Draft Rule for the Provision and Use of Data Link Services

Economic Appraisal

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EDITION NUMBER	EDITION DATE	INFOCENTRE REFERENCE	REASON FOR CHANGE	PAGES AFFECTED
0.1	01/11/06		First draft	All
0.2	20/11/06		Addition of extra equipage scenario and sensitivity analysis	All
0.3	22/11/06		Summary added	vi to vii
0.4	11/1/07		Operating costs added. Project model refined.	All
0.5	21/2/07		Analysis extended to all EU Member States. Weight exemptions for aircraft removed.	All

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SUMMARY

Introduction

Air-ground data link services are key enablers for the processes required to achieve the levels of capacity required for the development of air traffic management in Europe. They contribute to the improvement of service quality, safety and cost effectiveness and are already beginning to be implemented in Europe.

The terms of the Implementing Rule have not yet been finalised, but it has been assumed that equipage will become mandatory for new aircraft from 2009 and for existing aircraft from 2014, with state, FANS 1A and aircraft older than 20 years in 2014 being exempted. Ground implementation is assumed to progress from an initial group of 17 ATC centres, equipped by 2011, to all EU member states by 2016.

Method of appraisal

Data link is a tool to be used by controllers to reduce their work load and enable them to increase their productivity, thereby increasing peak sector capacity. This increase in capacity will make it possible to defer the addition of extra sectors, with the consequential avoidance of the additional operating costs. These avoided operating costs are the economic benefits of data link. They are initially produced by the air navigation service providers and passed on to the aircraft operators in the form of an avoidance of increased route charges.

The analysis has been carried out for each of the 37 ATC centres assumed to be covered by the Rule, using a range of traffic growth and aircraft equipage rates. The future numbers of sectors are estimated for each participating ACC, with and without data link, and the cost savings enabled by data link are evaluated.

Controller workload reduction

Simulations have indicated that data link can produce an 84% reduction in the time required for the radio-telephony tasks of the tactical controller. This can reduce total controller workload by up to 29% and increase maximum sector throughput by about 14% with 100% of flights equipped.

The effect on sectorisation

In 2006 there were 404 sectors in the data link airspace. By 2016, it is estimated that, without data link, the total will need to rise to 560 to keep pace with the growth in traffic and, by 2025, the total will have risen to 750. The introduction of data link should allow the number of sectors required by 2016 to be constrained to 520. As a consequence, by 2017, the level of costs avoided could reach €200m per year.

Considering the period to 2025, which allows for an operating period of just over 10 years after mandatory aircraft equipage, the benefits are likely to have a value of the order of €1,100m in present value terms. Savings are greater with the higher estimates of future traffic, but the rate of aircraft equipage is the most significant factor in the value of the cost savings.

Ground Implementation

Data link is currently implemented at the Maastricht UAC and there are plans to implement it at 16 further ACCs between 2008 and 2011. Cost information from Maastricht and the ANSPs intending to implement data link by 2008 indicate that the average cost per ACC may be in the region of €10m. Total ground implementation costs are expected to be about €365m.

The aircraft fleet

A traffic sample indicated that there are 9,922 aircraft operating in the data link airspace. Of these, 2,161 were assumed to be exempt from the Implementing Rule due to being FANS 1A aircraft or state or military aircraft. A further 3,065 aircraft will be more than 20 years old by the time of the date of mandatory retrofit in 2014 and were assumed to be exempt on the basis of age. This left 4,696 aircraft falling within the scope of the Rule. The exemptions leave only 47% of the aircraft subject to the Rule. However, these aircraft carry out 62% of the flights. This proportion will grow, as older aircraft are replaced by new ones which are subject to the Rule. The relevant fleet size is projected to grow to about 12,500 aircraft by 2014, with 1,344 aircraft retiring and 3,937 new aircraft being added to the fleet.

Aircraft equipage

Experience of past mandates shows that most airborne equipage tends to take place near to the deadline, with significant numbers missing the deadline. Accordingly, in addition to a *deadline* equipage scenario, which assumes that all eligible aircraft are equipped by the Implementing Rule deadline, two further implementation scenarios, *late* and *early*, have been considered. The late implementation rate is based on past experience whilst the early implementation rate assumes that airborne equipage runs in parallel with ground equipage.

It is estimated that about 5,283 aircraft will need to be retrofitted. By the end of 2016, it is estimated that about 3,978 new aircraft will be delivered equipped, bringing the total of equipped aircraft to almost 9,300. Due to the exemptions, the maximum long term level of equipage would only reach about 78% of aircraft. However, as eligible aircraft tend to fly more frequently than non-eligible aircraft, a proportion of almost 90% of flights by equipped aircraft can be reached with this level of aircraft equipage.

Aircraft equipage costs

Experience gained from the Pioneer scheme of the EUROCONTROL LINK 2000+ Programme suggests that the cost of equipping a relatively new aircraft may be as little as €5,000 but that the cost of installation in an old aircraft with no usable facilities may be as high as €100,000. The average cost will tend to be towards the lower end of this scale and may be of the order of about €40,000. The total cost of retrofit is likely to lie in the range €203m to €211m depending on how soon new aircraft will be delivered fully equipped. The total cost of new fit will be of the order of €20m per year, totalling about €255m by 2020 and will reach about €403m by 2025 if the cost of equipage does not fall.

Return on investment

The rate of return, on the basis of the most likely estimates of costs and implementation dates, is estimated at 23%, which is commensurate with that required of a high risk commercial investment. The most serious risks are that the rates of aircraft equipage or ground implementation will fall behind schedule. With late aircraft equipage the return could fall to 18% and a one year delay on the part of the ANSPs would reduce the return to 21%. However, these are still reasonable for the degree of risk involved.

Payback of the investment can be achieved by early 2018, just two years after the date for extension of data link services to all EU member states.

Paving the way for future concepts

Over the next decade, new technologies will have to be introduced into the ATC process to meet the growing demand. Data link is one of the first such new technologies and the experience gained with data link will be significant in the development of further concepts and technologies.

1 THE APPROACH TO THE APPRAISAL

1.1 Introduction

Air-ground data link services are a strategic element in the development of air traffic management in Europe. They are key enablers for the processes required to achieve the levels of capacity required by traffic evolution and performance targets and contribute to the improvement of service quality, safety and cost effectiveness.

Data link services are already beginning to be implemented in Europe. Since 2004, a service has been provided from the Maastricht UAC, covering the upper airspace of Belgium, the Netherlands and parts of western Germany, and the air navigation service providers of Germany, Italy, and Switzerland plan to implement data link services between the end of 2008 and early 2009. In addition, the service providers in France, Portugal, Spain and the UK have expressed their intention to implement data link services by 2011. As a consequence of the Pioneer scheme of the EUROCONTROL LINK 2000+ Programme over 300 aircraft will be equipped to operate controller-pilot data link communication (CPDLC) by the end of 2007.

Thus the value of data link services is already being recognised. This report considers the economic benefits of extending the implementation of these services through the imposition of a mandatory Implementing Rule.

1.2 The terms of the Implementing Rule

The terms of the Implementing Rule have not yet been finalised. Therefore, for the purposes of carrying out this economic appraisal, it has been necessary to make assumptions as to what the final terms of the Rule will be. The assumptions made are as follows.

Geographical area

Air navigation service providers (ANSP) in the area designated in Annex V of the Implementing Rule will be required to provide a data link service from 2011. This requirement is assumed to cover the airspace of Belgium, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain and the UK. Subsequently, the Implementing Rule will be applicable in the upper airspace (above FL285) of all 27 member states of the European Union from 2016. In addition, Switzerland, although not a member of the EU is planning to implement data link services and is included in this appraisal.

In the areas where a service is currently provided or where the service is expected to be provided before 2011, the earlier benefits have been taken into account. The Area Control Centres (ACC) covered by the Rule and their current implementation plans are indicated in Annex A.

Aircraft eligibility

For aircraft operating in the designated airspace, CPDLC airborne equipage will become mandatory for new aircraft (forward fit) from 2009 and for existing aircraft (retrofit) from 2014.

The Implementing Rule will apply to all aircraft with the exception of the following aircraft, which would be exempted:

- Exemption 1: FANS 1A aircraft
- Exemption 2: state aircraft, and
- Exemption 3: aircraft intended to be withdrawn from use before a specific date.

For the purposes of this appraisal it has been assumed that aircraft more than 20 years old in 2014 will be exempted. This assumption is derived from the fact that the average life in service of an aircraft in Europe is 25 years and that it would be unreasonable to expect an aircraft to be equipped for CPDLC operation unless it could derive at least five years useful life from the data link equipment. However, the effect on the numbers of eligible aircraft of varying the exemption rule has been evaluated.

1.3 Method of appraisal

The analysis is based on the premise that data link is a tool to be used by controllers to reduce their work load and enable them to increase their productivity. Specifically, it will enable them to manage more aircraft at any one time and hence to increase the peak sector capacity.

In the analysis it is assumed that, within the period considered, the management of each air traffic control centre (ACC) would be able to react to increasing volumes of traffic by increasing the numbers of sectors in order to prevent rising levels of delay. However, at an ACC where data link had been implemented, since controllers would be able to handle more traffic, the time at which it would become necessary add extra sectors may be deferred with the consequential avoidance of the additional operating costs which extra sectors would generate. These avoided operating costs are the economic benefits of data link services. They are initially produced by the air navigation service providers (ANSP) and the benefit is passed on to the aircraft operators in the form of an avoidance of increased route charges.

It should be noted that the analysis does not attribute a value for delay saving to data link services. It is considered that the level of delays would, in any event, be managed through the normal process of airspace planning but that the availability of data link services would provide the management of ANSPs with a cost saving option to additional sectorisation. However, there are diminishing returns from additional sectors and ANSPs will not be able to continue to open more sectors indefinitely. Although initiatives such as the move to 8.33 kHz channel spacing may remove the communications limitation on adding extra sectors, there will come a point at which the additional handover workload involved with a larger number of smaller sectors will negate the capacity benefit of the extra sectors. At this point, additional capacity will only be able to be provided through the use of new technology measures such as data link. However, the date at which additional sectorisation will become impractical has not yet been determined and so has not been incorporated into this analysis.

As with all ATM improvements that depend on the introduction of new technology, data link services will require substantial investment both on ground infrastructure and in aircraft. There are usually two problems associated with this:

- The uptake by airlines tends to be slow at the beginning but, near to a deadline for mandatory equipage, actions for equipage are undertaken in a rush. This is an inefficient and costly process, which delays the realisation of cost savings/benefits and unduly increases the cost of airborne investment.
- Delays in implementing ground systems by one or more ANSP means that the service cannot be implemented in a uniform manner and acts as a disincentive to aircraft operators to equip their aircraft in good time, thus delaying the achievement of project objectives by those ANSPs who have implemented systems.

The analysis therefore considers a number of scenarios:

- the situation in which data link is not implemented

- a deadline equipage case in which all ACCs and aircraft are equipped in a progressive manner in time to meet the Implementing Rule deadlines
- late equipage cases, based on the experience of previous EUROCONTROL mandates, in which there are delays in ground equipage and a proportion of aircraft miss the Implementing Rule deadline
- an early equipage case which assumes an accelerated rate of aircraft equipage that is synchronised with the planned provision of data link services by the early equipping ANSPs indicated in Annex A. This accelerated rate of equipage would require a form of incentive over and above the requirements of the Implementing Rule. However, the nature of this incentive is not considered in this report[1].

For each scenario, the future numbers of sectors are estimated for each participating ACC and the cost savings for each implementation scenario, relative to the situation without data link, are estimated.

2 THE BENEFITS OF DATA LINK

2.1 Derivation of benefits

The manner in which the benefits are derived is illustrated in Figure 1 and may be summarised as follows:

- data link enables a reduction in the radio telephony workload
- this produces a reduction in the overall workload of the tactical controller
- this, in turn, leads to a sector capacity increase
- this enables the opening of new sectors to be deferred, permitting the avoidance of additional controller costs and associated support costs.

The analysis is carried out for each of the 37 ATC centres assumed to be covered by the Rule.

