HELIOS

Cost benchmarking of NATS relative to selected air navigation service providers

Phase 2 report

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Executive Summary

The Economic Regulation Group (ERG) of the Civil Aviation Authority (CAA) is undertaking a review of the price control for regulated services of National Air Traffic Services (NATS). This will review the current price control for the years 2006 to 2010 and inform the next phase of price control for 2011 onwards.

In support of this review, the ERG asked Helios to undertake a cost benchmarking analysis of the cost performance of NATS relative to selected Air Navigation Service Providers. This would examine the work done and the data collected by the Eurocontrol Performance Review Commission (PRC) and Performance Review Unit (PRU) in their comparison of performance in European air traffic management, to see if further insight could be gained from these data into NATS's comparative performance. Helios was also asked to review whether possible exogenous factors, outside the control of ANSPs' management, might have an influence on comparative performance; and to assess whether any other benchmarking studies carried out recently could add to the ERG's understanding of NATS's performance.

Phase 1 of the work reviewed the data available and made recommendations for further analysis. This is the report of Phase 2 of the work, in which the work programme of Phase 1 was carried out.

The data behind our analysis was that collected by the PRU as part of its ATM Cost-Effectiveness (ACE) benchmarking programme. The PRU publish annual ACE reports comparing and monitoring cost-effectiveness performance across 36 European ANSPs. To focus on NATS's comparative performance, we narrowed the group of ANSPs examined to nine ANSPs that had a number of features in common with NATS, in terms of traffic density, national income, and other characteristics. We used the PRU's analytical framework as the basis for our analysis, with two main modifications:

- where possible, we focused on "en-route" performance indicators, rather than the "gate-to-gate" indicators published by the PRU. This was because the ERG's interest was in the regulated services provided by NATS En route plc (NERL), which correspond closely to the en-route services for which the PRU collects data. In many instances, however, this en-route focus was not possible with the data collected and we followed the PRU in using gate-to-gate indicators, which for NATS include an element of the unregulated services provided by NATS Services Limited (NSL);
- the PRU's indicators include some cost elements that we judged were best omitted from a comparison focusing on NATS. These comprised some "exceptional items" relating to particular circumstances in a given year, and also the "cost of capital" element included by the PRU – we would argue that NATS's unique price control arrangements mean that the cost of capital as recorded by the PRU is not representative of its performance. These elements were excluded from the analysis. In addition, certain elements of costs that were unique to NATS's ownership structure, such as the treatment of accounting goodwill, or to its responsibilities, such as the North Sea Helicopter service, were also omitted.

The analysis was concentrated on the situation in 2007, the latest year for which PRU data was available. We examined historic developments between 2003 and 2007, and made some reference to an earlier study conducted in 2004-5, which used data from 2001 and 2002. We also compared NATS's planned performance in comparison with other European ANSPs.

We concluded that NATS's en-route cost-effectiveness performance had improved over the five years to 2007, and was now better than the average of the European comparators chosen. NATS has ATCO productivity higher than the average of the sample, and lower ATCO employment costs. Support costs per unit of output (measured gate-to-gate) were also slightly better than the sample average. NATS's performance is planned to stay close to that of comparator ANSPs over the following five years, although there is substantial uncertainty over those plans, since they were prepared before the full impact of the current recession had been perceived and do not therefore take account of any recent revisions by NATS or other ANSPs. NATS's current position appears to represent an improvement from the position in the corresponding review conducted in 2004-2005, when NATS's performance in 2001-2003 was not in general as good as the average of a sample of comparators.

A comparison of NATS ACCs with those in comparable ANSPs showed that London AC and Scottish had higher productivity than the average, with that at London TC and Manchester being lower. In general, productivity is higher than ACCs with similar traffic conditions, and has generally improved over the last five years.

An examination of exogenous conditions, particularly those relating to traffic conditions, gave some interesting insights. We reviewed measures of traffic "complexity", focusing on whether ACCs **within an ANSP** showed any suggestion of the way traffic conditions influenced productivity. We found a strong association within ANSPs of productivity with the **structural** element of complexity measured by the PRU; ACCs with higher structural complexity tended to have lower productivity. There was also an association of high productivity with control of higher flight levels rather than lower. However, indications of any association with the PRU's other measure of complexity – the "adjusted density" – were weak.

We went on to examine whether any statistical inferences could be made concerning the scale of the influence of these exogenous variables. We examined two statistical models – one relating ATCO-hours on duty to traffic conditions for ACCs, and a second relating support costs to ANSP characteristics.

The ATCO-hour model indicated that there was statistical evidence for economies of scale in ACCs, both at the lower end – a minimum number of ATCO-hours were required however low the traffic levels - and at the upper end, through a diminishing requirement for extra ATCOs with increasing traffic. Other important variables contributing to the explanation of variations in productivity were the area controlled by the ACC – the larger, the more productive; the average flight level – upper airspace appears to require less controller effort; seasonal variability – the more variable, the harder it was to sustain high productivity; and the delay – high productivity was achieved at the expense of lower quality of service.

The conclusion concerning NATS ACCs was that while Manchester, Scottish and London TC had productivity levels higher than would have been expected from the statistical model, that of London AC was lower.

The support cost model indicated that support costs per unit of output, or per ATCO-hour, were influenced by the area controlled – larger areas, with a given level of activity, implied higher support costs; and the average age of assets, with lower costs associated with older assets. We found that there was a constant term, implying that a substantial proportion of ANSP's support costs are fixed and do not depend on activity levels. NATS's support costs appeared to be slightly higher than those implied by the statistical model.

The final piece of analysis concerned comparison with non-Europeans. The only other recent benchmarking work relevant to NATS was that undertaken by the Civil Air Navigation Services Organisation (CANSO), the trade association for ANSPs. CANSOs' data were, however, confidential. We therefore asked some of the non-European contributors to CANSO's benchmarking exercise to provide to us the same data they provided to CANSO. Two agreed. The results should be interpreted with caution given the small sample size and the operating environments of those two ANSPs may differ considerably from those in Europe. Comparisons show that the financial cost-effectiveness KPI is substantially better for the single non-European ANSP for which it was measurable, and that ATCO productivity is substantially higher in both, than for NATS and its European comparators. The non-Europeans also allowed us to benchmark the costs of NATS's Oceanic operation, where NATS's ATCO productivity was substantially higher than both non-European comparators, and the financial cost-effectiveness was slightly better than the one for which this indicator could be measured.

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1 Introduction

1.1 Background to the work

1.1.1 The Economic Regulation Group (ERG) of the Civil Aviation Authority (CAA) is undertaking a review of the price control for regulated services of National Air Traffic Service (NATS). This will review the current price control for the years 2006 to 2010, and will inform the next phase of price control for 2011 onwards.

1.1.2 In support of this, Helios was contracted to undertake a cost benchmarking analysis of the cost performance of NATS relative to selected Air Navigation Service Providers (ANSPs). The components of this study were:

- A review of the data collected and the analysis undertaken by the Eurocontrol Performance Review Commission (PRC) and Performance Review Unit (PRU), the bodies tasked under the Revised Eurocontrol Convention with monitoring and comparing performance in European air traffic management (ATM), to see if further insight could be gained beyond what is presented in their annual reports.
- An examination of other benchmarking exercises that have been undertaken outside Europe, such as the benchmarking study undertaken annually for the last few years by the Civil Air Navigation Services Organisation (CANSO). Such exercises may also provide further insight into the cost performance of NATS compared to ANSPs outside of Europe.
- An assessment of approaches and analyses that have been put forward for taking exogenous factors and quality of service indicators into account in cost benchmarking exercises; and a supplementary analysis based on these approaches, taking exogenous factors and quality of service indicators into account.

1.2 Objectives of the study

1.2.1 The objective of this benchmarking exercise was to provide a source of information for the CAA to help inform thinking on costs for NATS for the third price control period (CP3), comprising the years 2011 to 2016.

1.2.2 Phase 1 of this work was completed in April 2009. It explored the data collected regularly by the PRU and investigated potential extra value that can be gained in understanding the underlying cost performance of NATS.

1.2.3 Phase 1 of this work comprised the following elements:

- Review of existing Performance Review Commission (PRC) studies and the content of data on which these studies are based. The studies reviewed included the annual ACE (ATM Cost-Effectiveness) Benchmarking Reports, annual PRRs (Performance Review Reports), where relevant, and additional publications including the Stochastic Frontier Analysis of ANSP cost benchmarking undertaken by NERA Economic Consulting[1].
- Review of how quality of service (QoS) issues have been taken into account in benchmarking, and what approaches are suitable for the CAA's purposes.

[1] Cost Benchmarking of Air Navigation Service Providers: A Stochastic Frontier Analysis, NERA Economic Consulting (November 2006).

- Review of approaches for allowing for the effect of exogenous factors in comparing costs per flight-hour.
- Review of other benchmarking exercises that have been undertaken to extend the analysis beyond the scope of Eurocontrol states.
- Identification of potential gaps and proposal of further analysis to identify elements most relevant for providing a robust basis for benchmarking.

1.2.4 This is the report of Phase 2 of the work. It describes the results of the analysis of the programme of work defined in Phase 1. The time-scale available for the work required that only data that was already available was used; no primary data collection was undertaken. Furthermore, time-scales limited the ability to undertake detailed analysis of large-scale data bases.

1.3 Time horizon of the analysis

1.3.1 This study looks at the cost performance of NATS between 2003 and 2007. 2008 data was not yet available at the time of undertaking the analysis.

1.3.2 We also make some references to years before 2003, using the results of a study which reported in May 2005[2]. This work presented a benchmarking analysis of NATS compared to selected ANSPs for the years 2001 to 2003. We note, however, that 2002 figures are taken from the previous study published by the CAA and any updates that may have been undertaken by the PRU subsequent to May 2005 have not been included.

1.3.3 The 2005 study used a different sample of ANSPs from the present study. The intervening five years' data and experience have allowed us to choose a sample of ANSPs more closely focused on those ANSPs with similar characteristics to NATS. Any comparisons between the results of the analyses must therefore be treated with caution.

1.4 Structure of this document

1.4.1 This document contains the following sections:

- a description of our approach to the work and of the data preparation;
- a descriptive analysis at ANSP level focusing on NATS and a group of comparator ANSPs;
- a descriptive analysis at area control centre (ACC) level focusing on NATS ACCs and a group of comparator ACCs;
- a statistical analysis investigating the relationships between air traffic controller (ATCO) productivity and ANSP support costs and various exogenous factors;
- a descriptive analysis of insights gained from outside Europe; and
- our conclusions.

[2] Civil Aviation Authority, Cost benchmarking NATS relative to selected ANSPs, Final Report on benchmarking with existing data, 20 May 2005 (Solar Alliance and Steer Davies Gleave) http://www.caa.co.uk/docs/5/ergdocs/erg_ercp_sp2_anspbenchmarking.pdf.

2 Our approach

2.1 The analytical framework

2.1.1 The analysis undertaken in Phase 2 of the work follows the analytical framework that has been devised by the PRU and used in their annual ACE benchmarking reports. This provides a structured way to investigate, compare and contrast the various components that contribute to the overall cost of service provision.

2.1.2 The ACE framework is illustrated (in simplified form) in Figure 2-1.

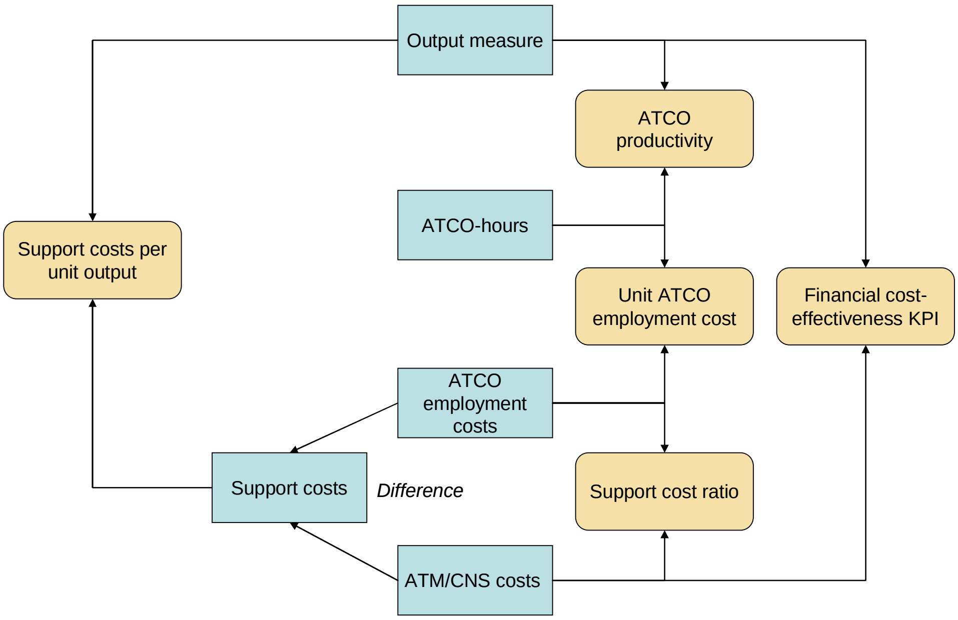

Figure 2-1: ACE analysis framework (simplified)

2.1.3 Some care needs to be taken concerning the scope of the PRU analysis, which differs from the scope of the CAA's price control. The indicators presented in the ACE analysis framework are gate-to-gate[3]. The CAA, however, is concerned with only NATS's regulated business. Therefore the framework has been adapted, where possible, to NATS's regulated business.

