a global and regional basis, are a necessary adjunct to these standards. There are substantial technological research programmes in Europe and the USA aimed at delivering low NO_x technologies. The use of economic approaches to address airport air quality concerns is presently limited to a relatively small number of airports, but a European-wide approach is in place that could facilitate the further unilateral adoption of airport emissions charges in the near future.

In 2005 and again in 2010, local authorities governing the community areas around airports, amongst others, will need to comply with EU-wide limits for specified pollutants. Projections indicate that this may be difficult for certain major EU airports. There are also early signals that aviation will need to comply with other wider air quality standards, such as those of the World Health Organization (WHO), possibly as early as 2010.

Moreover, current measurements and modelling of local air quality at airports show that road traffic is the major contributor to NO_x levels affecting communities around airports. In general, emissions standards on road vehicles are improving and a number of airports are already working with local communities and authorities on integrated approaches to air quality management. Access to airports by express rail services as means to reduce car access will therefore become a major requirement for further airport expansion.

8.4 Climate Change

The global energy related effect of air traffic on the atmosphere, including climate change, is potentially the most important issue affecting the future development of air transport over the long term. Air transport's climate impact has two dimensions: that related to carbon dioxide from aircraft burning fossil fuels and that related to other effects in the upper atmosphere, linked to emissions of NO_x, particles and water vapour.

Current estimates suggest that air traffic's contribution to climate change could be larger than originally thought, due to cirrus cloud enhancement, although considerable uncertainties remain. Recent research focuses on the direct effects of contrails and the aerosol induced cirrus change effects, with an update to the findings of the 1999 IPCC *Special Report on Aviation and the Atmosphere* expected in 2007.

The policy implications have already been identified with some preliminary studies suggesting that there may be substantial benefits in flying at altitudes or along routes that minimize the chance of contrail production. Whilst more research is needed, it might be assumed that such an action would reduce the chance of enhancing cirrus cloud, although it would lead to an increase in CO_2 emissions and entail significant ATM problems.

In the near to medium term (2005–2010), improving fuel efficiency is the most potentially rewarding mitigation approach to directly reducing or limiting air transport's climate impacts, although early action to reduce carbon dioxide over the long term is also essential. At the same time, priority should be given to reducing the uncertainty over the effects of contrails, cirrus cloud and NO_x. Whilst international emissions standards are primarily directed at reducing emissions in the vicinity of airports, any advances in this direction should help reduce emissions at cruise. There is also general agreement that technical, operational and economic measures need to be used in combination to attenuate air transport's climate impacts, and that trade-offs between noise and emissions, and between nitrogen oxide and carbon dioxide, should be taken into account.

There is now increasing political emphasis on the climate related impacts of air traffic. The current assumption is that emissions trading approaches, initially targeting carbon dioxide, are the best long-term option for controlling air transport's climate change impacts out to 2025. The jury is still out on whether aviation emissions should be incorporated into States' emissions trading schemes consistent with the UNFCCC process as this implies agreement on globally or regionally agreed quantitative targets for carbon dioxide emissions and climate change impacts.

In Europe, efforts in this direction are already underway with the prospect of aviation being incorporated in the EU emissions trading scheme as early as 2008 or more probably from 2012 onwards. Indirectly, incorporation of aviation in the EU scheme would appear to offer the best medium and long-term approach to reducing net effect. Aircraft emissions are a major issue for the EU given the projected doubling of air traffic related carbon dioxide emissions between 1990 and 2010 and the EU Kyoto commitment to cut GHG emissions by 8% below 1990 levels by 2010.

In the near future, there is some interest on the use of voluntary measures (under which the air transport industry and governments would agree to a target and/or set of actions to limit or reduce emissions). There is also interest in carbon dioxide emissions charges. However, the scope for introduction of such charges globally would appear to have been excluded, at least up to 2007 by recent international policy decisions. Although the introduction of an EU wide emissions charge does not appear likely in the near term, the introduction of such charges pending the development of emissions trading schemes cannot be discounted as a precursor to action at international level.

Since air transport's principal externality derives essentially from its projected climate change impacts, it can be expected that pressure will build in the near term for aviation to meet its external costs. This approach is supported by the view that long term signals and incentives are needed, owing to the long lead times needed to develop new aviation technology. The air transport sector in turn argues that the discussion on internalizing external costs has to be placed in the broader context of all modes of transport and all types of external costs, in particular to include infrastructure costs. It is argued that the real issue is balancing the mobility needs of society and its “true” costs in the provision of transport service versus the economic and social benefits of the transport system to society. Obviously, the debate on the identification and accounting of external costs is already under way. To summarise, there is an emerging view that international or regional agreements on environmental limits (noise, air quality and climate change) should be reached as soon as possible; however the air transport sector would not like to see that such agreements *artificially* restrict airport and ATC capacities even before the potential extra capacities can be tapped as shown in the study.

9. THE NEED TO PLAN FOR THE MOST CHALLENGING SCENARIO

The highest growth is forecast to occur under conditions of globalisation and rapid economic growth. The other forecasting scenarios would lead to lower demand (hence less airport congestion), but possibly also to higher airport capacity constraints. In case of lower demand growth the constraining effects are smaller but they still present unaccommodated demand and simply push the same problem further in the future. In addition, it is easier to delay capacity development than to accelerate it at a later stage. The study, therefore, recommends to assume the highest growth scenario (but without constraint mitigation) as the reference on which to base the strategic discussions and decisions.

The study has been conducted to provide an insight on the effect of the growth and the challenges it raises. It is a useful basis for a dialogue with all interested Stakeholders from the industry. The results of the study will also serve as an input to strategic planning in the context of the European ATM Master Plan. However it is clear that many of the implications and solutions are beyond the scope of Air Traffic Management.

10. REFERENCES

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