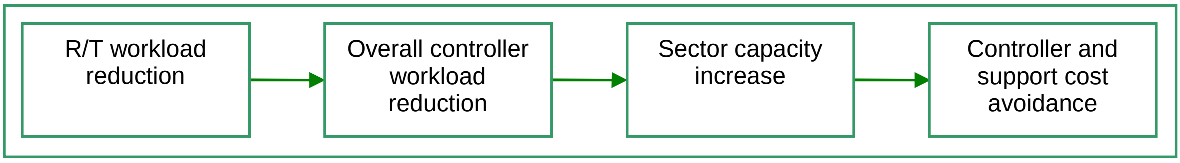

Figure 1 - Benefit linkage

2.2 Controller workload reduction

Real time simulations were conducted at the EUROCONTROL Experimental Centre (EEC) in Brétigny in September 1999 to determine the effect of CPDLC on the radio-telephony tasks of the tactical controller. These indicated a reduction in the time required for these tasks of up to 84%, depending upon the level of airborne equipage.

Studies by National Air Traffic Services (NATS) in UK and the Centre d'Etudes de la Navigation Aérienne (CENA) in France have shown that R/T workload is generally between 35% and 50% of the total workload of a tactical controller. Thus, using the lower value of

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[1] A proposal for a financial incentive scheme was prepared by EUROCONTROL and a submission for a TEN grant to fund the first part of the scheme was submitted to the European Commission.

35%, CPDLC could be estimated to reduce the total workload of the tactical controller by about 29% with 100% of flights equipped.

2.3 Capacity increase

Although a sector is manned by two controllers, the planner and the tactical controller, the workload of the tactical controller tends to be the limiting factor on sector capacity. Real time simulations were, therefore, undertaken to evaluate the impact of the overall reduction in the workload of the tactical controller on sector capacity. These simulations were conducted at the EUROCONTROL Experimental Centre, in September 1999. They lasted two weeks and involved 7 controllers. Four CPDLC equipage rates (0%, 50%, 75% and 100%) were examined under a range of traffic volumes. The results are shown in Figure 2.

In order to confirm these results, a fast time simulation was undertaken with the CAPAN (CAPacity ANalyser) fast time simulator in November 1999. This simulator uses a task based model where communication task execution times are determined through expert judgement, independently of the real time simulation results. The fast time simulation results are also indicated in Figure 2 below.

	Tactical controller workload		**Sector capacity gain**	
Flights equipped for CPDLC	R/T communication reduction	Overall reduction	Real time simulations	Fast time simulations
0%	0%	0%	0%	0.0%
25%				3.4%
50%	45%	16%	8%	7.8%
75%	61%	21%	11%	11.2%
100%	84%	29%	14%	15.9%

Figure 2 - Results of simulations

The fast time and real time simulations produced similar results, so the relationship between the workload reduction and the capacity gain was considered to be reliable. Thus the results indicate that the maximum sector throughput (expressed as the number of flights a sector can handle at peak hour) may be increased by about 14% with 100% of flights CPDLC equipped.

Figure 3 presents the results of the real time simulation graphically. As can be seen, the relationship between equipage and capacity increase may be represented as a linear one with a confidence limit (R^2) of 99.2%. This relationship has been used in the benefit estimates to predict capacity increases for different levels of CPDLC equipage, with the imposition of conservative constraints at the upper and lower levels of the equipage scale, as follows:

- a threshold level of equipage was imposed and no account was taken of benefits where the proportion of flights equipped was below 25%.
- a cap was put on benefits at the 75% level of equipage so that the capacity gain was effectively limited to 11%.
- for equipage levels between 25% and 75%, capacity gains were predicted from the relationship illustrated in Figure 3.

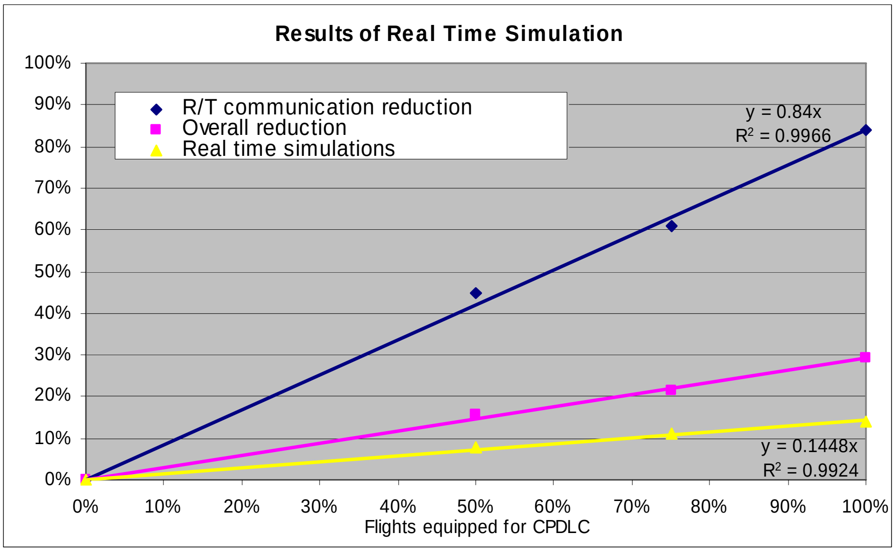

Figure 3 - The equipage/capacity relationship

2.4 Traffic growth

The traffic growth projections were based on the February 2007 STATFOR Medium Term Forecasts. These cover the period to 2013. After 2013, the growth rate for each area was assumed to remain at the 2013 level. The STATFOR forecasts are made for three traffic growth scenarios, ie:

- baseline traffic growth
- low traffic growth
- high traffic growth.

Benefit estimates were made for each of these scenarios.

2.5 The increase in sectors

The number of sectors currently operated by each of the centres was derived from the relevant Local Convergence and Implementation Plan - 2006-2010 (LCIP). The plans for the development of sectorisation in the period to 2008 were derived from the European Medium Term ATM Network Capacity Plan Assessment, 2007-2010. Since CPDLC is only planned to operate above FL285, approach sectors were excluded. To distinguish between upper and lower level en-route sectors, use was made of an EEC study[2] which classified sectors as lower, transition and upper. Transition sectors had a lower limit below FL285 but extended above this level. In this analysis, both upper and transition sectors have been included.

On the basis of the anticipated traffic growth (derived from STATFOR projections) and the currently planned increase in sectors (derived from the LCIP and the European Medium Term ATM Network Capacity Plan), the average volume of traffic per sector was calculated for each of the years from 2006 to 2008.

For the subsequent years it was assumed that:

- without CPDLC the volume of traffic per sector would not be allowed to exceed the maximum level which occurred between 2006 and 2008. Accordingly, each year, sufficient additional sectors would be opened to prevent the maximum being

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[2] Economic Differentiation between Lower and Upper Airspace, EEC, December 2003

exceeded. This assumption implies that, at some point in the period 2006 to 2008, some of the sectors approached their capacity limit.

- with CPDLC, sector capacity would increase by an amount depending on the level of equipage reached. Thus a higher maximum volume of traffic per sector could be calculated each year and a modified sector creation schedule developed.

An example of the estimates of sector numbers for the Maastricht UAC is given in Figure 20 in Annex B
.

2.6 Cost avoidance

Whenever it is possible defer the creation of a new sector, there is a cost avoidance equivalent to the cost of operating the sector for the period of the deferral. This cost avoidance is a function of:

- the local ATCO cost,
- the manning per sector,
- the number of hours per day for which the sector is open
- a manning factor to allow for maintaining the sector throughout the year
- additional local support costs.

The costs avoided will be critically affected by the number of hours per day for which a sector is open. It is normal practice that a sector should be open for at least two hours and, therefore, it might be assumed that new additional sectors would be open for perhaps two hours at each of the morning and afternoon peak times. However, with the rising levels of traffic, it is likely that sectors added at an earlier time may need to be open for longer during the course of the day. Therefore, to take account of this, it has been assumed that the average number of hours for which sectors are open each day at any ACC will not change with the addition of a new sector. Thus the overall effect on costs of the introduction of a new sector will be equivalent to the costs of opening that sector for the average sector open time for the ACC. The average sector open time for each ACC included in the study has been derived from the ACE 2004 Benchmarking Report[3].

The EUROCONTROL Human Factors department has developed a method of estimating the number of controllers required per control position, to keep that position staffed throughout the year. The method indicates that, for each control position, 9.14 controllers must be employed to keep the position open for 24 hours a day, with the number falling proportionately with shorter opening hours. A summary of the ATCO requirement calculation is presented in Figure 19 in Annex B.

The data and assumptions used in the calculations are summarised in Figure 4 below.

Factor	Value/source
Growth of traffic	STATFOR estimates for each country for the period 2007 to 2013. The growth in each of the subsequent years is assumed to remain at the same level as in 2013.

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[3] ATM Cost-Effectiveness (ACE) 2004 Benchmarking Report, Performance Review Unit (PRU) with the ACE 2004 Working Group, June 2006 http://www.eurocontrol.int/prc/gallery/content/public/Docs/ace2004/ace2004.pdf

Factor	Value/source
Number of sectors	LCIP values, as classified by the EEC study on upper and lower airspace and developed according to the European Medium Term ATM Network Capacity Plan Assessment, 2007-2010.
Sector traffic handling capability 2006-2008	Deduced from traffic estimates and sector numbers
Capacity increase 2009-2025	Deduced from equipage level using capacity/equipage relationship
Average cost of an ATCO	ACE 2004 Benchmarking Report. The most recent information available is for 2004. The 2004 costs have been updated to 2007 values using inflation values from European Central Bank statistics and forecasts (actual values of 2.2% for 2005 and 2.2% for 2006 and a forecast of 2.0% for 2007).
Support costs	It was assumed that with each additional sector, not only would there be an increase in controller costs, but also an increase in the costs of support personnel and equipment. These have been estimated as follows. For each 1% increase in the costs of operational controllers there is assumed to be: • 0.5% increase in other en-route staff costs • 0.5% increase in en-route direct operating costs • 0.1% increase in en-route depreciation and cost of capital Cost data is taken from the ACE 2004 benchmarking report.
Manning per sector	2 - tactical controller plus planner
Daily sector opening hours	Average for the ACC
Manning factor	9.14 for 24 hour per day coverage
Discount rate	8% - EUROCONTROL Standard Values. Present values are discounted to 2007 and expressed at 2007 price levels.

Figure 4 - Cost assumptions

2.7 The effect of CPDLC on sectorisation

In 2006, there were 404 sectors in the data link airspace. By 2016, based on the Baseline traffic growth and the other assumptions outlined above, it is estimated that, without data link, the total will need to rise to 560 to keep pace with the growth in traffic and, by 2025, the total will have risen to about 750. This estimate, however, takes no account of other measures which may be introduced to increase capacity, such as modifying routes and sector shapes, and which may restrain the increase in sectors. On the other hand, it assumes that additional sectors will produce a proportionate increase in capacity, whereas the additional inter-sector co-ordination required means that there will be diminishing returns from additional sectorisation. In addition, the estimates are based on the Baseline traffic growth assumptions which may prove to be under-estimates. Thus, in the absence of new technological developments, it is likely that there will need to be an increase in the number of sectors of the order estimated.

The introduction of data link should allow the number of sectors required by 2016 to be constrained to 520. Figure 5 illustrates the growth in sector numbers, showing the reduced rate of increase during the years 2009 to 2016, whilst data link is being implemented. Subsequently, the rate of growth increases, even with data link, but there is a continuing reduction in the total number of sectors due to data link, resulting in a continuous cost saving.

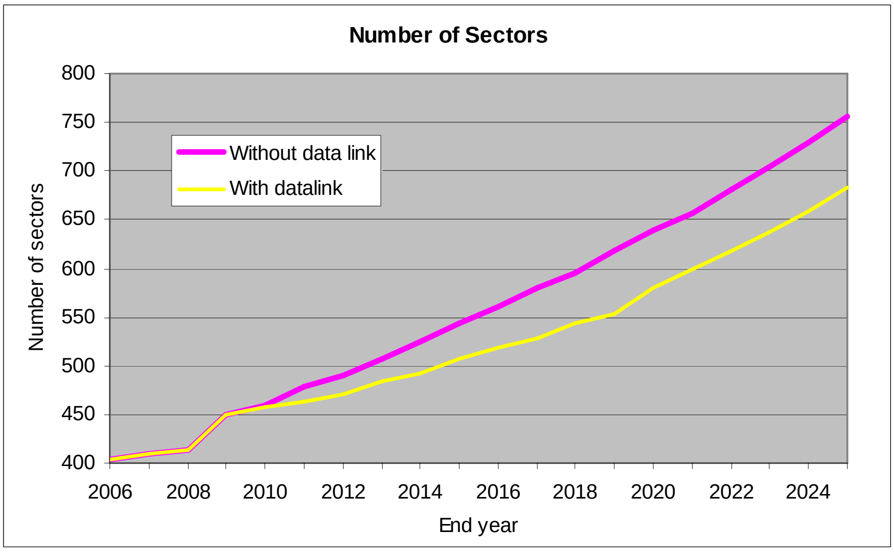


Figure 5 - Number of sectors

If the operation of an extra sector for one year is termed a *sector year*, then Figure 6 shows the total number of sector years avoided with data link and the additional saving due to early equipage.