2.1.4 The price control currently covers two elements of regulated services, operated by the NATS subsidiary NATS (En route) plc (NERL):

- "en-route" air traffic control services provided in the United Kingdom (UK) Flight Information Regions (FIRs); and
- "oceanic" services provided in the North Atlantic FIRs, responsibility for which has been assigned by the International Civil Aviation Organisation (ICAO) to the UK and thence to NERL under its licence.

2.1.5 The "en-route" services so defined are not the same as the "en-route" services defined by Eurocontrol, and on which data is collected and analysed by the PRU.

[3] The term 'gate-to-gate' comprises all phases of flight. The PRU has defined a composite measure of output so that the relative importance of en-route and terminal output in the composite measure was the same as the relative importance of en-route and terminal costs across the system. This resulted in a definition of the composite output measure; composite flight-hours.

The latter comprise for all European ANSPs apart from NATS only those en-route services which are charged through the Eurocontrol Route Charging System. The "en-route" services provided by NERL include in addition services provided by the London Terminal Control Centre, the charges for which are made through a separate London Approach Charge. For PRU purposes, NATS has divided the costs of services covered by the London Approach Charge into a portion allocated to en-route and a portion allocated to terminal. We consider that any difference in comparability introduced by this factor is unlikely to introduce any significant distortion.

2.1.6 "Gate-to-gate" costs, however, include a substantial proportion of costs that are incurred by NATS's unregulated subsidiary, NATS Services Limited (NSL).

2.1.7 NATS, unlike any other European ANSP, has a financial year running from April until the following March. They report figures to the PRU for the year from April 2007 until March 2008 as relating to 2007. We have retained this approach.

2.1.8 All financial data presented in this report is in constant 2007 euros, unless otherwise stated.

2.2 NATS comparators

2.2.1 The Phase 1 report proposed a list of nine ANSPs comparable to NATS (ANS CR, Austro Control, Belgocontrol, DFS, DSNA, ENAV, LVNL, MUAC and Skyguide). The sample was chosen to comprise ANSPs with comparable national income and traffic complexity. To measure the latter we use the PRU's aggregated complexity score (see Section 4.3 for further details). The sample comprises ANSPs with GDP per head greater than €10,000 and an aggregated complexity score greater than 5.

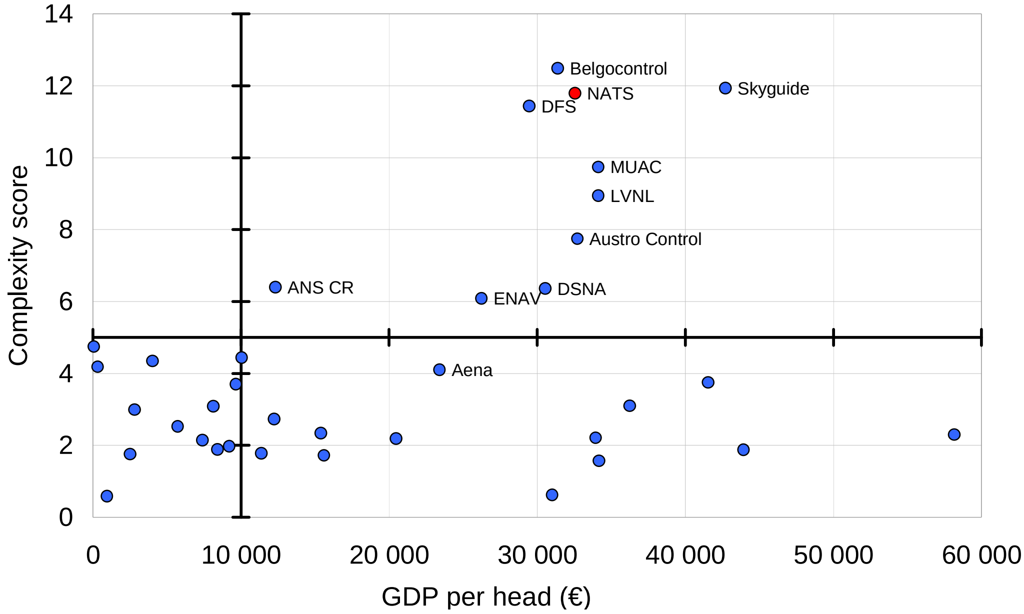

Figure 2-2: Selection of comparators based on GDP per head and complexity score

2.2.2 Spain has a comparable income to the UK, though the traffic controlled by Aena is less complex. It cannot be ignored, however, as it is so large. Aena also has an anomalous cost structure and institutional structure.

2.2.3 Therefore, in the context of this study, Aena is shown alongside the comparators in all tables and figures (because of its similarities with regard to traffic volume, variability and GDP per head). However, **Aena is excluded from the calculation of sample averages** (mainly because of its atypical cost structure and lower aggregated complexity).

2.2.4 It is also interesting to examine certain other characteristics of the ANSPs in the sample. Figure 2-3 shows both the overall scale of the operations of the ANSPs, as measured by the traffic handled[4], and the seasonal variability[5] of that traffic. The areas of the circles representing the ANSPs are proportional to their aggregated complexity score.

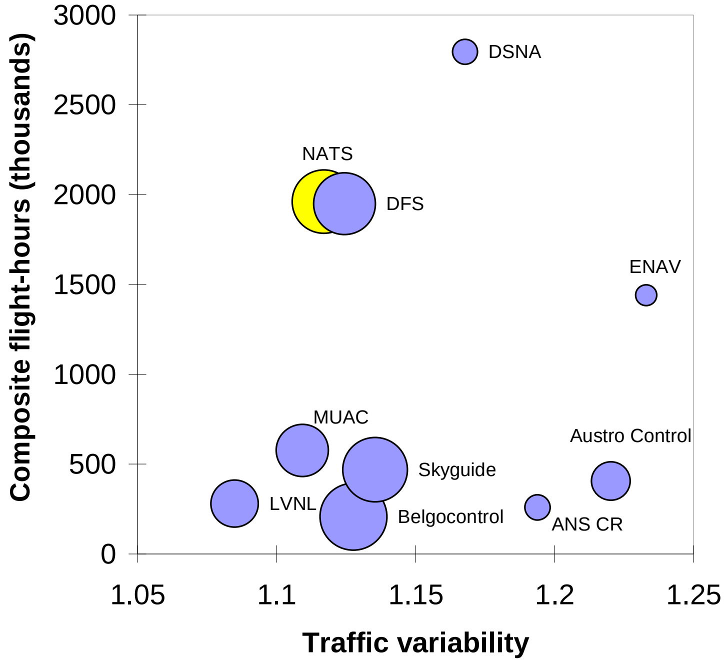

Figure 2-3: Composite flight-hours versus traffic variability

2.2.5 The sample chosen, with the addition of Aena, represents a substantial share of the total European composite flight-hours and gate-to-gate costs. NATS position is highlighted by the red arrow.

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[4] Measured using the PRU's "composite flight-hours", which measure both en-route and terminating traffic and are defined in footnote 3

[5] Seasonal variability is measured by the PRU as the traffic in the peak week divided by the traffic in an average week.

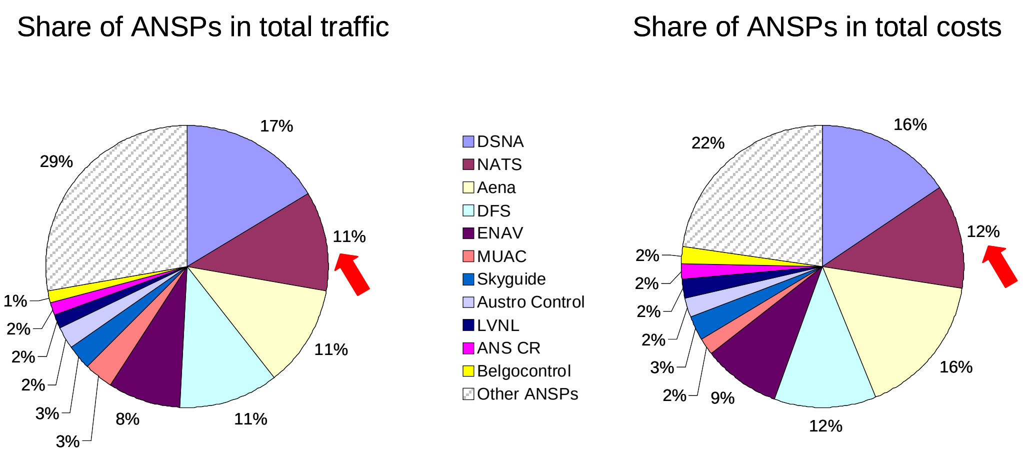

Figure 2-4: Share of ANSPs traffic (composite flight-hours) and costs (gate-to-gate)

2.3 Measures of performance

2.3.1 The key performance indicators examined in this report are based on the PRU's ACE framework, but adapted where possible to reflect the fact that the CAA's interest is in NERL's en-route business. We have also excluded from the overall costs the PRU's "cost of capital" element, which we regard as not appropriate for benchmarking of NATS's or NERL's performance for reasons discussed in paragraph 2.4.21.

2.3.2 At en-route level, we examine:

§ en-route financial cost effectiveness - the en-route cost per flight-hour.

2.3.3 At gate-to-gate level, we examine:

§ ATCO employment cost per composite flight-hour;

§ ATCO productivity - the composite flight-hours controlled per ATCO-hour on duty (at ANSP level);

§ ATCO employment cost per ATCO-hour, broken down into the following multiplicative components:

- average ATCO cost per year; and
- average ATCO-hours per year.

§ support costs per composite flight-hour; support costs comprise the following additive components:

- staff costs for non-ATCOs;
- non-staff costs; and
- depreciation costs.

2.3.4 We also acknowledge that the airspace served by an individual ANSP can be heterogeneous, and it can therefore be instructive to look at some performance measures at the level of the individual operating units. Unfortunately, however, no data are available on costs at this level, and our analysis of individual area control centres (ACCs) is therefore confined to the ATCO productivity indicator:

- ATCO productivity as measured by flight-hours per ATCO-hour on duty in the ACC.

2.3.5 In addition we analyse indicators of quality of service, focusing on en-route ATFM delay and horizontal flight-efficiency. For en-route ATFM delay we analyse total en-route ATFM delay in minutes.[6] The analysis presented in this report is not comparable with the analyses published by the PRC in their annual reports. They use delay figures greater than 15 minutes. For this analysis we have used total en-route ATFM delay. Horizontal flight-efficiency measures the extent to which aircraft are forced to fly greater distances than the shortest possible “great-circle” distance and is measured in terms of “excess kilometres flown”; the lower this excess, the higher the flight-efficiency.

2.3.6 The Key Performance Indicators (KPIs) analysed in Phase 2 are presented in Figure 2-5.

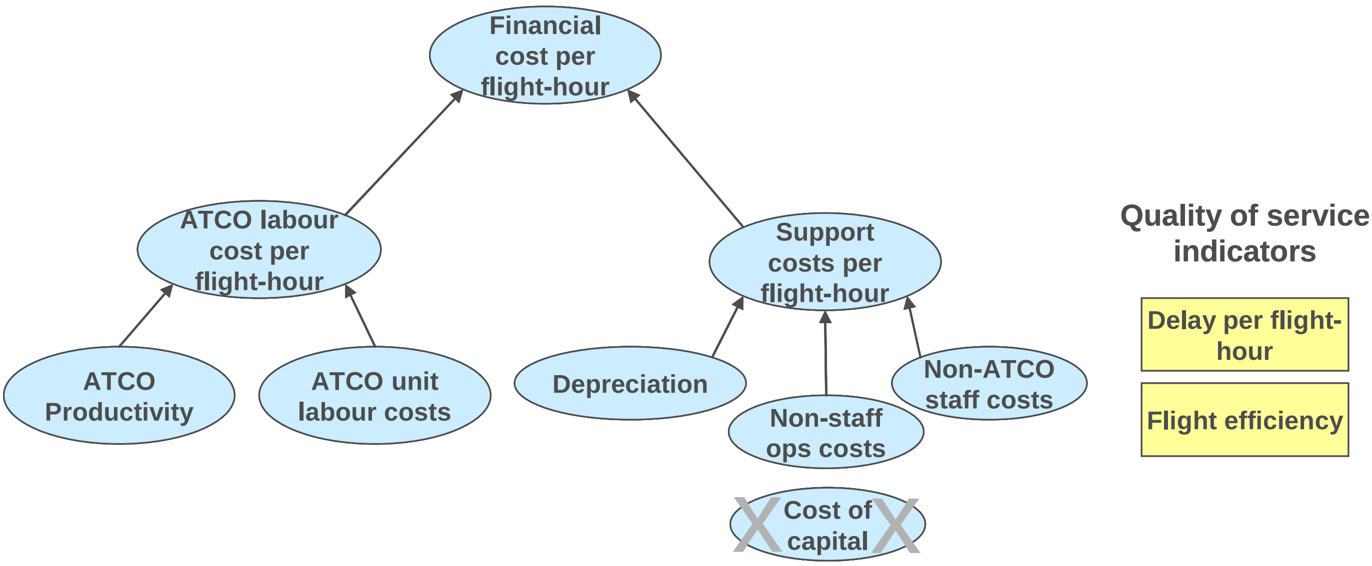

Figure 2-5: KPIs measured in this report

2.4 Identified issues

2.4.1 A number of issues have arisen when using the ACE benchmarking data for the purposes of the CAA work. These issues include:

- whether to undertake the analysis at en-route or gate-to-gate level;
- how to take account of the traffic controlled by the Maastricht Upper Air Centre (MUAC) and its costs;
- how to deal with exceptional cost items that are disclosed by the ANSPs, and the changes in “goodwill” that are disclosed by NATS;

[6] En-route ATFM delay is the duration between the last take-off time requested by the aircraft operator and the take-off slot given by the Eurocontrol Central Flow Management Unit as a result of flow restrictions imposed in en-route airspace.

- how to account for NATS including costs related to providing services to North Sea Helicopters and military operations in their ACE submissions to the PRU;
- whether to take cost of capital into account;
- variability in exchange rates and inflation.

2.4.2 Each of these issues, and our mitigating actions, are described in the following sections.

En-route or gate-to-gate?

2.4.3 This benchmarking study for the CAA is concerned with NATS's regulated business, and therefore, we propose to undertake the analysis at en-route level where it is possible to do so. This introduces an extra potential pitfall in that there is inconsistency in drawing the boundary between en-route and terminal both between ANSPs and over time within an ANSP.

2.4.4 These inconsistencies are well understood and are accounted for in our analysis. Where we have reallocated costs to account for such changes the rationale for doing so and the impact of the change is described clearly.

2.4.5 In many cases sufficient data is not available to carry out the analysis for en-route, and in these instances we revert to a gate-to-gate analysis. We have chosen therefore to sacrifice consistency across the range of indicators, instead selecting at each level the indicator that provides the most relevant comparison between NATS and the rest of the sample.

The MUAC effect

2.4.6 MUAC is operated by Eurocontrol on behalf of Belgium, the Netherlands and Germany. The operations at MUAC use the communications, navigation and surveillance (CNS) infrastructure purchased and maintained by Belgocontrol, LVNL and DFS. There is therefore a bias when comparing MUAC to other ANSPs, since the costs associated with the use of the CNS infrastructure is not borne by MUAC. The magnitude of the costs paid by Belgocontrol, LVNL and DFS but actually benefiting to MUAC operations is not known. Correcting for the MUAC effect is therefore not straightforward.

2.4.7 One way of adjusting for this is to reallocate the costs of operations at MUAC and the traffic that it serves to these three countries. This reallocation provides a more realistic figure for the costs and traffic for the countries that delegate services in part of their airspace to Eurocontrol.

2.4.8 This reallocation was put forward by the PRU in 2007, but was not used before that date (data is not available to reallocate MUAC costs and traffic between 2003 and 2006).

2.4.9 To ensure consistency between traffic and costs, we included the financial contributions to MUAC made by Belgocontrol, DFS and LVNL in their respective en-route costs.

MUAC	Belgium	Germany	Netherlands
Flight-hours allocated to:	180,598	199,792	194,912
Costs allocated to:	€37.1m	€53.2m	€30.8m

Table 2-1: MUAC traffic and costs reallocation

Exceptional cost items and "goodwill"

2.4.10 Exceptional costs (part of the operating costs in the ACE analysis) have been excluded from our analysis so that we can benchmark ANSPs' operating costs independently of exceptional effects.

2.4.11 A particular issue relates to the disclosure of costs arising from the recognition that pension provisions needed to be higher. According to Article 12 of EC Regulation No 550/2004, ANSPs shall publish financial accounts complying with the international accounting standards adopted by the Community. The conformance to international accounting standards has obliged some ANSPs to restate some of their balance sheet items and in particular pension provisions. In this context, DFS had to recognise that its pension liabilities were understated, and that DFS staff costs had been understated in previous years. DFS will compensate for the lack of provisions by raising additional revenues from user charges. To limit the impact on the German unit rate it was decided to spread the additional costs over 15 years. In the PRU cost-benchmarking exercise, these costs were treated as exceptional costs, and will also be spread over 15 years.

2.4.12 When looking at historical data there is therefore some bias in comparing performance. ANSPs which have made adequate provisions year by year may then show higher pension costs than those which have made provisions that have subsequently been judged to be inadequate, according to the newly required international accounting standards. On the other hand, including the exceptional adjustments in the analysis was not realistic as they were one-off and in some cases extremely large compared to the overall costs of the organisation.

2.4.13 Exceptional costs have not been consistently disclosed by ANSPs; some ANSPs disclose costs which could be classed as exceptional items under other classes of cost.

2.4.14 In 2007, exceptional costs were reported by NATS (€28.8m), DFS (€18.2m), ENAV (€4.6m), Skyguide (€2.0m) and Belgocontrol (€1.1m). For NATS, exceptional costs were mainly associated with redundancy and relocation costs following the transfer of London Terminal Control (London TC) operations (including 500 people) from West Drayton to Swanwick. Exceptional costs for DFS related to the revaluation of pension obligations according to IFRS, and for ENAV they were also associated with accounting adjustment of some asset values.

2.4.15 Practices in the classification of costs as "exceptional" differ across ANSPs. For example, the ENAV 2007 asset revaluation (some € 5.8m) might not have been classified by NATS as an exceptional item. However, since the nature of exceptional costs reported by the comparators between 2003 and 2007 was not always known, we preferred to remain consistent with the PRU classification of exceptional costs and to systematically exclude them[7].

2.4.16 NATS also disclosed costs relating to asset impairment in their ACE submissions. These are excluded from calculations of unit rate and other regulatory calculations. The asset impairment costs appeared to be of the same type as the costs classified as "exceptional" by ENAV in 2007. We therefore agreed that they should be excluded.

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[7] The impact of including ENAV 2007 exceptional costs in the analysis would have had a marginal effect, with no impact on NATS position relative to its comparators average performance, and no visible impact on ENAV in the graphs displaying the changes between 2003-2007 and 2006-2007.

2.4.17 NATS include the value of "goodwill" on their balance sheet. This goodwill is an accounting concept that arises because of the transaction in which partial ownership of NATS was transferred to the private sector. Changes in goodwill therefore have no analogue in any other ANSP and are not related to performance. We therefore agreed that items relating to goodwill should be excluded from the benchmarking comparison. This includes both goodwill impairment (re-estimates of the value of the goodwill), and the amortisation of goodwill; both these items were included by NATS in their disclosed depreciation costs.

2.4.18 NATS gave us the following information to allow asset impairment charges, goodwill impairment charges, and goodwill amortisation charges to be excluded.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Asset impairment (€m)	-5.4	-13.7	-22.5	-12.4	-2.0	0.0	0.0	0.0	0.0	0.0
Goodwill amortisation (€m)	-20.1	-20.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Goodwill impairment (€m)	0.0	0.0	0.0	0.0	0.0	0.0	-25.0	-5.1	-2.5	-11.0

Table 2-2: Adjustments for asset impairment and changes in goodwill

North Sea Helicopters and military operations

2.4.19 The cost of services provided to North Sea Helicopter operations was included in NATS's submissions to the PRU as part of "en-route" costs. These costs should be excluded for benchmarking purposes as there were no flight-hours associated with these costs, and they have no analogue among the comparator ANSPs. NATS provided Helios with the information to exclude these costs.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Staff costs (€m)	-0.5	-0.6	-0.7	-0.7	-0.7	-0.8	-0.8	-0.8	-0.8	-0.8
Non-staff operating costs (€m)	-4.8	-5.9	-6.4	-6.5	-6.0	-6.7	-7.6	-7.5	-7.5	-7.5
Depreciation costs (€m)	-1.0	-1.3	-1.4	-1.4	-1.3	-1.5	-1.6	-1.6	-1.6	-1.6
Cost of Capital (€m)	-0.9	-0.9	-1.0	-1.0	-1.0	-1.2	-1.4	-1.4	-1.4	-1.3

Table 2-3: Adjustments to take account of North Sea Helicopter operations

2.4.20 NERL also makes a charge to the UK military for the provision of certain services. The costs of these services are removed from the figures disclosed to the PRU. We endorse this practice as appropriate for benchmarking[8].

[8] NATS made a late adjustment to their ACE 2007 information disclosure. This adjustment was required because the cost of capital correctly allocated to the service provided to the military had been erroneously subtracted from en-route operating costs in the original submission. We have not received confirmation from the PRU that this adjustment was omitted from the ACE 2007 analysis. Therefore, we have not been able to take account of this adjustment. We understand, from NATS, that the value of the adjustment was £4.8m which should be added to the operating cost for NATS.

Cost of capital

2.4.21 There is a major difference between the way that the "cost of capital" element of the costs examined by the PRU is calculated for NATS, on the one hand, and for all other ANSPs, on the other. For all ANSPs other than NATS, the cost of capital is assessed as the actual cost of debt finance, plus a reasonable assessment (made by each individual member state) of an appropriate return on equity finance. This element is included in their cost base and recovered from users in their revenues. The cost of capital for NATS, by contrast, is inferred from their regulated revenues, and therefore includes the return on equity that they actually achieved. As a consequence, good performance in terms of cost reduction to an extent greater than originally foreseen in the price control conditions will increase the cost of capital reported. We therefore judged, in consultation with the CAA, NATS, and a sample of users consulted at the first stakeholder workshop that it was not appropriate to include the cost of capital in this benchmarking analysis.

Exchange rate variability and inflation

2.4.22 The Phase 1 report identified difficulties of undertaking benchmarking analysis in national currencies, especially when a time variation is introduced.

2.4.23 Inflation rates over the 2003-2007 period and across our sample of countries have been relatively homogeneous, with annual average inflation rates ranging from 1% in Switzerland to 2.5% in Czech Republic. Inflation rates in the United Kingdom, Italy, Belgium, Austria, Germany and France have been very similar.

2.4.24 In 2008 there were considerable fluctuations in the value of national currencies within the comparator sample. However, the analysis of the data for the purposes of the work for the CAA will not consider data for 2008, as it is not yet available from the PRU. The exchange rates for the UK, as well as for all of the other countries of interest, remained quite stable between 2003 and 2007 (see Table 2-4). This issue is likely therefore to be less important than might at first appear.

	2003	**2004**	**2005**	**2006**	**2007**
Czech Republic	31.82	31.87	29.76	28.30	27.72
Switzerland	1.52	1.54	1.55	1.57	1.64
United Kingdom	0.70	0.68	0.68	0.68	0.71

Table 2-4: Exchange rates for non-€ members (national currency per €)

2.4.25 Should this analysis be extended to take account of 2008 then this issue will need to be revisited.

3 Descriptive analysis at ANSP level

3.1 Introduction to ANSP analysis

3.1.1 This chapter presents our analysis of the KPIs for NATS compared to other selected ANSPs.

3.1.2 In Section 3.2 we examine the en-route financial cost per flight-hour. At a gate-to-gate level, Section 3.3 presents an analysis of the ATCO employment costs per composite flight-hour[9], and Section 3.4 examines the relationship between gross wages and salaries of ANSP staff and national income, as measured by Gross Domestic Product (GDP) per head.

3.1.3 Support costs at gate-to-gate level are analysed in Section 3.5, including an analysis of the relationship between support costs and ATCO productivity. Indicators of the quality of service provided by the sample ANSPs are presented in Section 3.6, focusing on en-route ATFM delay per flight-hour and horizontal flight-efficiency.

3.1.4 The final section in the analysis at ANSP level is the projected performance between 2008 and 2012.

3.1.5 The graphs presented in this report compare NATS's performance with the average[10] of the selected ANSPs. This average is calculated excluding NATS and Aena. The results for Aena are, however, presented on the graphs for information purposes.

3.2 En-route financial cost per flight-hour

3.2.1 Figure 3-1 below shows the 2007 en-route ATM/CNS provision costs per flight-hour (including staff costs, non-staff operating costs, depreciation costs, but excluding exceptional items and the cost of capital). The graph includes the reallocation of flight-hours and costs from MUAC to its contributing ANSPs, as described in Section 2.4.

[9] The results of this study are based on PRU data as of April/May 2009. There is a minor difference in the calculation of composite flight-hours. For the final report the PRU changed the weighting factor for composite flight-hours from 0.253 to 0.255. The impact of this change on the results of this benchmarking study is negligible and the change affects all ANSPs. Our investigations have shown that this change does not affect the ranking of ANSPs.

[10] The average for the comparators is calculated by, for the example of en-route cost per flight-hour, taking the sum of the en-route cost for the comparator ANSPs (excluding NATS and Aena) and dividing it by the sum of the flight-hours controlled.