Sector years avoided	2010	2015	2020	2025
Low traffic growth	2	112	362	679
Baseline traffic growth	3	129	399	733
High traffic growth	3	132	426	805

Figure 6 - Sector years avoided

Full details of the projected sector numbers and sector years saved are presented in Figure 21 in Annex B.

2.8 Estimate of costs avoided

The sector years avoided have been evaluated, using the assumptions presented in Figure 4, to produce an estimate of the potential costs avoided. The analysis indicates that, with baseline traffic growth and the deadline equipage case, cost savings of €12m are first achieved in 2010 and that, by 2017, the savings reach a level of €200m per year (at 2007 price levels). The present value of the costs avoided up to 2020 is €760m (discounted to 2007 using a discount rate of 8%) and €1120m to 2025.

3 GROUND IMPLEMENTATION

3.1 Current implementation plans

CPDLC is currently implemented at the Maastricht UAC and there are plans to implement it in 16 further ACCs progressively between 2008 and 2011. Current planned implementation dates for these ACCs are indicated in Annex A. The remaining 20 ACCs are assumed to equip just in time for the 2016 deadline.

3.2 The cost of implementation

Cost information on ground implementation is available from the experience at Maastricht and the plans of the ANSPs intending to implement CPDLC by 2008. The costs vary from centre to centre depending on the nature and age of the current equipment at the centres, the amount of software development required to integrate new and old systems and the volume of work (particularly software programming) which the ANSP proposes to carry out using internal staff. However, based on this information, the average cost per ACC is expected to be in the region of €10m. (No specific ACC costs are quoted in this report because of current tender actions.) It has been assumed that this expenditure will be made over a period of 24 months prior to the operational date.

A small amount of further expenditure is required at Maastricht but, for the purposes of this analysis, no account has been taken of past expenditure there, as these are *sunk costs* and should play no part in the decision to extend implementation to other ACCs.

On the basis of the above experience and assumptions, the total cost of ground implementation is expected to be about €365m.

3.3 Operating costs

The operation of CPDLC will involve an additional communication charge. It is assumed that this will take the form of a fixed annual charge made by the communications service provider to each ANSP providing data link services. It is estimated that this would be of the order of €100,000 per year for each ANSP.

No further operating costs have been assumed, as the incremental effect of CPDLC on ground running and maintenance costs is likely to be minimal.

4 AIRBORNE IMPLEMENTATION

4.1 The aircraft fleet

4.1.1 Sources of information

Airborne CPDLC equipage consists of retro-fitting existing aircraft and forward fitting new aircraft. Therefore it is necessary to analyse the current fleet, to see which aircraft would be covered by the Implementing Rule, and to estimate the future numbers of such aircraft. The data sources used and the analysis carried out are described below.

The traffic sample

This is an analysis of actual traffic movements for the month of June 2006 for the upper levels (over FL285) of the airspace assumed to be subject to the Implementing Rule. It was compiled from flight plans submitted to the EUROCONTROL Central Flow Management Unit (CFMU) and analysed by means of the EUROCONTROL PRISME aircraft database. For each aircraft recorded it shows the operator, type, weight, registration identification, age and the number of flights carried out in the relevant airspace during the month. The sample contained 13,325 records covering 453,368 flights by 9,922 individual aircraft.

Airbus Global Market Forecast 2004-2023

The Airbus Global Market Forecast includes data on the average replacement age of an aircraft for different regions. This is presented in Figure 7 below and is used to assess the likely effect on retrofit numbers of the date exemption.

The average replacement age for Western Europe is about 22 years and that for Eastern Europe, about 27 years. Given the significant volume of eastern European aircraft operating in the proposed data link airspace, the average for aircraft operating in the airspace has been taken to be 25 years. It has then been assumed that aircraft included within the Implementing Rule should have a useful working life of at least five years after the date for mandatory equipage and, therefore, should be no more than 20 years old in 2014. Thus aircraft manufactured in 1994 and earlier have been treated as being exempt on grounds of age.

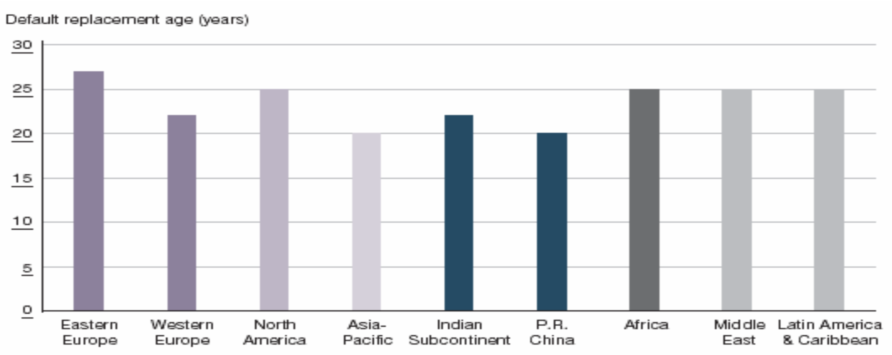


Figure 7 - Replacement age

4.1.2 Analysis of the data

The data was analysed in the manner described below. A fuller description of the analysis is presented in Annex C.

- Flights in the traffic sample carried out by aircraft whose registration markings were not recorded were dealt with by assuming that, if the same operator had at least one aircraft of a similar type, then the flights were carried out under repetitive flight plans by other, identified aircraft in the operator's fleet. However, if there were no similar aircraft in the same operator's fleet, then the flights were assumed to be carried out by a unique additional aircraft whose registration markings had been omitted from the flight plan.
- The aircraft were analysed in relation to the anticipated criteria of the Implementing Rule.
- A relationship between the age of an aircraft and the number of flights carried out per day was determined.
- The number of flights anticipated for future years was projected using the average annual growth rates for Europe estimated by the EUROCONTROL STATFOR service.
- The future fleet size required to carry out these flights was projected using the age/flights relationship.

On the basis of this information and the target equipage scenario, the retrofit and new fit aircraft numbers were determined.

4.1.3 The Current Fleet

Following the modifications to deal with flights by aircraft without registration markings noted above, the CRCO traffic sample contains records of 9,922 aircraft operating in the upper airspace of the data link area. These were sorted in line with the proposed terms of the Implementing Rule as indicated in Figure 8.

	Aircraft		Flights	
	Number	%	Number	%
State aircraft	635	6%	3,558	1%
FANS aircraft	1,526	15%	44,937	10%
Age exempt	3,065	31%	125,172	28%
Eligible	4,696	47%	279,701	62%
Total	9,922	100%	453,368	100%

Figure 8 - Analysis of fleet

Thus of the 9,922 aircraft in the sample:

- 635 were exempt due to being state or military aircraft.
- 1,526 were exempt due to being FANS 1A aircraft.
- 3,065 aircraft will be more than 20 years old by the time of the date of mandatory retrofit in 2014.
- The number of aircraft in the current fleet falling within the scope of the Rule was 4,696.

In addition to these 4,696 aircraft, the total number of aircraft eventually requiring to be retrofitted will also include new aircraft delivered without CPDLC after June 2006, as indicated in section 4.2.

4.1.4 Consequences of the exemptions

State/military aircraft account for only 1% of the flights and, therefore, their exemption makes little difference to the benefits which may be achieved. Some military transport aircraft may be equipped voluntarily, reducing further the impact of this exemption.

15% of the aircraft were judged to be FANS 1A aircraft. These tend to be the large intercontinental jets which spend only a proportion of their time in continental airspace and thus they only accounted for 10% of the flights.

Age exempt aircraft account for 31% of the aircraft. They are less heavily used than the newer aircraft, carrying out just 28% of the flights, but could make a significant contribution to benefits. Age exemption is considered in more detail in section 4.1.5 below.

The exemptions leave only 47% of the aircraft subject to the Rule. However, these aircraft carry out 62% of the flights. This proportion will grow, as older aircraft are replaced by new ones which are subject to the Rule.

4.1.5 Effect of varying the age exemption criterion

An analysis of the age profile of the aircraft in the traffic sample is presented in Figure 9. In addition to the cyclicality of aircraft purchases, one of the most notable aspects of the data is the age of the aircraft. There remain a significant number of aircraft above the average retirement age of 25, with some being up to 40 years old. [The relatively low number for 2006 is due to the sample being taken in June 2006, thus including only half a year’s new aircraft.]

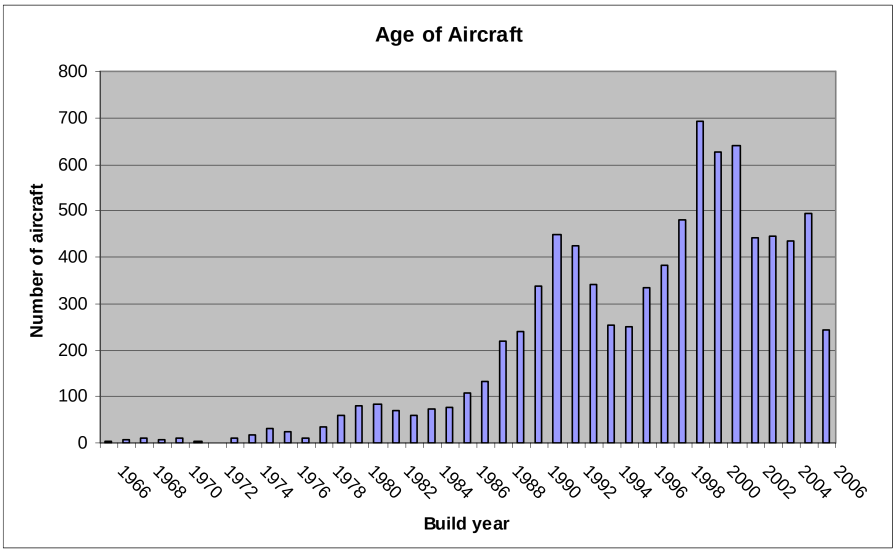


Figure 9 - Age of aircraft

It was assumed above that aircraft having reached the age of 20 years by 2014, ie built in 1994 or earlier, would be exempt from the Implementing Rule. However, an aircraft just meeting this exemption criterion would only be 13 years old in 2007. Thus, if it were retrofitted in 2007, it may be expected to have a working life of at least 12 years as a CPDLC equipped aircraft, and possibly longer if it were one of the longer serving aircraft. Therefore useful members of the CPDLC fleet may be lost through this exemption.

The effect of varying the age exemption criteria in the Rule has therefore been analysed. Figure 10 shows the effect of changing the initial assumed limit from an age of 20 years at the mandatory implementation date down to 15 years or up to 25 years. The increase to 25 years brings an extra 1,786 aircraft from the current fleet within the scope of the Implementing Rule and liable for retrofit. This represents an increase of 38%. However, the 20 year assumption has been retained in the following projections.

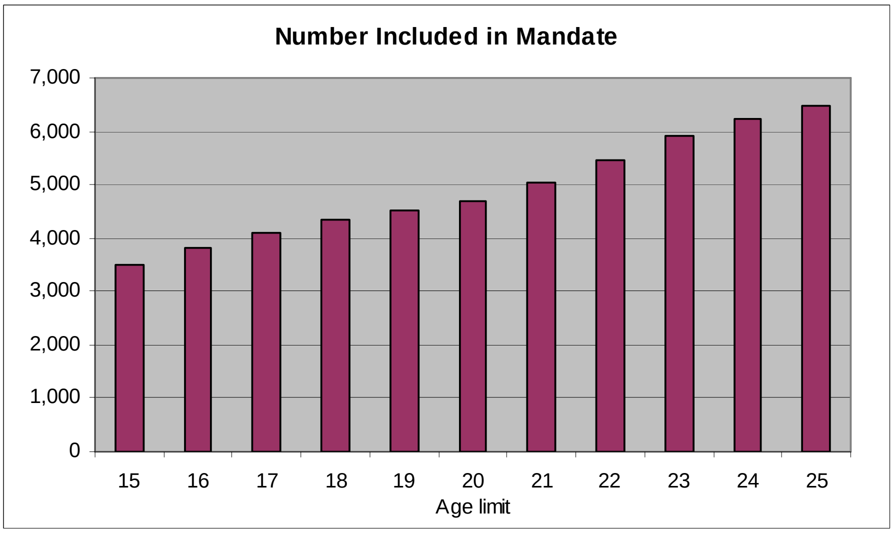


Figure 10 - Effect of varying the age limit

4.1.6 Projections of the future fleet size

A set of projections of aircraft numbers and flights has been created based upon the aircraft numbers and the June 2006 values for flights in the traffic sample. In addition the following assumptions have been made.