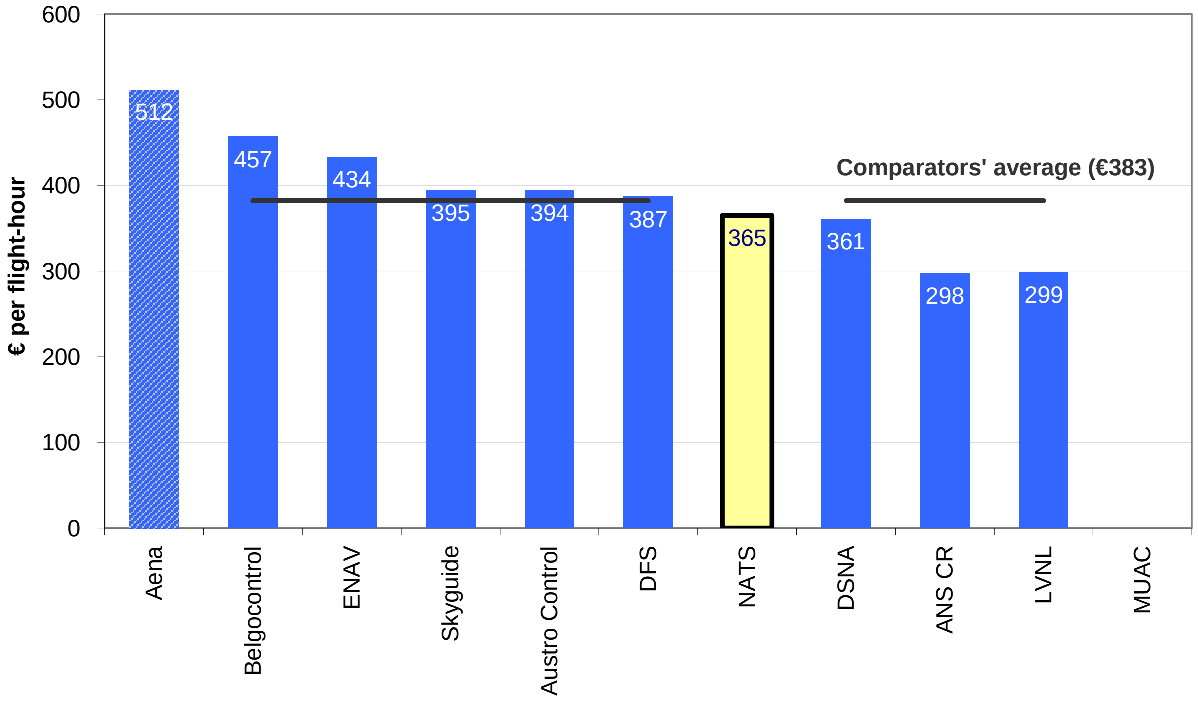


Figure 3-1: Financial cost per flight-hour (en-route)

3.2.2 The average en-route ATM/CNS provision cost per flight-hour of the selected comparators is €383. NATS has an en-route cost of €365 per flight-hour, which is nearly 5% lower than the average of the comparators.

Changes in en-route cost per flight-hour over time

3.2.3 Figure 3-2 below shows that over the 2003-2007 period NATS en-route cost per flight-hour fell by 5%, while its comparators' en-route cost per flight-hour fell on average by nearly 13%[11].

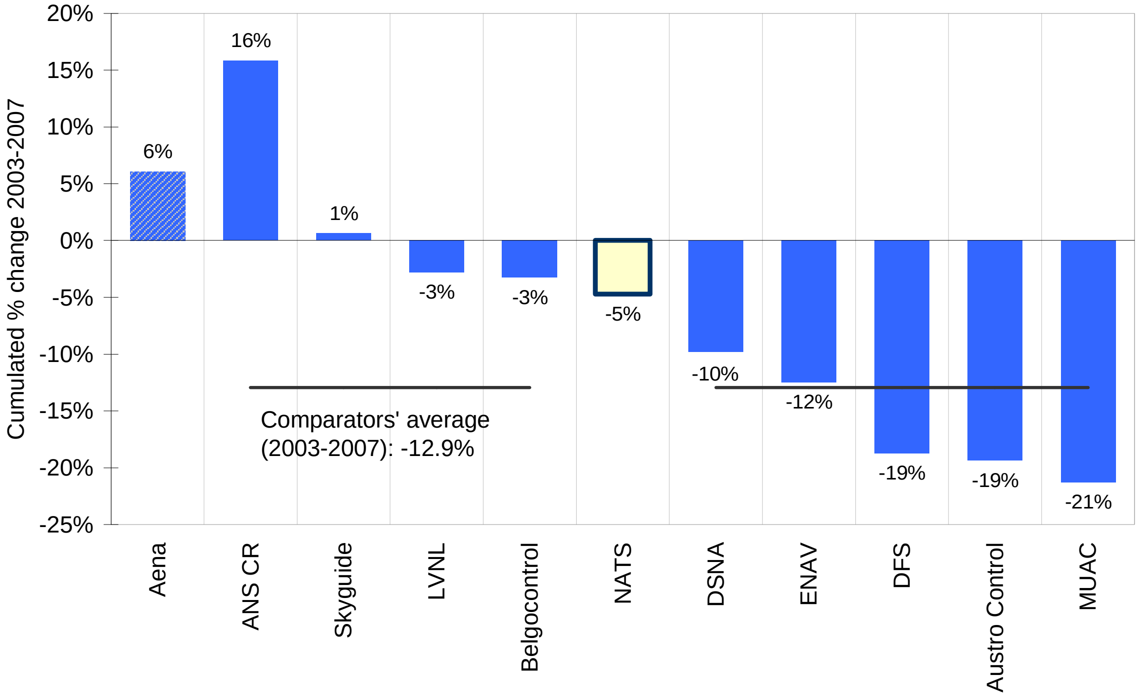


Figure 3-2: 2003-2007 changes in en-route cost per flight-hour

3.2.4 The 2005 benchmarking study showed that NATS achieved a reduction of more than 5% in the en-route cost per flight-hour between 2001 and 2003. The comparator set in the 2005 study showed an average increase of approximately 4% in en-route cost per flight-hour over the same period[12]. The comparator set used for the 2005 study was different, but overlaps considerably with the set used for this analysis.

3.2.5 Figure 3-3 below shows that over the 2006-2007 period NATS en-route cost per flight-hour fell by 4%, while its comparators en-route cost per flight-hour fell on average by 2.4%. NATS reduced en-route cost per flight-hour by more than average between 2006 and 2007.

---

[11] ANS CR revised its definition of terminal and en-route services in 2007, resulting in a shift of costs from terminal to en-route. This change brought ANS CR closer into line with the practice of most of the rest of the sample. For the purposes of the analysis of changes over time, however, we have made an estimate of the magnitude of this effect and adjusted the change in ANS CR's figures to reflect the underlying change in en-route costs.

[12] The analysis included in this report has removed the asset impairment charges, goodwill impairment charges and goodwill amortisation charges, as described in paragraphs 2.4.16 and 2.4.17. These costs were not excluded in the 2005 benchmarking report, which makes it difficult to compare the results of the two analyses. Excluding these costs improves NATS's cost performance in 2003 compared to the results presented in the 2005 benchmarking study.

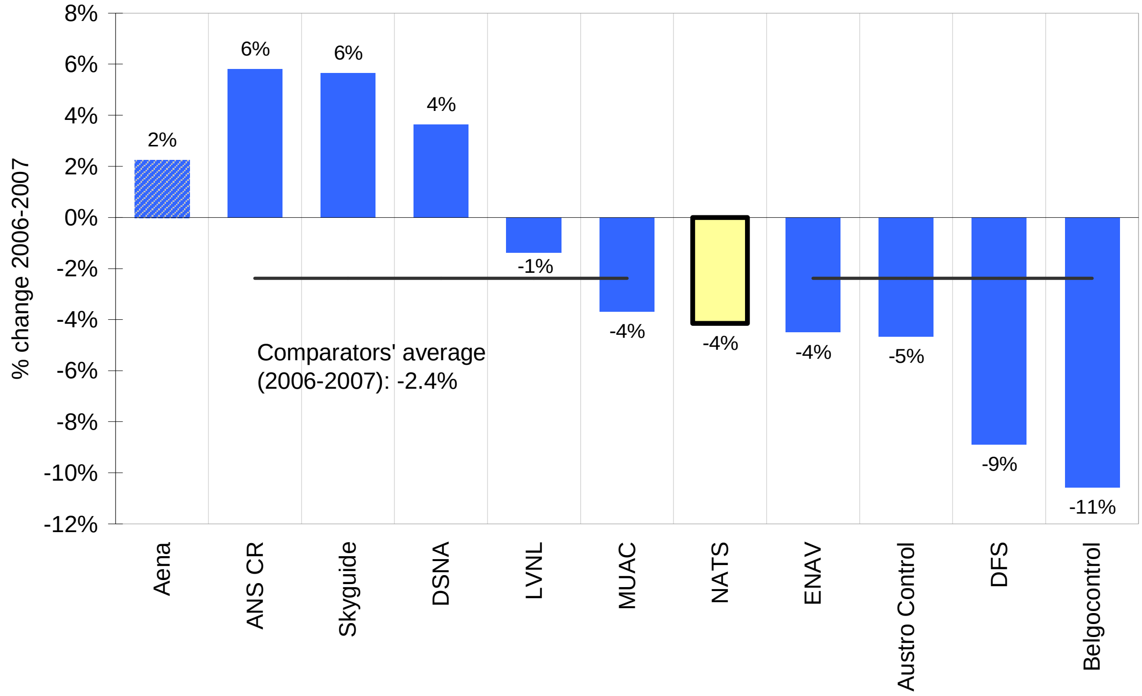


Figure 3-3: 2006-2007 changes in en-route cost per flight-hour

Cost and volume effect on en-route cost per flight-hour

3.2.6 En-route cost per flight-hour can change for a combination of two reasons:

- a change in the output (the traffic served) – higher traffic will improve the indicator, and lower traffic will worsen it; and
- a change in the costs.

3.2.7 Figure 3-4 below shows how these two effects combine to give rise to the changes discussed above.

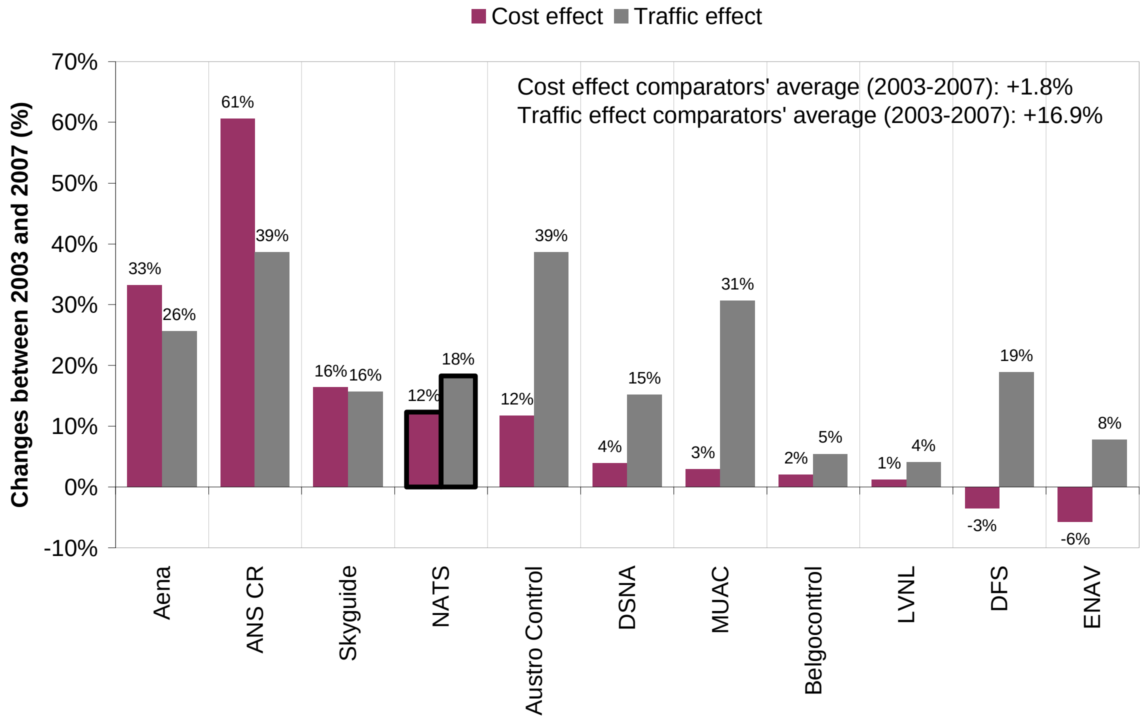


Figure 3-4: Changes in en-route costs and flight-hours (2003-2007)

3.2.8 All ANSPs, except DFS and ENAV, show cost increases between 2003 and 2007. In most cases, however the increase in traffic has far outweighed the increases in costs. For example, MUAC has seen a 3% increase in costs, but a 31% increase in traffic. This has resulted in the 21% reduction in en-route cost per flight-hour between 2003 and 2007 (see Figure 3-2). Austro Control has also benefited considerably from increasing traffic demand, with a 39% increase in traffic between 2003 and 2007. This goes some way towards explaining the 19% reduction in en-route cost per flight-hour observed over the same period of time.

3.2.9 LVNL and Belgocontrol have kept cost under control, but have suffered because of low traffic growth resulting in only a 3% decrease in en-route cost per flight-hour between 2003 and 2007.