- Traffic is assumed to grow at 3.4% per year (the average growth in the number of flights in Europe over the period to 2013, in the baseline scenario of the STATFOR Medium Term Forecast).
- An aircraft retirement schedule has been developed by removing aircraft from the total when they reach an age of 25 years. This has the effect of reflecting the cyclical purchase pattern in the retirement and re-purchase schedule whilst maintaining the same number of old aircraft (ie those more than 25 years old) in the system.
- New aircraft are introduced to replace retired aircraft and to handle the growth in demand. All new aircraft included within the terms of the Implementing Rule are assumed to be equipped from 2009.

The resulting aircraft projections up to 2014 (the deadline for equipage) are summarised in Figure 11. The terminology used is as follows:

- *eligible aircraft* meet all the criteria of the Implementing Rule
- *age exempt aircraft* meet all the criteria of the Implementing Rule except for the age criterion
- *other exempt aircraft* are either FANS 1A aircraft or are state aircraft.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Fleet size development										
Fleet size at end year										
Eligible aircraft	4,696	4,989	5,283	5,783	6,100	6,481	6,868	7,369	7,894	
Age exempt aircraft	3,065	3,001	2,942	2,684	2,616	2,492	2,369	2,140	1,895	
Other exempt aircraft	2,161	2,225	2,291	2,358	2,427	2,498	2,572	2,648	2,726	
	9,922	10,215	10,516	10,825	11,143	11,471	11,809	12,157	12,515	
Retirements during year										
Eligible aircraft	-	-	-	-	-	-	-	-	-	-
Age exempt aircraft	-	64	59	258	68	124	123	229	245	1,170
Other exempt aircraft	-	7	1	124	7	12	9	5	9	174
	-	71	60	382	75	136	132	234	254	1,344
New aircraft during year										
Eligible aircraft	-	293	294	500	317	381	387	501	525	3,198
Age exempt aircraft	-	-	-	-	-	-	-	-	-	-
Other exempt aircraft	-	71	67	191	76	83	83	81	87	739
	-	364	361	691	393	464	470	582	612	3,937

Figure 11 - Aircraft projections

The fleet size is projected to grow from 9,922 in 2006 to 12,515 aircraft by 2014, with 1,344 of the current fleet retiring and 3,937 new aircraft being added to the fleet over the period. Airbus and Boeing in their market forecasts (Airbus Global Market Forecast 2004-2023 and Boeing Current Market Outlook 2006) have similar views on the growth in traffic but their assumptions differ as to how this translates into aircraft numbers. Airbus anticipate hub and spoke operations with more large aircraft and predict new world-wide aircraft sales averaging 866 per year over the next 20 years. Boeing expect more point to point operations with mid-sized aircraft and predict average sales of 1,360 per year over a similar period. Thus the figures predicted above infer that between 35% and 55% of new aircraft delivered will operate on a regular basis in the upper airspace of the states offering a data link service.

4.2 Aircraft equipage

4.2.1 Equipage scenarios

The Implementing Rule requires that all aircraft which are not exempted shall be equipped by the specified date. Although it is common for mandates to allow a notice period of around seven years, experience shows that most airborne equipage tends to take place near to the mandate deadline, thus delaying the generation of the benefits.

There is a natural incentive for airlines to save money by postponing the investment in CPDLC systems as late as possible before the Implementing Rule comes into force. However, if it were possible to remove this incentive to equip late and replace it with one to equip early, given the long lead in time of over seven years to the implementation deadline, significant benefits may be gained from earlier implementation. Accordingly, in addition to a *deadline* equipage scenario, two further implementation scenarios, *late* and *early*, have been used in the analysis to investigate this possibility.

The deadline equipage scenario assumes that all eligible aircraft are equipped by the Implementing Rule deadline in a progressive manner which takes account of the practical constraints of equipping a large number of aircraft. The late implementation rate is based on past experience and assumes a low initial rate of implementation, followed by a rapid increase just before the implementation deadline. The early implementation rate has been developed in line with the known CPDLC equipage plans of the ANSPs and is based on an objective in which 25% of all flights in the data link area would be made by CPDLC equipped aircraft by early 2009 (by which time 4 ACCs would be equipped) and 70% by the end of 2012 (17 ACCs equipped). Relative to the late equipage case, early equipage offers a gain of about 5 years during which the traffic may grow by around 20%.

4.2.2 Rates of equipage

In the deadline equipage scenario, combining the 4,696 eligible aircraft from the current fleet (as shown in Figure 11) with the projected new deliveries of 293 and 294 eligible but unequipped aircraft in 2007 and 2008 respectively gives an estimated number of aircraft liable for retrofit of 5,283. By the end of 2016, it is estimated that 3,978 new aircraft will be delivered equipped which, with the 5,283 retrofit aircraft, would bring the total of equipped aircraft to 9,261.

In the late equipage scenario, the numbers of aircraft retrofitted or delivered by 2016 is the same as in the deadline scenario but the build up to these levels is slower. However, in the early equipage scenario, earlier equipage of new aircraft allows the number of aircraft requiring retrofit to be reduced.

Details of the equipage projections, including numbers of flights by equipped aircraft, are given in Figure 25 and Figure 26 in Annex D.

4.2.3 Flights by equipped aircraft

If these equipage rates could be achieved, the proportion of aircraft equipped would follow the pattern illustrated in Figure 12 below. Due to the exemptions, the maximum long term level of equipage would only reach about 78% of aircraft. However, as deduced from the traffic sample, eligible aircraft tend to fly more frequently than non-eligible aircraft and, thus, a proportion of almost 90% of flights by equipped aircraft can be reached with this level of aircraft equipage.

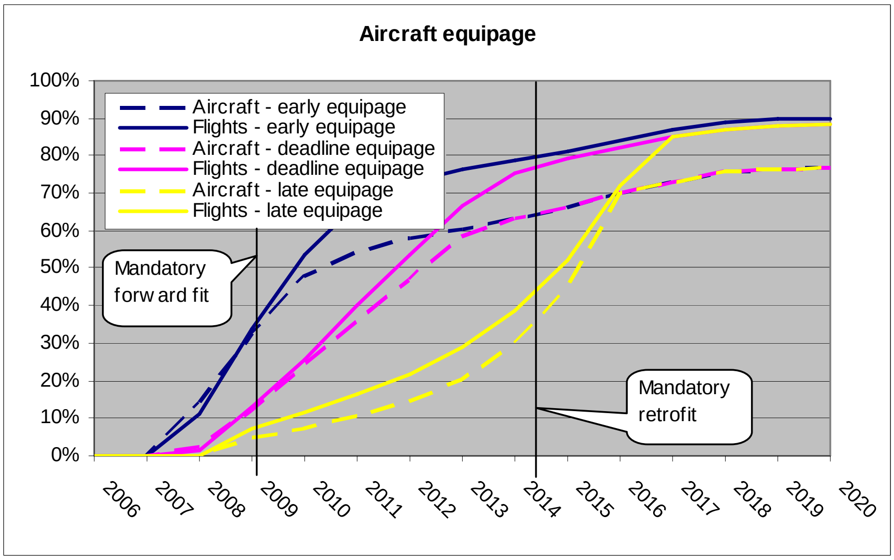


Figure 12 - Equipage levels

4.3 Implementation costs

Investment costs include the purchase price of equipment, on board implementation costs and certification costs. These costs may vary considerably from one aircraft type to another and from one airline to another depending, in particular, on the number of aircraft of the same type to be equipped.

The current aircraft fleet may be considered in four categories:

- new aircraft – recently delivered aircraft which may be equipped easily
- provisioned aircraft – aircraft with appropriate wiring but not equipped for CPDLC
- ACARS aircraft – these aircraft have some of the wiring and antennae required
- aircraft with no relevant facilities

Under the Pioneer scheme of the EUROCONTROL LINK 2000+ Programme, 140 aircraft have already been equipped and there are current plans to equip a further 160. Experience gained from this scheme suggests that the cost of installing CPDLC systems in a relatively new aircraft may be as little as €5,000 but that the cost of installation in an old aircraft with no usable facilities may be as high as €100,000. Given the predominance of the B738 and the A320/A319 in the European fleet (see Figure 24 in Annex C), the average cost will be towards the lower end of the scale and may be of the order of about €40,000.

The costs may also vary over time. Hardware costs represent a part of the total cost and may decrease between the present time and the Implementing Rule deadline as the manufacturers recover their development costs and the size of the market grows. However, the remaining costs are mainly staff costs that could remain fairly stable due to the productivity gains expected as implementation of CPDLC proceeds.

Given the experience of the Pioneer scheme and the possible price variations noted above, the cost of installation used in the analysis has been assumed to remain at an average of €40,000 throughout the period considered.

Based on the above assumptions, the total cost of retrofit to the airline industry will be about €211m in the deadline and late equipage cases or €203m with early equipage since, in this case, fewer new aircraft would be delivered unequipped. The total cost of new fit would be of the order of €20m per year.

4.4 Operating costs

Aircraft operating CPDLC are likely to utilise VDL2 communications for their operational communications. Thus, taking into account the effect on operational communications, the net effect of CPDLC on operating costs is likely to be negligible. Therefore no incremental operating costs have been assumed.

5 RESULTS OF THE APPRAISAL

5.1 Costs

Figure 13 below shows the ground and airborne investment costs for the periods to 2020 and to 2025 with the deadline equipage case. Up to 2020, ground costs are of the order of €365m, with aircraft retrofit costs at €211m and aircraft new fit costs at €255m, giving a total of €831m. By 2025 there are no further ground and retrofit costs but new fit costs rise to €403m as more new aircraft come into service.

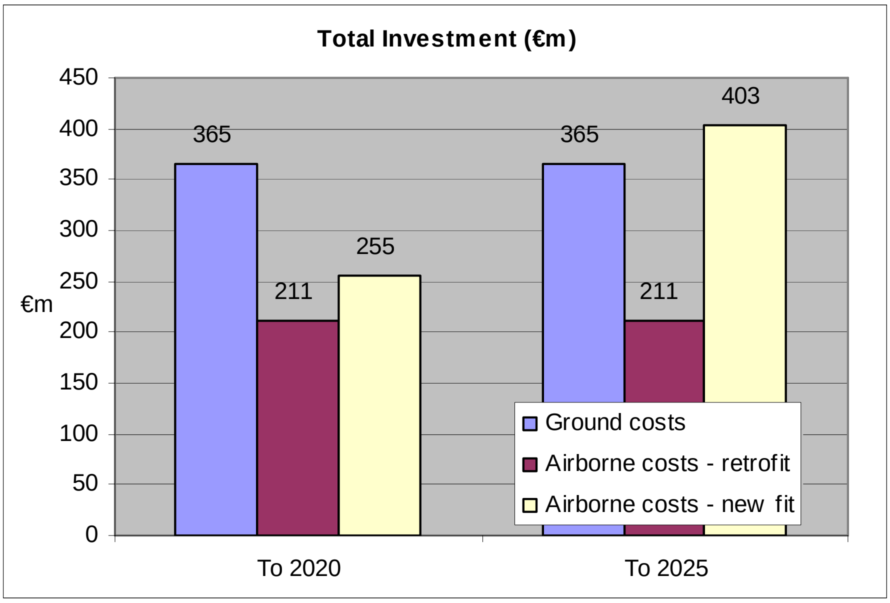


Figure 13 - Investment costs

This assumes that the cost of implementation in new aircraft continues at the average level of €40,000 per aircraft. However, it is unlikely that the cost would remain at this level, which is an average for retrofit and new fit at the initial stages of implementation. After 2020, it is likely that CPDLC equipment will have become standard fit and that manufacturers will have recovered much of their development costs. Therefore it is likely that prices will come down substantially, meaning that the €403m cost estimate is likely to be a significant over-estimate.