3.2.10 Figure 3-5 below shows the changes in en-route costs and flight-hours between 2006 and 2007.

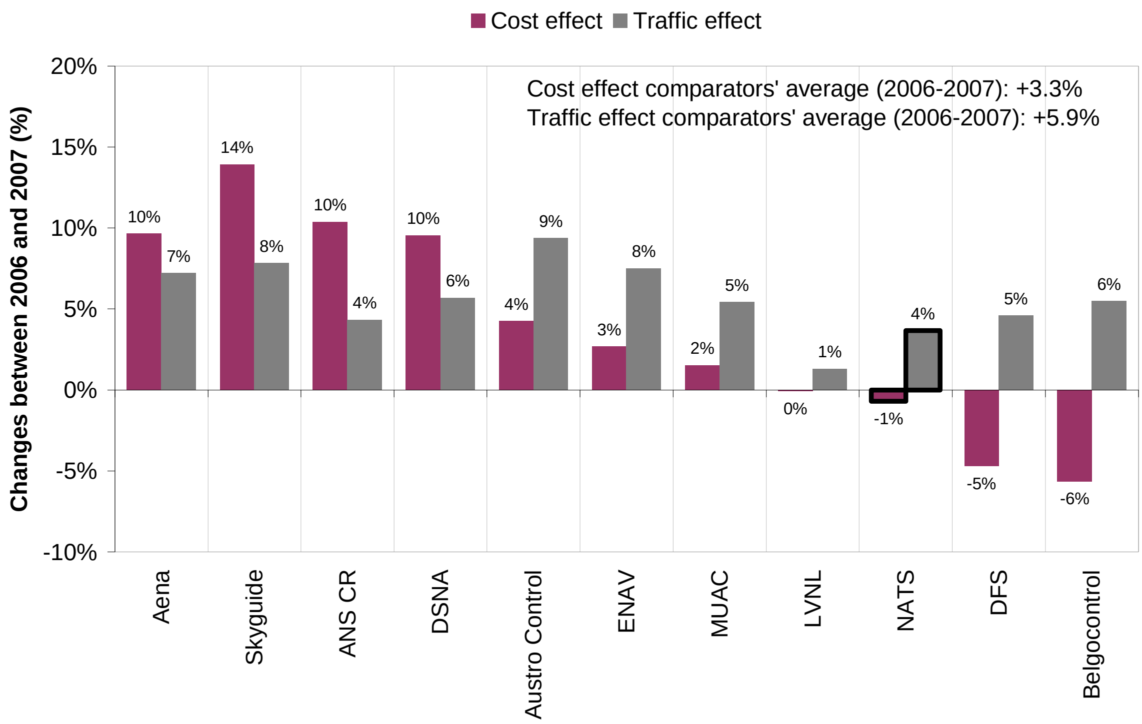


Figure 3-5: Changes in en-route costs and flight-hours (2006-2007)

3.2.11 Between 2006 and 2007, NATS en-route cost (en-route cost per flight-hour excluding exceptional costs and cost of capital) has fallen by 1%, while its comparators average cost per flight-hour has risen by 3.3%. Furthermore, NATS traffic growth has been below the average of the comparators.

3.3 ATCO employment costs (gate-to-gate)

3.3.1 The ATCO employment cost analysis is done at gate-to-gate level because the PRU collects ATCO employment costs as a whole, without separating the costs into en-route and terminal. The breakdown between en-route and terminal cannot be easily estimated from the number of ATCOs since the ATCO breakdown is between area control centres on the one hand, and approach control units and tower control units on the other, rather than between en-route and terminal – most ANSPs classify much or all of the services provided by approach control units as "en-route".

3.3.2 The ATCO employment cost includes all salary, employment tax and social security charges, and the costs of pensions borne by the employer. There is substantial diversity within our sample concerning how these costs are assessed, and the results should therefore be viewed with some caution. There is particular uncertainty associated with the way the costs of continuing obligations resulting from the provision of "defined-benefit" pensions are accounted for. The move to the use of International Financial Reporting Standards (IFRS) has resulted in very substantial reassessment of these obligations in some of the ANSPs that have adopted IFRS. Furthermore, even within those ANSPs that have adopted IFRS, there are substantial differences in the apparent cost of pensions to the ANSP, depending chiefly on whether the ANSP has retained full responsibility for past and present pension obligations, or, as in some cases, passed them to national governments in exchange for a defined annual or lump sum payment.

3.3.3 The ATCO employment cost per flight-hour can be broken down into two indicators:

- ATCO employment cost per composite flight-hour: ATCO productivity divided by ATCO employment cost per ATCO-hour.
- ATCO employment cost per ATCO-hour: ATCO employment cost per year divided by average hours on duty per ATCO.

3.3.4 Figure 3-6 presents the ATCO employment cost per composite flight-hour for the ANSPs in 2007. NATS is approximately 11.5% lower than the sample average; Aena, excluded from the sample, has a figure over three times that of NATS.

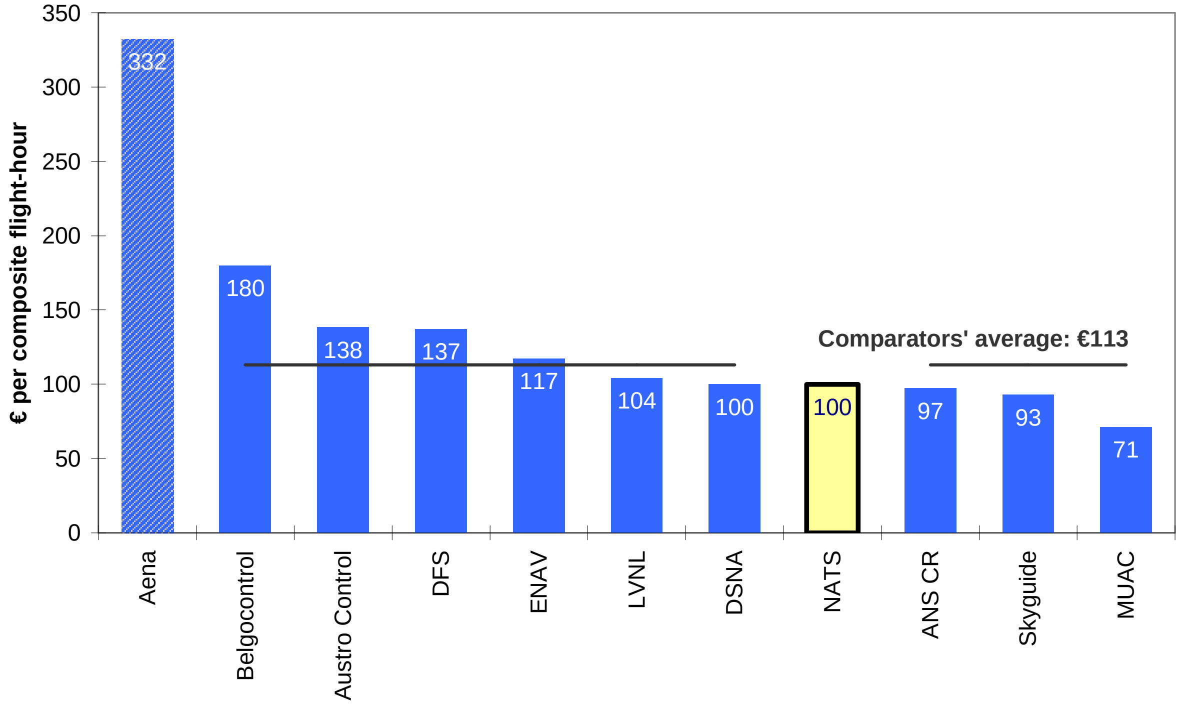


Figure 3-6: ATCO employment cost per composite flight-hour

3.3.5 ATCO productivity is one of the components of ATCO employment cost per composite flight-hour, and is calculated by taking the ratio of composite flight-hours controlled to ATCO-hours. It can be viewed as the average number of aircraft controlled per ATCO on duty.

3.3.6 Figure 3-7 presents the ATCO productivity for the sample in 2007.

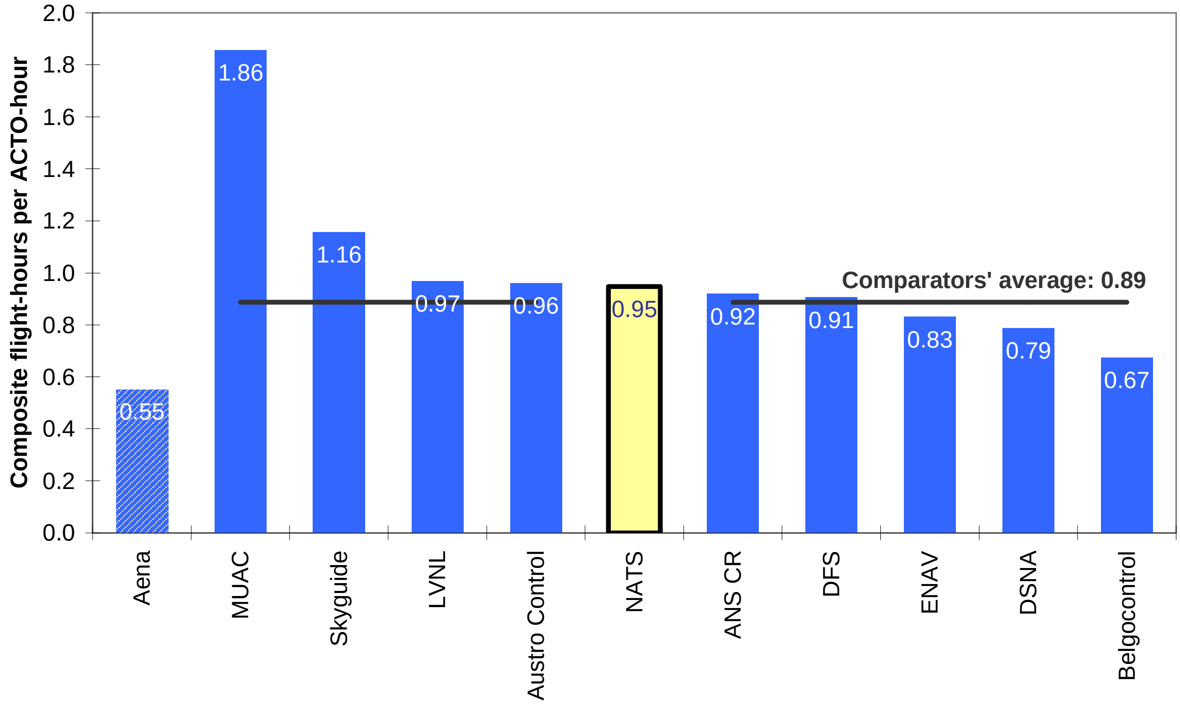


Figure 3-7: ATCO productivity

3.3.7 In 2007 NATS had a higher ATCO productivity than the average of the comparators, at 0.95 composite flight-hours per ATCO-hour compared with 0.89 for the average. MUAC has by far the highest ATCO productivity in the sample at 1.86 composite flight-hours being controller per ATCO-hour. As we shall see in Figure 4-10 productivity is generally higher in upper airspace.

3.3.8 In the 2005 benchmarking study[2] NATS ATCO productivity was approximately 1.0 composite flight-hour per ATCO-hour in 2001, falling to approximately 0.9 in 2002 and 2003. Examination of the data at ACC level indicates that this fall was largely attributable to the London AC switch to tactical/planner operations.

3.3.9 NATS had the fourth highest ATCO productivity among the ANSPs in our sample in 2001, 2002, and 2003. Since then Austro Control has raised its ATCO productivity and is now ranked higher than NATS.

3.3.10 ATCO employment cost per ATCO-hour is the second component of employment cost per composite flight-hour, and is the ratio of total ATCO employment cost to ATCO-hours.

3.3.11 Figure 3-8 below shows that NATS ATCO employment cost per ATCO-hour on duty is the third lowest of the sample and is 5% below the comparators' average.

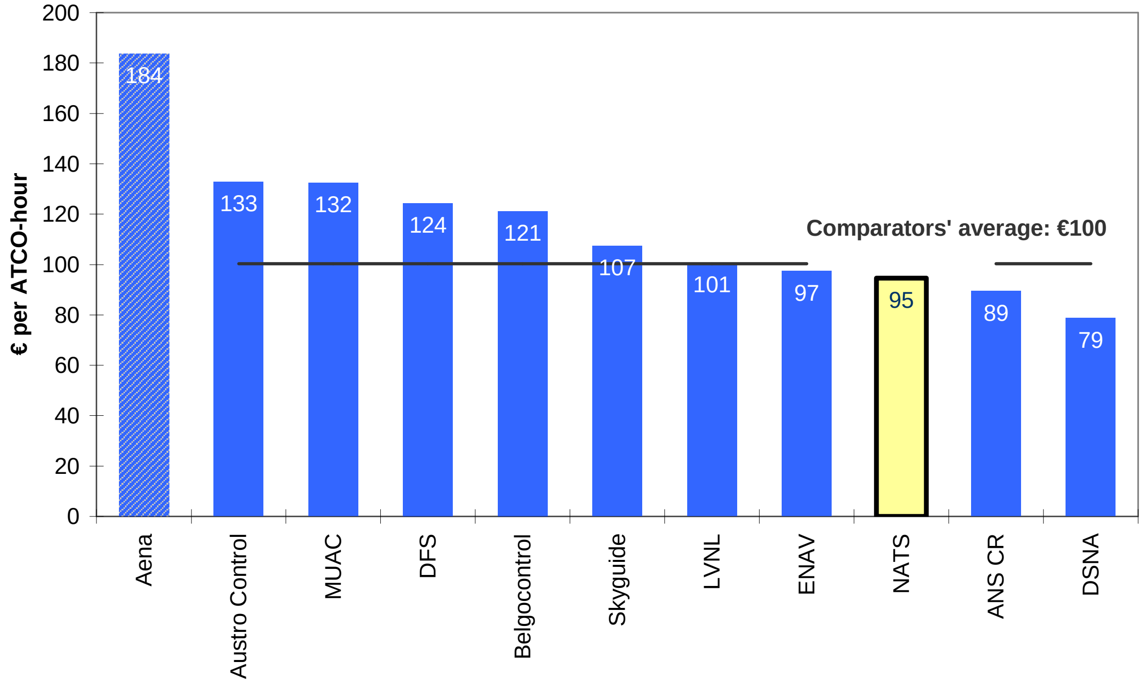


Figure 3-8: ATCO employment cost per ATCO-hour

3.3.12 In the 2005 benchmarking study[2] examining 2001 and 2002 data, NATS's ATCO employment cost per ATCO-hour was also close to the sample, being slightly above the average of the sample in 2001 and slightly below in 2002.

3.3.13 Figure 3-9 presents the average ATCO employment cost for the year 2007.

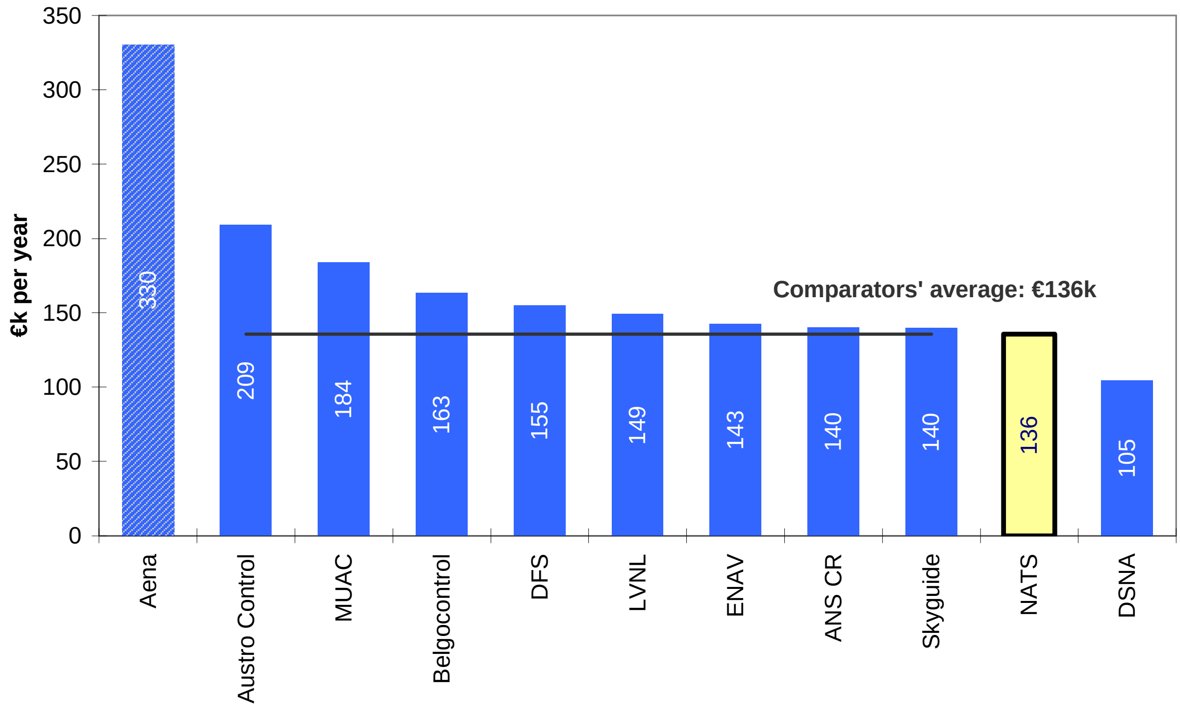


Figure 3-9: Average ATCO employment cost per year

3.3.14 NATS's average ATCO employment cost per year in 2007 was the second lowest of the sample, with only DSNA lower. However, DSNA are facing a gradual increase in social and pension contributions to the government.

3.3.15 The second component of the ATCO employment cost per ATCO-hour is the average annual hours on duty per ATCO, which is presented in Figure 3-10.

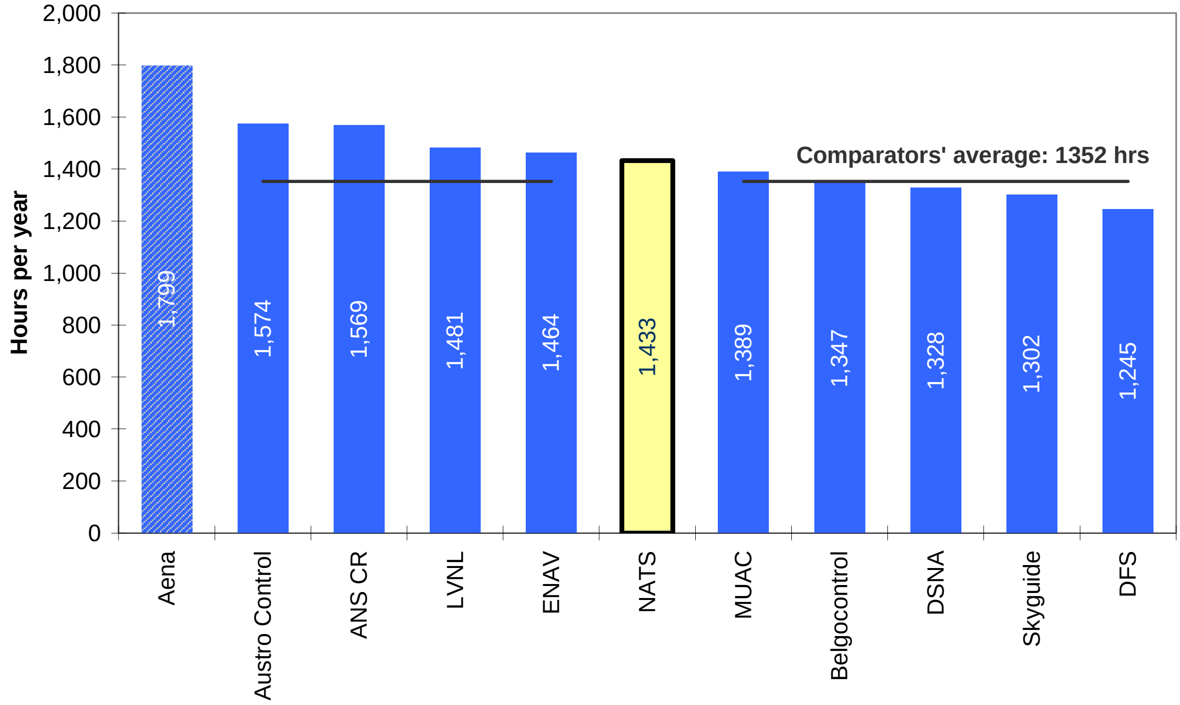


Figure 3-10: Average hours on duty per ATCO

3.3.16 On average, the ATCOs at NATS work more hours than the sample average (1433 hours a year compared with 1352 hours). Austro Control has both the highest hours worked per year and the highest ATCO cost per year.

Pension and social security costs

3.3.17 The ANSPs fund the pensions of staff in different ways. Some ANSPs pay a contribution to the national government which then funds pensions, whilst some ANSPs fund the pension schemes fully. In some, the full costs associated with the funding of pension obligations may not yet have been recognised.

3.3.18 Figure 3-11 presents a staff cost breakdown for the ANSPs in the sample. Aena and ANS CR pension costs are to some extent included in the State social security scheme contributions.

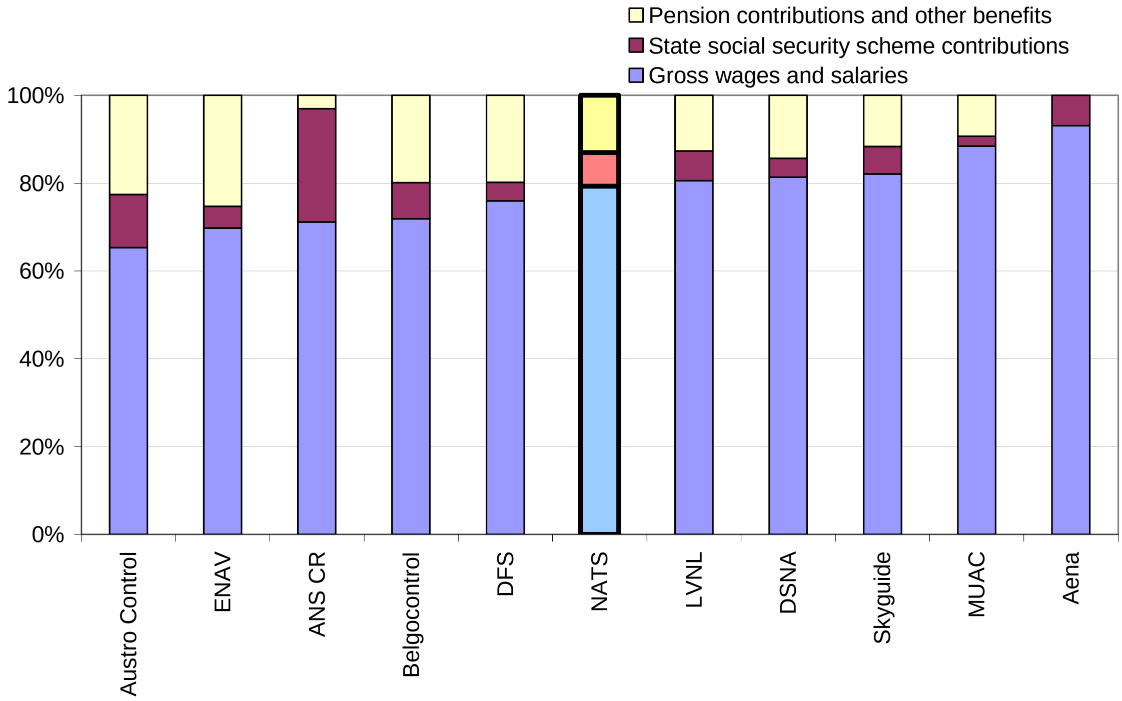


Figure 3-11: Staff cost breakdown

3.3.19 There are a number of differences in the pension costs and social security contributions made by ANSPs. In the absence of a thorough investigation of the levels of pension entitlement, and how these are funded and accounted for[13], it is difficult to come to any firm conclusions. However, it appears that NATS is not an outlier on this issue.

Changes in ATCO employment cost over time

3.3.20 Figure 3-12 presents the change in the average ATCO employment cost per year between 2003 and 2007.

[13] NATS and DFS report their pension costs in their statutory accounts and to the PRU in different ways, both of which are permitted under IFRS. Our investigations have shown that this does not result in an inconsistency in this analysis.

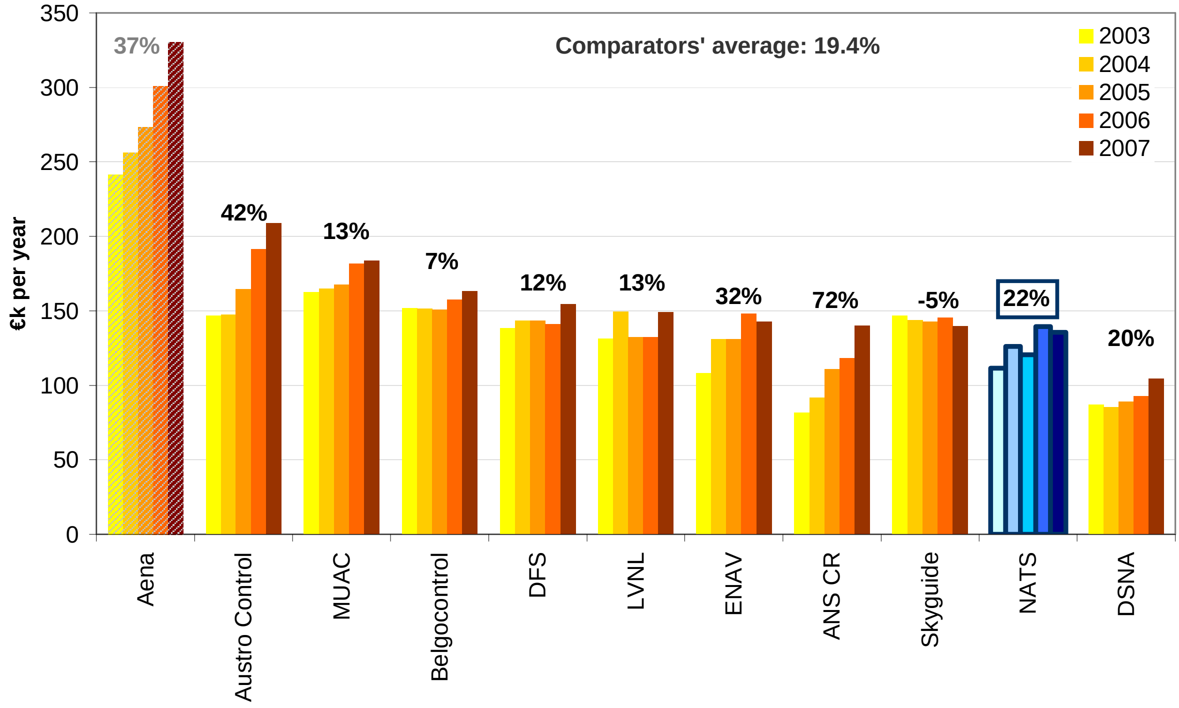


Figure 3-12: Average ATCO employment costs between 2003 and 2007

3.3.21 NATS's average ATCO employment cost per year grew by 22% between 2003 and 2007, which is slightly greater than the sample average of 19.4%. ANS CR and Austro Control have increases of 72% and 42% over the same period, whilst Belgocontrol (+7%) and Skyguide (-5%) have been more successful in controlling average ATCO employment cost. There may also be other factors, such as changes in the age distribution of ATCOs, which we have not accounted for and that may affect apparent performance.

3.4 Gross wages and salaries

3.4.1 It is interesting to examine the gross wages and salaries for ANSP staff, excluding social and pension contributions to see whether there is a relationship between the average ANSP wages and salaries and the general level of income in a country.