Further details of the costs are shown in present value terms in Figure 15.

5.2 Benefits

Studies and simulations have shown that, with the implementation of data link services, sector capacity (maximum number of aircraft handled in a given sector within one hour) may increase by up to 14% with 100% equipage and by proportionate amounts at lower levels of equipage. Thus significant productivity benefits may be obtained. The achievement of productivity gains enables the opening of new sectors to be deferred and, thus, the costs of operating them over the period of deferment to be avoided.

The analysis indicates that the benefits of data link services are substantial. Considering the period to 2025, which allows for an operating period of just over 10 years after the Rule comes into force, the benefits are likely to have a value of about €1,124m. Over 80% of the benefits are generated in the states specified for early implementation in Annex V of the Implementing Rule. These are the states taking part in the EUROCONTROL LINK 2000+ Programme where the benefits were expected to be the greatest.

5.3 Cash flow

Figure 14 shows the cash flows associated with the data link service. The twin peaks in the investment curve correspond to the ground investment in the Annex V states, which coincides with the aircraft retrofit stage, and the later ground equipage in the other states. Subsequent investment represents the cost of new fit in aircraft and follows the aircraft purchase cycle. Cost avoidance depends on the difference in sector numbers with and without data link and so is an irregular step function.

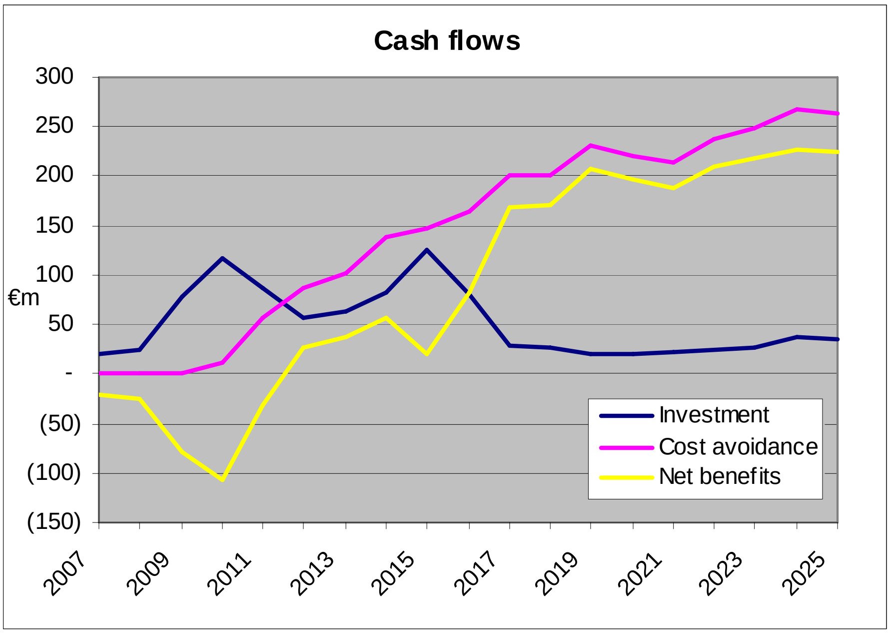


Figure 14 - Cash flow

5.4 Appraisal of the principal case

The principal case assumes that:

- traffic growth is in line with the STATFOR baseline traffic growth estimates,
- all ANSPs and aircraft operators meet the deadlines in the Implementing Rule, and
- the averages of ground and aircraft installation costs are close to the values assumed.

On this basis, the following results are achieved:

- net present value of project - €527m
- return on investment - 23%
- payback by early 2018

A summary of the present value of the costs and benefits is presented in Figure 15, which also indicates the values associated with Annex V states. The present values are discounted to 2007 using a discount rate of 8% and are expressed in millions of euro.

	Annex V	Other	Total
Aircraft investment	339	-	339
ANSP investment	137	108	246
	477	108	585
Operating costs	7	5	12
Cost avoidance	930	194	1,124
NPV	447	81	527

Figure 15 – Present value of costs and benefits

All but 108 of the 9,922 aircraft which appeared in the traffic sample for the whole area, also appeared in the airspace of the Annex V states. Therefore, all of the aircraft equipage costs have been associated with these states, since they are the first to implement data link services. Substantial benefits, sufficient to justify their ground costs and the total airborne investment, are generated in these states. The extension of the data link service to all EU states produces a small, but significant surplus, largely due to the fact that no additional aircraft need to be equipped.

The rate of return is high and commensurate with that required of a high risk commercial investment (see section 5.7). However, this requires confidence that the assumptions used in the analysis will remain valid for a period of nearly 20 years.

Payback of the investment can be achieved by early 2018, just two years after the extension of data link services to all EU member states. This is a discounted payback period using a discount rate of 8%, ie it represents the time required to recover the investment and an 8% return on the investment.

5.5 The effect of varying assumptions

The major uncertainties related to the introduction of data link are considered to be:

- the cost of ground equipage
- the cost of aircraft equipage
- the timing of ground installation
- the rate of aircraft equipage
- the rate of traffic growth

These factors are introduced into the sensitivity analysis presented below. The variations in the cost of ground equipage are based on the range of estimates for those centres whose preparation is the most advanced. The upper and lower estimates of the cost of aircraft equipage represent variations in the average cost for all aircraft, not the upper and lower values for individual aircraft. The effect of a one year delay in implementation at all ACCs has been considered and, for symmetry though less likely, the effect of a one year advance. The rates of aircraft equipage are the early, deadline and late rates considered earlier and the rates of traffic growth are the STATFOR high, base and low estimates.

The results of the analysis are presented in tabular form in Figure 16 below. This shows the overall net present value produced to 2025 when each of the five variables is given a lower, base or upper value, whilst the other variables are maintained at the base value.

	Assumption			Net present value to 2025		
	Lower	Base	Upper	Lower	Base	Upper
Traffic growth rate	Low	Baseline	High	425	527	615
Equipage scenario	Late	Deadline	Early	345	527	556
Ground installation delay (yrs)	1	0	-1	456	527	584
Aircraft investment (€)	30,000	40,000	50,000	570	527	420
ACC investment (€m)	8.0	10.0	15.0	612	527	442

Figure 16 - Sensitivity analysis

The results are also shown in graphical form in Figure 17. This shows deviations from the base net present value (NPV) of €527m produced by the upper and lower assumptions for each of the variables. This indicates that the most serious risk is that the rate of aircraft equipage will fall behind schedule. With late equipage, which is the typical outcome of previous EUROCONTROL mandates, the NPV could fall to €345m, reducing the return on investment to 18%. This is the reason why EUROCONTROL has proposed the introduction of a financial incentive scheme to encourage aircraft operators to equip early. The lack of symmetry in this variable is due to the later equipage by the non-Annex V states. Earlier equipage by aircraft operators would have to be accompanied by earlier equipage by ANSPs for this option to yield more substantial benefits.

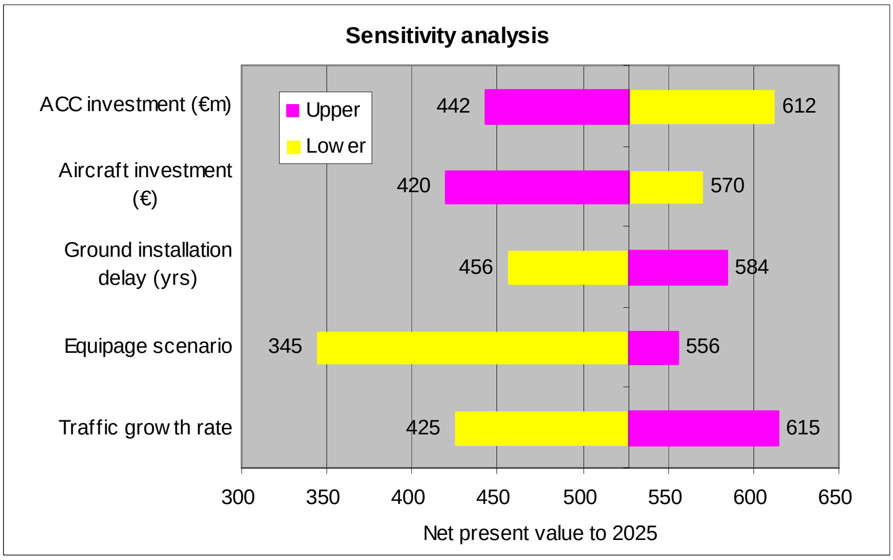


Figure 17 - Variation in results

Late implementation by ANSPs also represents a significant problem. A delay of one year would reduce the value of data link services by about €70m in present value terms, reducing the return on investment to 21%. A two year delay would roughly double the loss and experience in the past has shown that such delays also act as a disincentive to the aircraft operators to meet their implementation deadlines.

As indicated earlier, the estimate of the cost of aircraft equipage is more likely to be an over rather than an under estimate and so the risk of cost escalation on aircraft equipage is considered to be relatively low. In the case of ground installation, since the costs are known for one centre and reliable estimates exist for three more, it is considered that there is a reasonable probability that the average for all centres will be close to the assumed value, particularly when the experience of the first installations can be of benefit in subsequent installations.

As might be expected, the savings are greater with the higher estimates of future traffic. In recent years (with the exception of 2001) STATFOR projections have, if anything, tended to under-estimate traffic levels. Thus recent experience would suggest that the STATFOR baseline growth estimate provides the better guide to the future than the low growth estimate and that one can be reasonably confident that the baseline traffic growth benefits may be achieved.

Thus, in conclusion, delays in implementation, both by the ANSPs and the aircraft operators are likely to present the greatest risks to the successful application of data link services.

5.6 The return to each of the parties

The rates of return quoted above are the rates of return for the aviation community as a whole but the question is often asked, what is the return to each of the parties involved? The simple answer to that question is that the CRCO charging system is specifically designed to ensure that the effect of investment is, as far as possible, cost neutral to the ANSPs and that the aircraft operators receive all of the benefit. Thus the return to the ANSPs is 0% and the return to the aircraft operators is the full value quoted above.

The ANSPs and the aircraft operators may each incur investments and changes to operating costs as a result of implementing data link. The charging system permits the ANSP to pass on all changes in operating costs to the aircraft operators in the year in which they are incurred. The system also allows the ANSP to recover the full cost of capital investments over the life of the equipment through a depreciation related element in the charges. However, this would leave the ANSP bearing the cost of funding the investment between the initial expenditure and the time at which the costs are eventually recovered in the charges. In order to compensate the ANSP for this, there is a cost of capital element in charges which passes the burden of funding to the aircraft operator. Thus the financial effect on the airline operators is equivalent to a situation in which they raise the funds to pay for the capital investments of the ANSPs and bear the interest costs of the notional borrowing required.

There is some scope allowed to the ANSP in setting the cost of capital element in charges but the charge is generally equivalent to the actual interest cost of funding the investment or the notional cost if it were fully funded by debt.

There are, of course, differences between the ANSPs in their corporate structure and means of financing. Many are now corporatised entities, mostly state owned but, in the case of NATS in the UK and potentially with the DFS in Germany, with a substantial private sector shareholding. Some, such as the DSNA in France remain a government department. The corporate entities frequently do fully fund their investments with debt, whereas the government departments are funded by the state budget. However, regardless of the corporate structure, the CRCO charging system ensures that the nature of the charge is the same.

Ultimately, on routes where there is a significant level of competition between the airlines, the value of the benefits of data link will flow through to the passengers.

5.7 Comparable rates of return

The rate of return expected from the investment in data link should be judged in the light of returns expected from other investments, given the relative level of risk involved. To do this it is necessary to consider the structure of a return on investment or interest rate. This may be considered as comprising three elements:

- a no risk return on money – historically this has been of the order of 2% to 2.5%
- compensation for the erosion of investment due to inflation. European Central Bank statistics indicate that euro inflation is currently running at an annual rate of about 2.0%
- a premium for risk.

Very low risk investments such as government bonds are currently yielding an average of just under 4% in France and Germany and a little over 4% in the UK. The largest venture capital investor in Europe (3i plc) is currently targeting a rate of return of 25% on high risk new business investments. Thus financial markets are currently considering a range of investments varying from 4% for low risk to 25% for high risk investments.