3.4.2 For this analysis all ANSP staff are included, as it is not possible to split ATCOs from non-ATCOs.

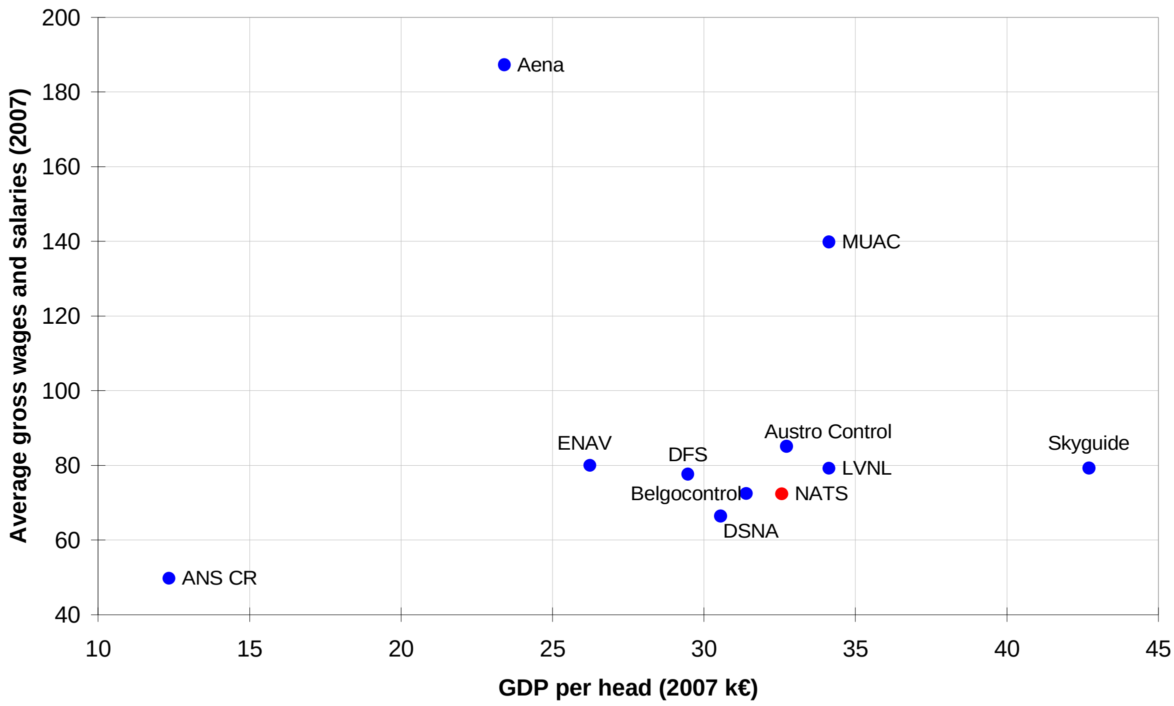


Figure 3-13: Average gross wages and salaries to GDP per head

3.4.3 The relationship between ANSP gross wages and national Gross Domestic Product (GDP) per head is weak. ENAV, DFS, LVNL and Skyguide operate in countries with GDP per head ranging from about €25,000 to €40,000 and all have about the same average wages. On the other hand, average wages at Aena and MUAC are much higher than at ENAV and LVNL, although they operate in countries with similar GDP per head. The slight correlation that can be observed suggests that the relationship is less than linear – ANSP staff tend to be paid more, relative to the average wage, in the less well-off countries.

3.4.4 Figure 3-14 presents the average ATCO employment cost compared to the GDP per head in the associated countries. The picture is broadly similar to that observed for ANSP wages, with a relatively weak correlation between wages and GDP per head, a less than linear relationship, and with Aena and MUAC as conspicuous outliers. NATS is not an outlier in this sample of ANSPs.

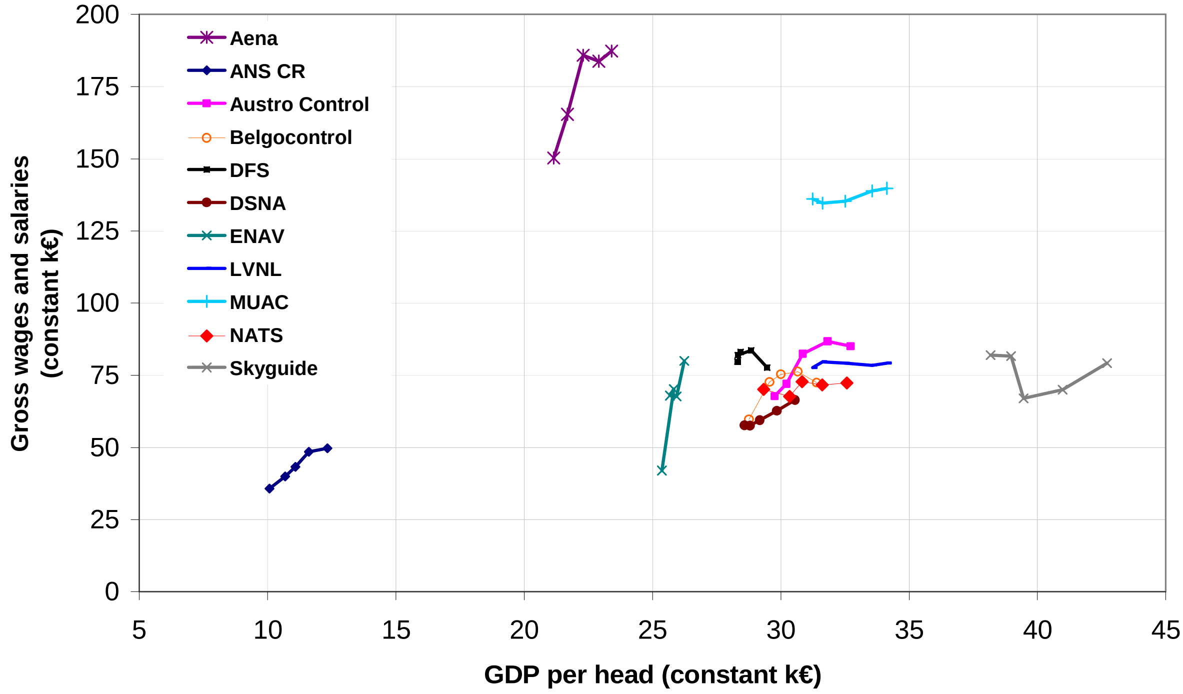


Figure 3-14: Average ATCO employment cost compared GDP per head

3.5 Support costs (gate-to-gate)

3.5.1 The unit support cost, which is the sum of the non-ATCO staff cost, non-staff operating cost and depreciation costs, excluding cost of capital, is presented in Figure 3-15.

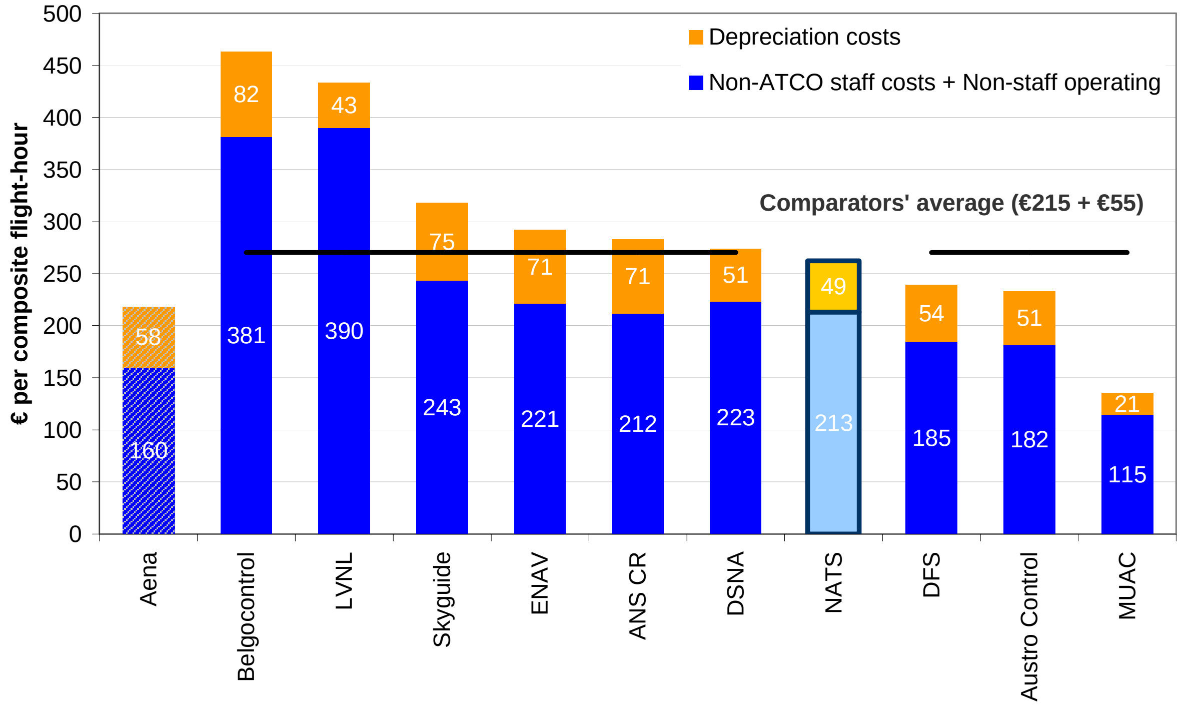


Figure 3-15: Unit support costs

3.5.2 NATS unit support costs are very close to the sample average. The depreciation is lower than average (€49 per composite flight-hour compared to the average of €55) with non-staff operating costs and non-ATCO staff costs also being marginally lower than average (€213 per composite flight-hour, compared to the average of €215).

3.5.3 Figure 3-16 presents the changes in unit support costs between 2003 and 2007.

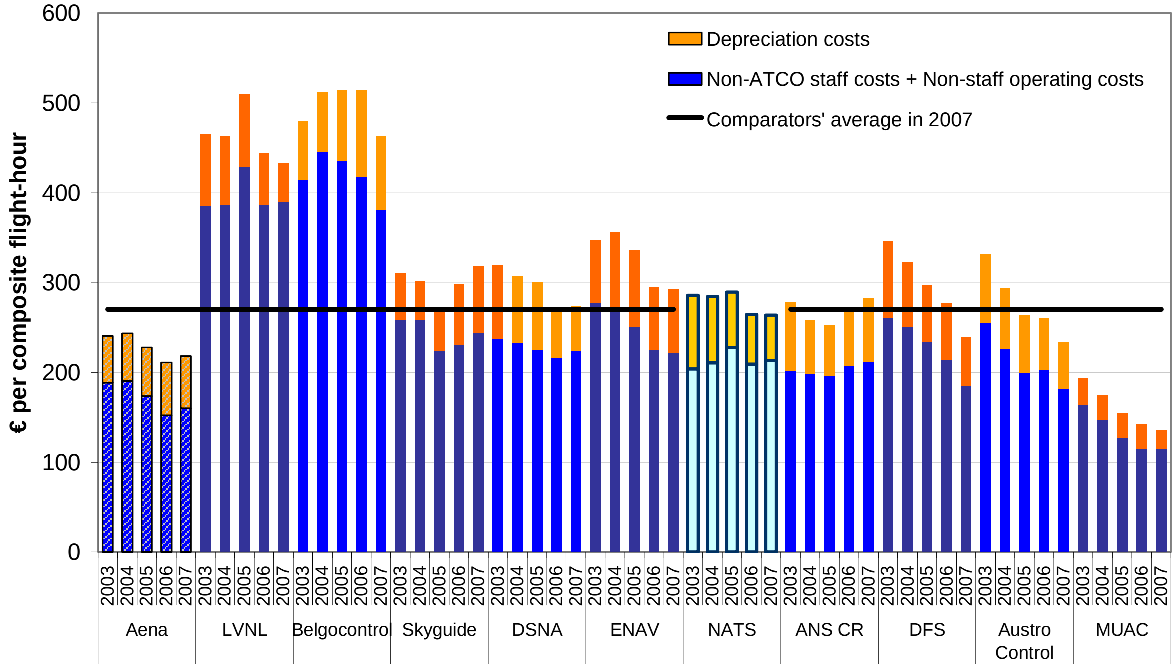


Figure 3-16: Changes in unit support costs between 2003 and 2007

3.5.4 In 2003, NATS's support costs per composite flight-hour were approximately 14% lower than those of its comparators (that is €286 compared with €331). In 2007, this difference was reduced to only 3% (that is €262 compared to €270). Between 2003 and 2007, the reduction in NATS support costs per composite flight-hour was entirely driven by a reduction in depreciation costs (-33%). LVNL, DSNA, Austro Control, DFS and MUAC also reported a reduction in depreciation costs over the period.

3.5.5 This contrasts with NATS's position in 2001, where their unit support costs (excluding depreciation) were the highest in the sample. These were reduced considerably in 2002, but remained above the sample average. This appears to be the result both of support cost reductions in NATS and substantial rises in some of the comparators.

3.5.6 The following analyses present the support costs broken down into its constituent parts:

- staff costs for non-ATCOs, including a breakdown on non-ATCO staff;
- non-staff operating costs; and
- depreciation costs.

3.5.7 A number of ANSPs outsource some of their staff and services. Outsourcing a service transfers a cost from staff costs for non-ATCOs to non-staff operating costs, and this limits the usefulness of comparisons of the first two components individually.

Non-ATCO staff cost and non-staff operating costs

3.5.8 Figure 3-17 presents the non-ATCO staff cost and the non-staff operating cost components of support cost, per composite flight-hour, for the sample of ANSPs.