In the case of data link, the major risk to be considered is the risk that it will not deliver the benefits forecasted by means of the simulations. This risk must be judged in the light of the reliability of simulations carried out for previous projects and the experience to date with the limited operation of data link at Maastricht. Experience at Maastricht is encouraging in the sense that, once they become used to it, controllers and pilots are enthusiastic users of data link, but the number of aircraft equipped for data link is currently too small to judge the effect on capacity.

Nevertheless, the 23% rate of return estimated for data link in the principal case is of a similar order to that required for a high risk investment, as long as delays in implementation can be avoided.

5.8 Paving the way for future concepts

Over the next decade, a range of measures will have to be introduced to cope with the anticipated growth in traffic. Initially, these will consist of modifications to route structures and the arrangement and number of sectors. However, these measures will produce diminishing returns and there is a limit to their effectiveness. The costs of not meeting the demand, in terms of delay and foregone revenue for the airlines may be high, particularly if the current traffic estimates are exceeded. Thus it is recognised that new technologies will have to be introduced into the ATC process to meet the growing demand. CPDLC is one of the first such new technologies which can make a direct impact on ATC capacity.

From 2015 more advanced control concepts will begin to be introduced. The experience gained by controllers in working with CPDLC will be a necessary condition for the introduction of these concepts and will accelerate the transition towards new technologies which may otherwise be more uncertain.

Thus, in addition to the direct benefits of CPDLC estimated above, there are further benefits which cannot at present be quantified but which are likely to be significant in the development of future concepts and technologies.

ANNEX A GEOGRAPHICAL SCOPE

The geographical scope and dates for the implementation of data link service provision are presented below.

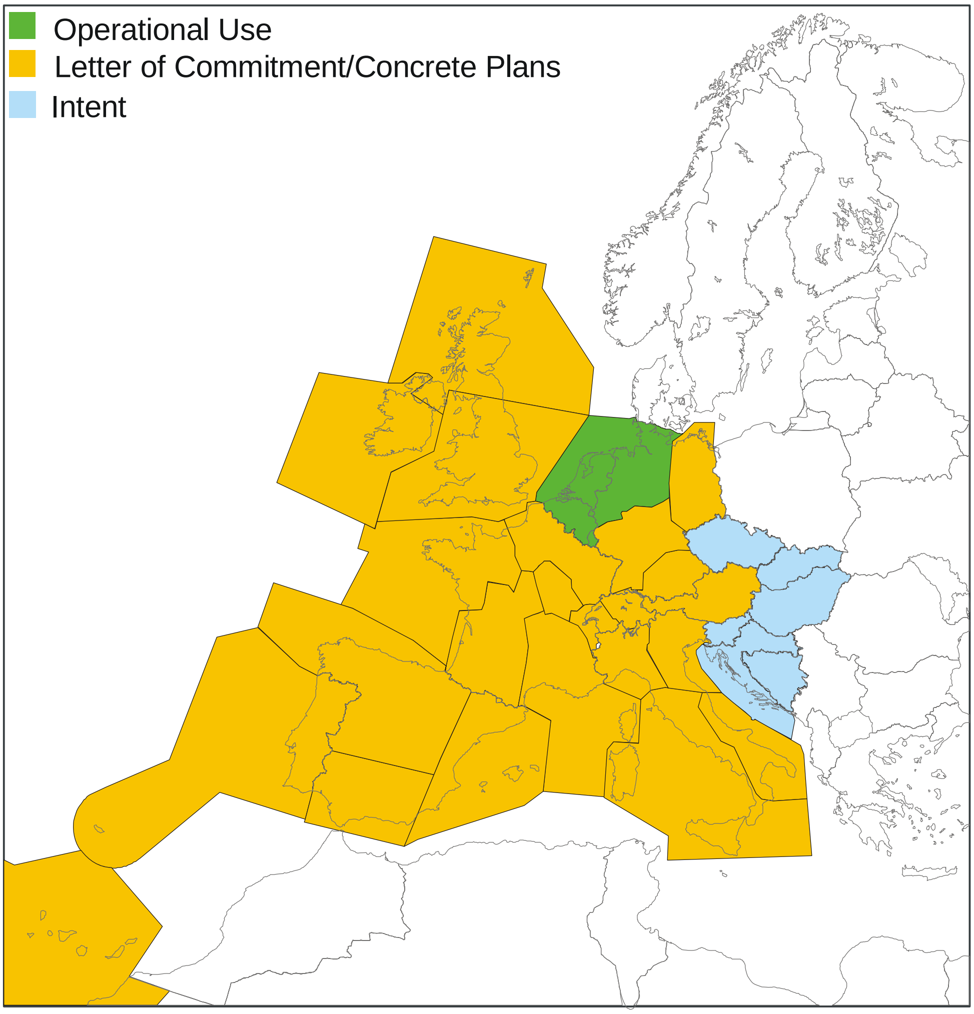


Figure 18 - Geographical scope

The area shown in green is that covered by the Maastricht UAC, from where data link services are currently provided over the upper airspace of Belgium, the Netherlands and parts of western Germany.

The area shown in yellow covers states having firm implementation plans or who have made definite commitments to implement data link services. These are France, Germany, Ireland, Italy, Portugal, Spain, Switzerland and the UK. However, due to the revision of the original plan to build the CEATS UAC in Vienna, there are, at present, no definite plans for implementation in Austria.

The states shown in blue (Bosnia & Herzegovina, Croatia, Czech Republic, Hungary, Slovak Republic and Slovenia) were to have been covered from the CEATS UAC but now have no immediate plans for implementation. However, the Czech Republic, Hungary, the Slovak Republic and Slovenia, as EU members, will be required by the Implementing Rule to implement data link services from 2016.

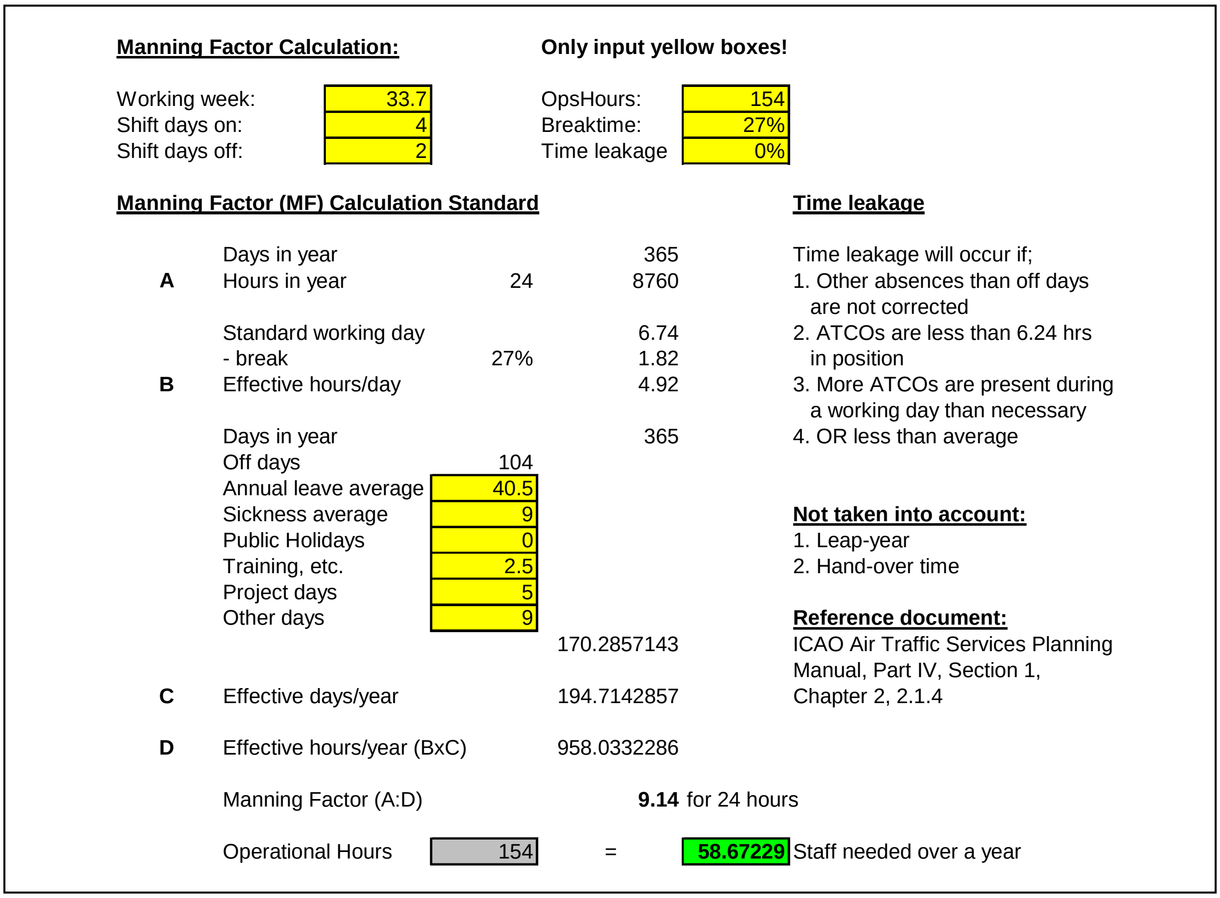
The full list of ACCs required to provide data link services, together with their assumed implemention date is shown below.

Country	ANSP	ACC	Planned startup date
4 States	MUAC	MUAC	2004
Austria	AustroControl	Wien	2016
Bulgaria	ATSA Bulgaria	Sofia	2016
Cyprus	DCAC Cyprus	Nicosia	2016
Czech Republic	ANS CR	Prague	2016
Denmark	NAVIAIR	Copenhagen	2016
Estonia	EANS	Tallinn	2016
Finland	Finland CAA	Rovaniemi	2016
Finland	Finland CAA	Tampere	2016
France	DSNA	Bordeaux	2011
France	DSNA	Brest	2011
France	DSNA	Marseille	2011
France	DSNA	Paris	2011
France	DSNA	Reims	2011
Germany	DFS	Karlsruhe	2009
Greece	HCAA	Athens	2016
Greece	HCAA	Makedonia	2016
Hungary	HungaroControl	Budapest	2016
Ireland	IAA	Shannon	2011
Italy	ENAV	Roma	2008
Latvia	LGS	Riga	2016
Lithuania	Oro Navigacija	Vilnius	2016
Malta	MATS	Malta	2016
Poland	PATA	Warsaw	2016
Portugal	NAV Portugal	Lisboa	2010
Romania	ROMATSA	Bucharest	2016
Slovak Republic	LPS	Bratislava	2016
Slovenia	Slovenia CAA	Ljubliana	2016
Spain	Aena	Barcelona	2011
Spain	Aena	Canarias	2011
Spain	Aena	Madrid	2011
Spain	Aena	Seville	2011
Sweden	LFV	Malmo	2016
Sweden	LFV	Stockholm	2016
Switzerland	Skyguide	Swiss	2008
United Kingdom	NATS	London	2011
United Kingdom	NATS	Scottish	2011

ANNEX B THE BENEFITS OF DATA LINK

ATCO requirement calculation

An example of the ATCO requirement calculation is shown in Figure 19 below. In the calculation, a standard manning factor of 9.14 is derived from assumptions regarding the standard working day, holidays, sickness and 'off the job' activities. In the particular example shown, a control position is required to be open for 154 hours per week, leading to the requirement to employ 59 controllers.



Manning Factor Calculation:

Only input yellow boxes!

Working week:	33.7	OpsHours:	154
Shift days on:	4	Breaktime:	27%
Shift days off:	2	Time leakage	0%

Manning Factor (MF) Calculation Standard

	Days in year		365
A	Hours in year	24	8760
	Standard working day		6.74
	- break	27%	1.82
B	Effective hours/day		4.92
	Days in year		365
	Off days	104	
	Annual leave average	40.5	
	Sickness average	9	
	Public Holidays	0	
	Training, etc.	2.5	
	Project days	5	
	Other days	9	
			170.2857143
C	Effective days/year		194.7142857
D	Effective hours/year (BxC)		958.0332286
	Manning Factor (A:D)		**9.14** for 24 hours
	Operational Hours	154	= 58.67229 Staff needed over a year

Time leakage

Time leakage will occur if;
1. Other absences than off days are not corrected
2. ATCOs are less than 6.24 hrs in position
3. More ATCOs are present during a working day than necessary
4. OR less than average

Not taken into account:
1. Leap-year
2. Hand-over time

Reference document:
ICAO Air Traffic Services Planning Manual, Part IV, Section 1, Chapter 2, 2.1.4

Figure 19 - ATCO requirement calculation

Estimates of sector numbers

Figure 20 presents an illustration of the method used to estimate the future sector requirements using, as an example, the Maastricht UAC. A similar exercise was carried out for each ACC considered in the study. The method takes the following approach.

Input data

- cost of an ATCO
- number of controllers required for whole year operations
- support cost ratio
- traffic growth rates
- indication of ground infrastructure readiness.

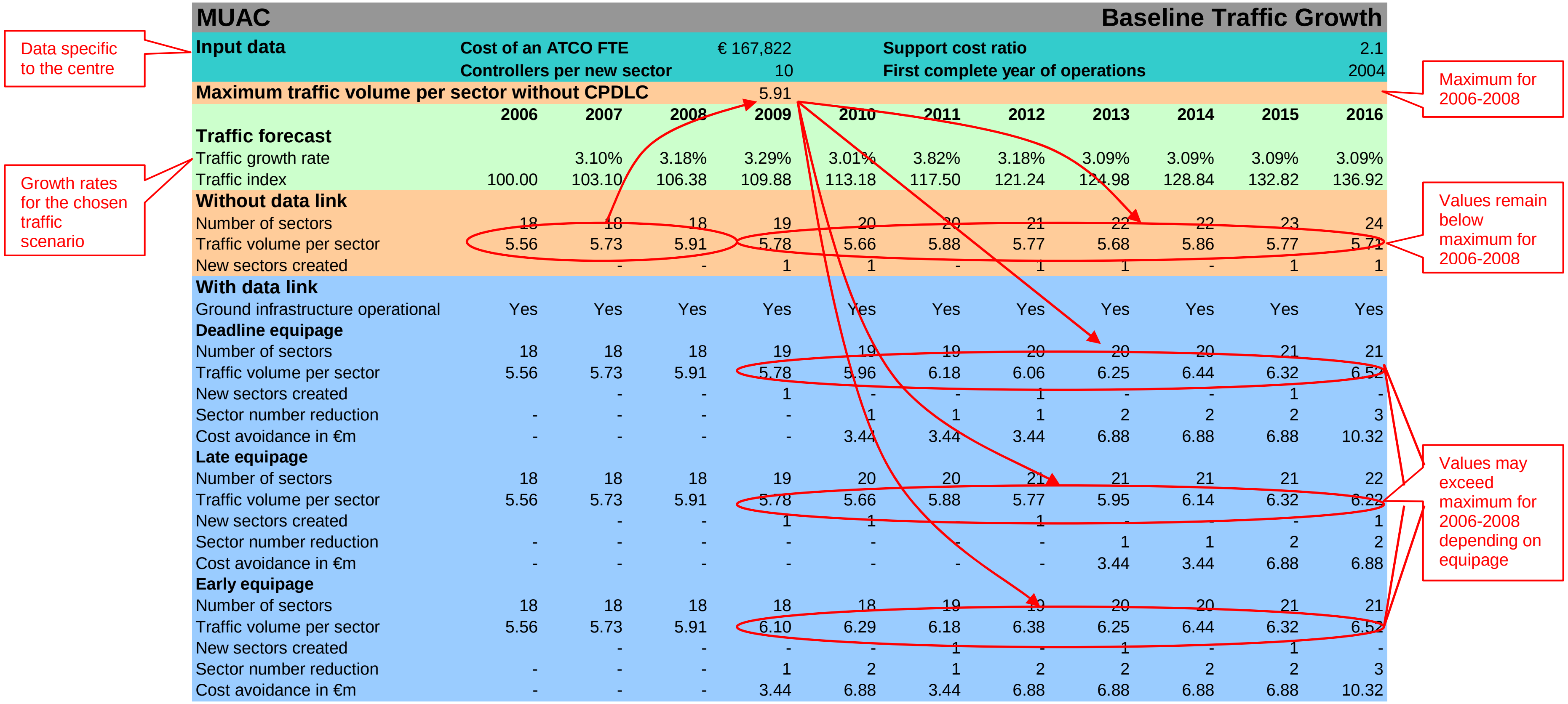
Calculation steps

- Generate a traffic index starting from a base of 100 in 2006 and growing with the rate of traffic growth.
- Calculate the traffic per sector for the period 2006 to 2008. This is expressed as the traffic index divided by the number of sectors.
- Determine the maximum traffic per sector value over the period 2006 to 2008.
- Determine the number of sectors required from 2009 onwards without data link, ensuring that the traffic per sector does not exceed the maximum for 2006-2008.
- Determine the number of sectors required from 2009 onwards for each of the data link equipage scenarios. The traffic per sector may exceed the maximum for 2006-2008 by an amount dependent upon the equipage level.
- Determine the reduced number of additional sectors required in data link case relative to the situation without data link.
- Determine the costs avoided by this reduced requirement. For each year, this is the product of the sector number reduction, the ground infrastructure factor, the cost of an ATCO, the manning level per sector, the annual manning factor and the support cost ratio.

Output data

- sector number projections
- sector operating costs avoided.

Figure 21 presents a summary of the total number of sectors and the sector years saved for each of the traffic growth scenarios and each equipage scenario.



MUAC											**Baseline Traffic Growth**
Input data	**Cost of an ATCO FTE**		€ 167,822		**Support cost ratio**						2.1
	Controllers per new sector		10		**First complete year of operations**						2004
Maximum traffic volume per sector without CPDLC			5.91								
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Traffic forecast											
Traffic growth rate		3.10%	3.18%	3.29%	3.01%	3.82%	3.18%	3.09%	3.09%	3.09%	3.09%
Traffic index	100.00	103.10	106.38	109.88	113.18	117.50	121.24	124.98	128.84	132.82	136.92
Without data link											
Number of sectors	18	18	18	19	20	20	21	22	22	23	24
Traffic volume per sector	5.56	5.73	5.91	5.78	5.66	5.88	5.77	5.68	5.86	5.77	5.71
New sectors created		-	-	1	1	-	1	1	-	1	1
With data link											
Ground infrastructure operational	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Deadline equipage											
Number of sectors	18	18	18	19	19	19	20	20	20	21	21
Traffic volume per sector	5.56	5.73	5.91	5.78	5.96	6.18	6.06	6.25	6.44	6.32	6.52
New sectors created		-	-	1	-	-	1	-	-	1	-
Sector number reduction	-	-	-	-	1	1	1	2	2	2	3
Cost avoidance in €m	-	-	-	-	3.44	3.44	3.44	6.88	6.88	6.88	10.32
Late equipage											
Number of sectors	18	18	18	19	20	20	21	21	21	21	22
Traffic volume per sector	5.56	5.73	5.91	5.78	5.66	5.88	5.77	5.95	6.14	6.32	6.22
New sectors created		-	-	1	1	-	1	-	-	-	1
Sector number reduction	-	-	-	-	-	-	-	1	1	2	2
Cost avoidance in €m	-	-	-	-	-	-	-	3.44	3.44	6.88	6.88
Early equipage											
Number of sectors	18	18	18	18	18	19	19	20	20	21	21
Traffic volume per sector	5.56	5.73	5.91	6.10	6.29	6.18	6.38	6.25	6.44	6.32	6.52
New sectors created		-	-	-	-	1	-	1	-	1	-
Sector number reduction	-	-	-	1	2	1	2	2	2	2	3
Cost avoidance in €m	-	-	-	3.44	6.88	3.44	6.88	6.88	6.88	6.88	10.32

Data specific to the centre

Growth rates for the chosen traffic scenario

Maximum for 2006-2008

Values remain below maximum for 2006-2008

Values may exceed maximum for 2006-2008 depending on equipage

Figure 20 - Example of sector projections

Total number of sectors	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Low traffic growth																				
Without data link	404	409	414	448	455	467	480	490	505	520	534	546	564	580	595	614	630	651	665	692
Data link - deadline equipage	404	409	414	448	453	460	462	466	478	486	492	504	512	523	538	553	570	587	605	620
Data link - late equipage	404	409	414	448	455	467	480	484	493	500	502	504	512	523	538	553	570	587	605	620
Data link - early equipage	404	409	414	444	449	456	461	466	478	486	492	504	512	523	538	553	570	587	605	620
Baseline traffic growth																				
Without data link	404	409	414	450	460	478	490	508	525	543	561	579	596	618	640	657	682	705	729	756
Data link - deadline equipage	404	409	414	450	457	464	470	484	492	508	519	528	543	554	580	599	618	637	658	683
Data link - late equipage	404	409	414	450	460	478	490	500	508	520	521	528	543	554	580	599	618	637	658	683
Data link - early equipage	404	409	414	446	453	462	467	480	492	508	519	528	543	554	580	599	618	637	658	683
High traffic growth																				
Without data link	404	409	414	452	468	484	505	522	545	565	586	610	635	659	682	715	742	770	797	833
Data link - deadline equipage	404	409	414	452	465	472	484	494	512	530	540	552	573	594	619	641	669	697	722	749
Data link - late equipage	404	409	414	452	468	484	505	512	528	540	543	552	573	594	619	641	669	697	722	749
Data link - early equipage	404	409	414	447	461	469	482	491	511	530	540	552	573	594	619	641	669	697	722	749

Sector years avoided	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Low traffic growth																				
Deadline equipage	-	-	-	-	2	9	27	51	78	112	154	196	248	305	362	423	483	547	607	679
Late equipage	-	-	-	-	-	-	-	6	18	38	70	112	164	221	278	339	399	463	523	595
Early equipage	-	-	-	4	10	21	40	64	91	125	167	209	261	318	375	436	496	560	620	692
Baseline traffic growth																				
Deadline equipage	-	-	-	-	3	17	37	61	94	129	171	222	275	339	399	457	521	589	660	733
Late equipage	-	-	-	-	-	-	-	8	25	48	88	139	192	256	316	374	438	506	577	650
Early equipage	-	-	-	4	11	27	50	78	111	146	188	239	292	356	416	474	538	606	677	750
High traffic growth																				
Deadline equipage	-	-	-	-	3	15	36	64	97	132	178	236	298	363	426	500	573	646	721	805
Late equipage	-	-	-	-	-	-	-	10	27	52	95	153	215	280	343	417	490	563	638	722
Early equipage	-	-	-	5	12	27	50	81	115	150	196	254	316	381	444	518	591	664	739	823

Figure 21 - Sector and sector year projections

ANNEX C THE TRAFFIC SAMPLE

Structure of the data

The traffic sample originally contained 13,325 records, each one describing a particular aircraft and giving:

- the operator user name and country
- the registration markings
- the aircraft type
- the maximum take off weight
- a civil or military designation
- the age of the aircraft
- the number of flights carried out in the upper airspace of the data link states (>FL285) during the month of June 2006.

Cleaning the database

There were 568 records without registration markings. This was largely due to either repetitive flight plans or the registration markings being omitted from the flight plan. It was dealt with by assuming that, for flights carried out by an unidentified aircraft:

- if the same operator had at least one aircraft of a similar type, then the flights were carried out under repetitive flight plans by other, identified aircraft in the operator's fleet. The flights were therefore associated with these other aircraft and no additional aircraft were included in the total (508 records).
- if there were no similar aircraft in the same operator's fleet, then the flights were carried out by a unique additional aircraft whose registration markings had been omitted from the flight plan (66 records).

With the addition of the 508 records noted above, the database contained a total of 2,895 duplicated aircraft records. These were consolidated so that there was only one record per aircraft, with all the flights carried out by this aircraft included on the one record.

Following the cleaning process, the database contained 9,922 records, each of which was assumed to represent a unique aircraft.

The age/flights relationship

In the case of the aircraft without registration markings and for aircraft which could not be identified in the PRISME database, the age of the aircraft was not available. This was dealt with by determining an assumed age from the rate of flying, as described below.

Figure 22 shows a graph of the average numbers of flights per day against the age of the aircraft. Despite the scatter, a clear trend of declining numbers of flights with age can be seen. Using regression techniques, a second degree polynomial curve has been fitted to the data, with a confidence level of 89%.

This relationship was initially used to derive an assumed age for the unidentified aircraft, this being determined from the number of flights per day they carried out. The second use of this relationship was in projecting future numbers of flights. It was assumed that the relationship would remain valid for the future so that, each year, the number of flights carried out by an aircraft could be estimated from its age.

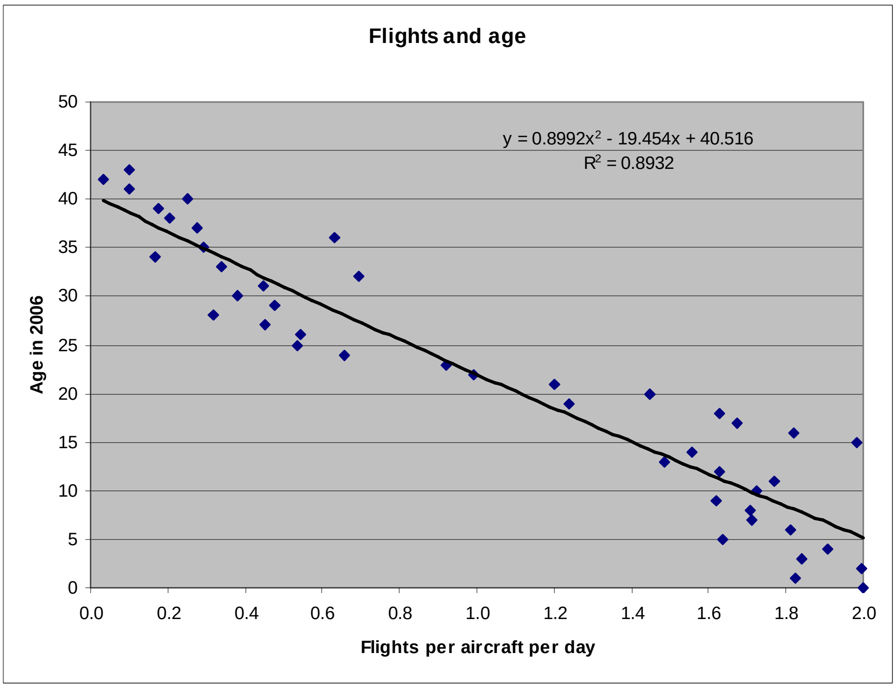


Figure 22 - The age/flights relationship

Analysis by Implementing Rule criteria

For each aircraft, it was now possible to determine the type, usage and age so that it was possible to determine the size of the aircraft fleet to which the Implementing Rule and its exemptions would apply. Figure 23 summarises the results. The aircraft which met all the requirements of the Rule, including the assumed age criteria, were by some margin the 'hardest working' aircraft. They formed only 47% of the total fleet but carried out 62% of the flights.

	Aircraft		Flights	
	Number	%	Number	%
State aircraft	635	6%	3,558	1%
FANS aircraft	1,526	15%	44,937	10%
Age exempt	3,065	31%	125,172	28%
Eligible	4,696	47%	279,701	62%
Total	9,922	100%	453,368	100%

Figure 23 - Aircraft and flights in the data link airspace

The data was further analysed by type of aircraft. Figure 24 indicates that 80% of all flights are carried out by only 19 aircraft types. The concentration was, in fact, greater than this suggests since the Airbus 320 family and the Boeing 737 series accounted for 8 of the 19 types.

Aircraft type	Flights	%	Cum %
A320	62,138	13.7%	14%
B738	51,378	11.3%	25%
A319	38,170	8.4%	33%
B733	23,919	5.3%	39%
A321	21,360	4.7%	43%
B752	17,880	3.9%	47%
B737	15,298	3.4%	51%
CRJ2	14,833	3.3%	54%
B735	14,670	3.2%	57%
B734	14,105	3.1%	60%
MD82	13,673	3.0%	63%
B763	12,641	2.8%	66%
B744	12,412	2.7%	69%
E145	11,498	2.5%	71%
B772	9,437	2.1%	74%
F100	9,359	2.1%	76%
A332	7,260	1.6%	77%
A343	6,181	1.4%	79%
MD87	4,242	0.9%	80%

Figure 24 - Aircraft types

ANNEX D AIRCRAFT AND TRAFFIC PROJECTIONS

Projection of flight numbers

The number of flights anticipated in the upper airspace of the data link states each year was projected assuming a growth rate of 3.4% per year. This rate was derived from the STATFOR Medium Term Forecast (February 2007) and is the average growth in flights projected for Europe for the period to 2013. This rate of growth was assumed to continue after 2013.

Projection of the future fleet size

An aircraft retirement schedule was developed by removing aircraft from the total when they reach an age of 25 years. This has the effect of reflecting the cyclical purchase pattern in the retirement and re-purchase schedule whilst maintaining the same number of old aircraft (ie those more than 25 years old) in the system.

The future fleet size required to carry out the projected number of flights was projected using the age/flights relationship. Thus for any particular year, the number of flights capable of being carried out could be calculated from the age of the fleet. An iterative method was used to introduce sufficient new aircraft to replace retired aircraft and to handle the growth in demand. The growth in traffic and the introduction of new aircraft to handle this will mean a reduction in the average age of the fleet. Applying the age/flights relationship to this younger fleet means that, on average, the fleet will carry out more flights and will thus need to grow at a lower rate than the growth in flights and thus there is an implied productivity increase. It was found that a growth rate of 2.9% in the fleet was enough to cope with the 3.4% growth in traffic.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Low traffic growth																					
Late equipage																					
Number of retrofit aircraft	-	-	-	-	-	-	106	264	792	1,321	2,800	-	-	-	-	-	-	-	-	-	5,283
Number of new fit aircraft	-	-	-	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,078
Retrofit costs (€m)	-	-	-	-	-	-	4.2	10.6	31.7	52.8	112.0	-	-	-	-	-	-	-	-	-	211.3
New fit costs (€m)	-	-	-	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	403.1
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	0%	5%	7%	10%	14%	20%	30%	44%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	0%	7%	12%	16%	22%	29%	39%	52%	72%	85%	87%	88%	88%	89%	89%	89%	89%	89%	
Deadline equipage																					
Number of retrofit aircraft	-	-	264	528	1,057	1,057	1,057	1,057	264	-	-	-	-	-	-	-	-	-	-	-	5,283
Number of new fit aircraft	-	-	-	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,078
Retrofit costs (€m)	-	-	10.6	21.1	42.3	42.3	42.3	42.3	10.6	-	-	-	-	-	-	-	-	-	-	-	211.3
New fit costs (€m)	-	-	-	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	403.1
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	3%	12%	24%	36%	47%	58%	63%	66%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	2%	13%	26%	40%	54%	67%	75%	79%	82%	85%	87%	88%	88%	89%	89%	89%	89%	89%	
Early equipage																					
Number of retrofit aircraft	-	-	1,266	1,519	1,519	506	253	-	-	-	-	-	-	-	-	-	-	-	-	-	5,063
Number of new fit aircraft	-	-	221	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,299
Retrofit costs (€m)	-	-	50.6	60.8	60.8	20.3	10.1	-	-	-	-	-	-	-	-	-	-	-	-	-	202.5
New fit costs (€m)	-	-	8.8	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	411.9
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	14%	32%	48%	54%	58%	61%	63%	66%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	11%	34%	54%	67%	73%	76%	79%	81%	84%	87%	89%	90%	90%	90%	90%	90%	90%	90%	
Baseline traffic growth																					
Late equipage																					
Number of retrofit aircraft	-	-	-	-	-	-	106	264	792	1,321	2,800	-	-	-	-	-	-	-	-	-	5,283
Number of new fit aircraft	-	-	-	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,078
Retrofit costs (€m)	-	-	-	-	-	-	4.2	10.6	31.7	52.8	112.0	-	-	-	-	-	-	-	-	-	211.3
New fit costs (€m)	-	-	-	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	403.1
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	0%	5%	7%	10%	14%	20%	30%	44%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	0%	7%	12%	16%	22%	29%	39%	52%	72%	85%	87%	88%	88%	89%	89%	89%	89%	89%	
Deadline equipage																					
Number of retrofit aircraft	-	-	264	528	1,057	1,057	1,057	1,057	264	-	-	-	-	-	-	-	-	-	-	-	5,283
Number of new fit aircraft	-	-	-	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,078
Retrofit costs (€m)	-	-	10.6	21.1	42.3	42.3	42.3	42.3	10.6	-	-	-	-	-	-	-	-	-	-	-	211.3
New fit costs (€m)	-	-	-	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	403.1
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	3%	12%	24%	36%	47%	58%	63%	66%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	2%	13%	26%	40%	54%	67%	75%	79%	82%	85%	87%	88%	88%	89%	89%	89%	89%	89%	
Early equipage																					
Number of retrofit aircraft	-	-	1,266	1,519	1,519	506	253	-	-	-	-	-	-	-	-	-	-	-	-	-	5,063
Number of new fit aircraft	-	-	221	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,299
Retrofit costs (€m)	-	-	50.6	60.8	60.8	20.3	10.1	-	-	-	-	-	-	-	-	-	-	-	-	-	202.5
New fit costs (€m)	-	-	8.8	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	411.9
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	14%	32%	48%	54%	58%	61%	63%	66%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	11%	34%	54%	67%	73%	76%	79%	81%	84%	87%	89%	90%	90%	90%	90%	90%	90%	90%	

Figure 25 - Projections of equipped aircraft and flights (low and baseline traffic growth)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
High traffic growth																					
Late equipage																					
Number of retrofit aircraft	-	-	-	-	-	-	106	264	792	1,321	2,800	-	-	-	-	-	-	-	-	-	5,283
Number of new fit aircraft	-	-	-	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,078
Retrofit costs (€m)	-	-	-	-	-	-	4.2	10.6	31.7	52.8	112.0	-	-	-	-	-	-	-	-	-	211.3
New fit costs (€m)	-	-	-	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	403.1
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	0%	5%	7%	10%	14%	20%	30%	44%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	0%	7%	12%	16%	22%	29%	39%	52%	72%	85%	87%	88%	88%	89%	89%	89%	89%	89%	
Deadline equipage																					
Number of retrofit aircraft	-	-	264	528	1,057	1,057	1,057	1,057	264	-	-	-	-	-	-	-	-	-	-	-	5,283
Number of new fit aircraft	-	-	-	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,078
Retrofit costs (€m)	-	-	10.6	21.1	42.3	42.3	42.3	42.3	10.6	-	-	-	-	-	-	-	-	-	-	-	211.3
New fit costs (€m)	-	-	-	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	403.1
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	3%	12%	24%	36%	47%	58%	63%	66%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	2%	13%	26%	40%	54%	67%	75%	79%	82%	85%	87%	88%	88%	89%	89%	89%	89%	89%	
Early equipage																					
Number of retrofit aircraft	-	-	1,266	1,519	1,519	506	253	-	-	-	-	-	-	-	-	-	-	-	-	-	5,063
Number of new fit aircraft	-	-	221	500	317	381	387	501	525	623	744	725	655	512	515	576	614	680	957	866	10,299
Retrofit costs (€m)	-	-	50.6	60.8	60.8	20.3	10.1	-	-	-	-	-	-	-	-	-	-	-	-	-	202.5
New fit costs (€m)	-	-	8.8	20.0	12.7	15.2	15.5	20.0	21.0	24.9	29.8	29.0	26.2	20.5	20.6	23.0	24.6	27.2	38.3	34.6	411.9
Operating costs (€m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Aircraft equipped	0%	0%	14%	32%	48%	54%	58%	61%	63%	66%	70%	73%	76%	76%	77%	77%	78%	78%	78%	78%	
Flights equipped	0%	0%	11%	34%	54%	67%	73%	76%	79%	81%	84%	87%	89%	90%	90%	90%	90%	90%	90%	90%	

Figure 26 - Projections of equipped aircraft and flights (high traffic growth)

ANNEX E GLOSSARY OF TERMS

ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre
AIP	Aeronautical Information Publication
ANSP	Air Navigation Service Provider
AOC	Aeronautical Operational Communications
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Service
CEATS	Central European Air Traffic Services
CFMU	The EUROCONTROL Central Flow Management Unit
CPDLC	Controller-Pilot Data Link Communication
CRCO	The EUROCONTROL Central Route Charges Office
DFS	Deutsche Flugsicherung GmbH, the air navigation service provider in Germany
DSNA	Direction des Service de la Navigation Aérienne, the air navigation service provider in France
EEC	EUROCONTROL Experimental Centre
ICAO	International Civil Aviation Organization
LCIP	Local Convergence and Implementation Plan
NATS	National Air Traffic Services, the air navigation service provider in the UK
NPV	Net Present Value
PRISME	Pan European Repository of Information Supporting the Management of EATM
STATFOR	The EUROCONTROL Statistics and Forecast Service
UAC	Upper Airspace Centre