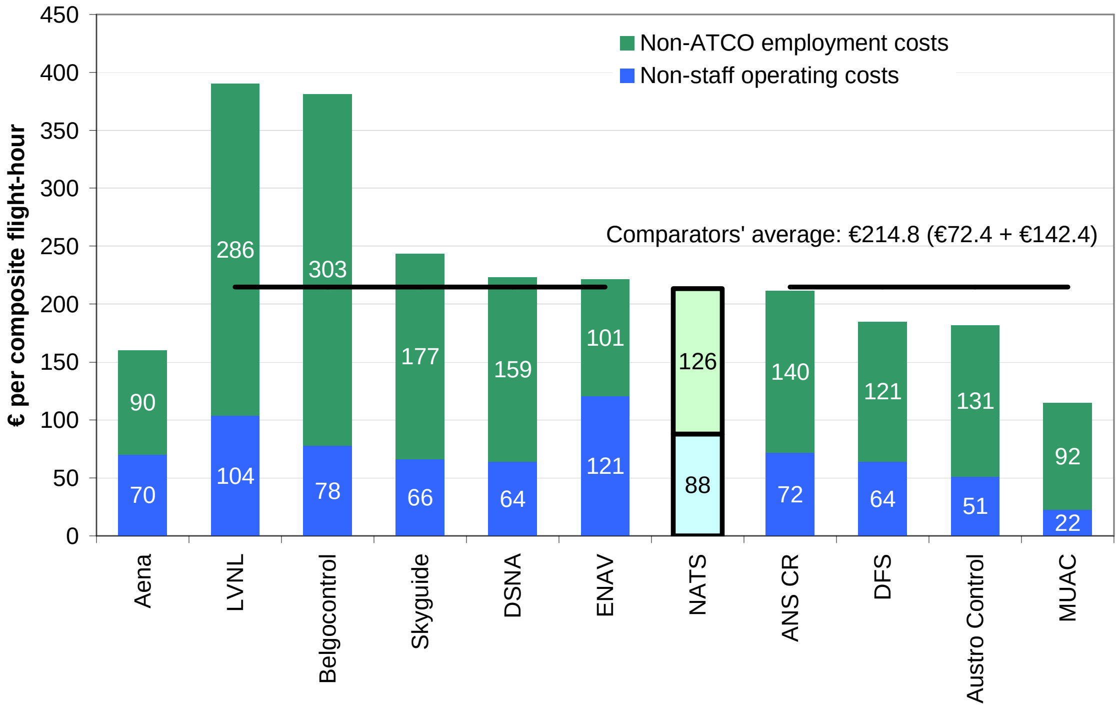


Figure 3-17: Non-ATCOs staff costs and non-staff operating costs

3.5.9 NATS has a non-ATCO staff cost per flight-hour below the sample average. However, NATS non-staff operating cost per composite flight-hour (€88) is considerably higher than average (€72).

3.5.10 The high values of non-staff operating cost for NATS and ENAV reflect the high amount of outsourcing employed by these ANSPs.

Staff breakdown

3.5.11 Figure 3-18 shows the support staff ratio, defined by the PRU as:

$$\text{Support Staff Ratio} = \frac{\text{Total staff}}{\text{Total ATCOs in Ops}}$$

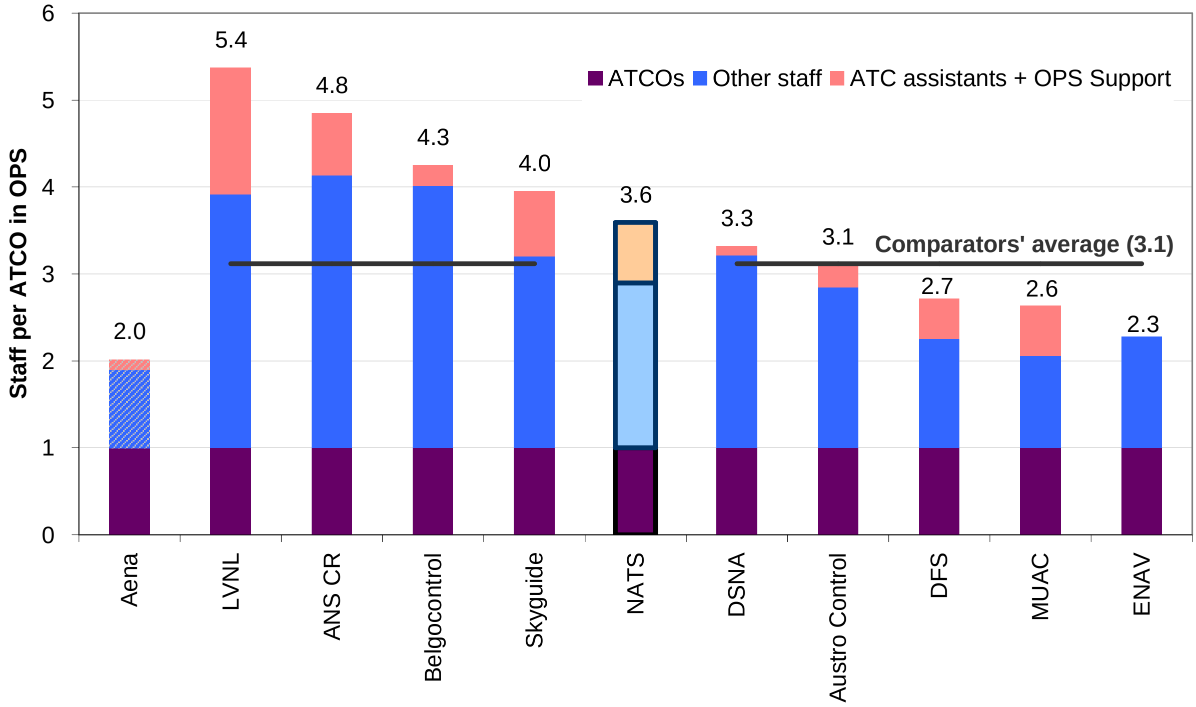


Figure 3-18: Support staff ratio

3.5.12 For every ATCO on operational duty NATS employs 2.6 additional staff, while on average the comparators require 2.1 additional staff.

3.5.13 NATS's practice at London TC and its other centres was to staff operating positions with a mixture of qualified ATCOs and Air Traffic Service Assistants (ATSAs) qualified to a less rigorous standard. This practice is unusual in the European context.

3.5.14 It could be argued that the use of ATSAs in an operational role might increase the productivity of the ATCOs. Since, however, by the PRU's definitions, ATSAs and their equivalents elsewhere are counted as "support", it would increase the support cost per unit output. This is consistent with the apparent high productivity of NATS ATCOs, combined with their high support costs.

Depreciation costs

3.5.15 The depreciation cost for each ANSP per composite flight-hour is presented in Figure 3-19.

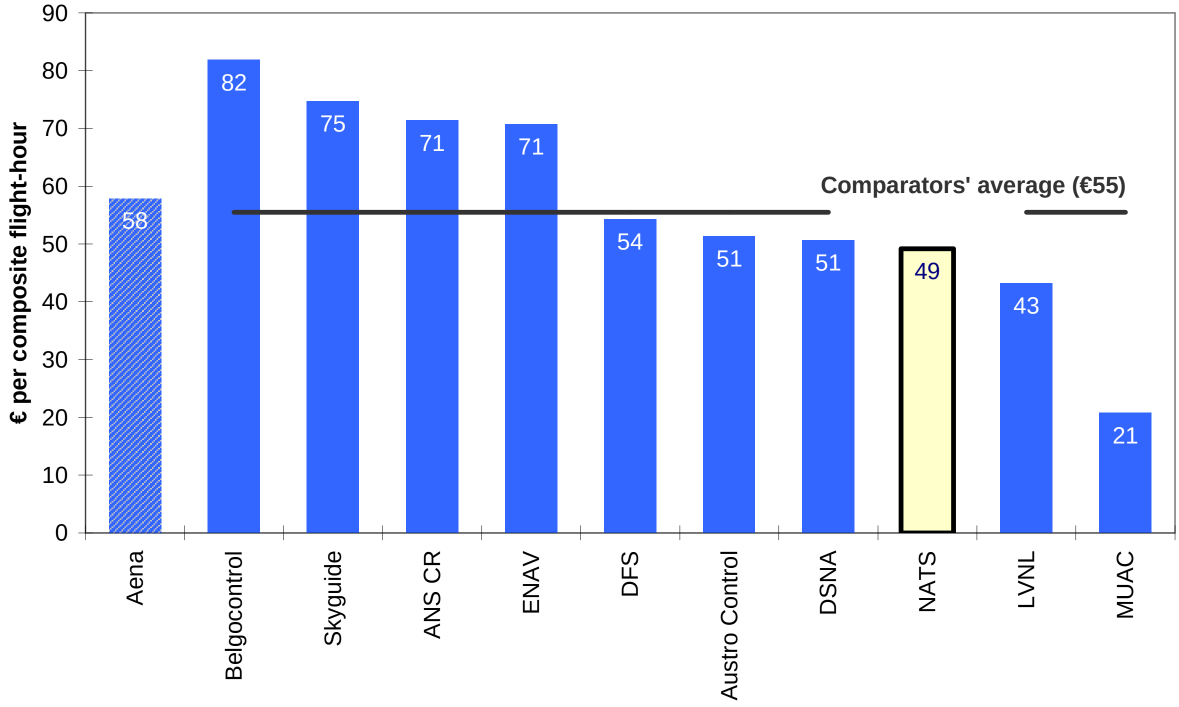


Figure 3-19: Depreciation costs

3.5.16 NATS's depreciation costs are 11% below the sample average. This constitutes a reduction relative to their position in 2003, in which NATS were 7% below the sample average.

Support cost and ATCO productivity

3.5.17 It is interesting to assess whether there is a relationship between ATCO productivity and the support cost per ATCO-hour, that is, is there any suggestion that spending more money 'behind the scenes' for each ATCO-hour employed is associated with a rise in the productivity of that ATCO-hour?

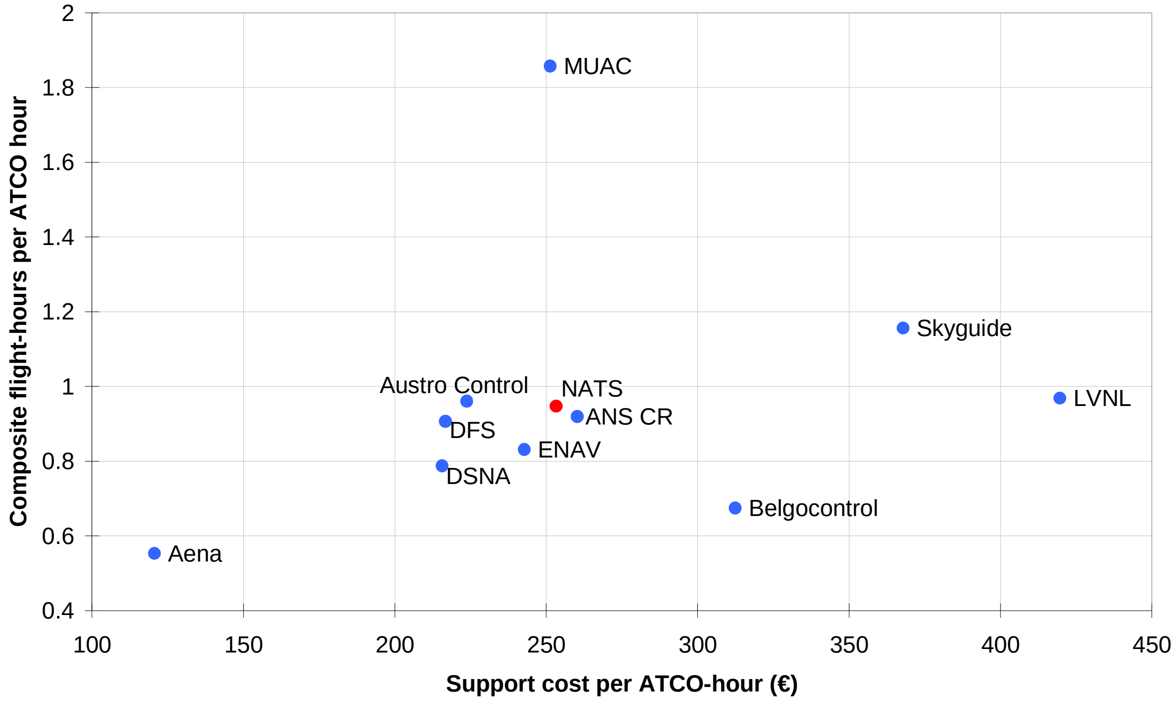


Figure 3-20: Support cost per ATCO-hour versus ATCO productivity

3.5.18 Figure 3-20 presents the support cost per ATCO-hour compared with the ATCO productivity. From visual inspection there appears to be a weak positive association between support costs and ATCO productivity. It also shows that NATS is not an outlier compared to the sample.

3.5.19 Support costs for Belgocontrol, LVNL and (to a lesser extent) DFS are overstated, and those for MUAC understated, because the CNS infrastructure costs for the airspace MUAC controls are borne by the national ANSPs. Reallocating the composite flight-hours per ATCO-hour for MUAC would require making a series of problematical assumptions on ATCO productivity and ATCO working hours. We have not attempted such a correction – however, it would be unlikely to alter the fact that MUAC's productivity is unusually high.

3.6 Quality of service at ANSP level

3.6.1 Quality of service is an important aspect of ANS provision. Poor quality of service can lead to airlines suffering increased costs as a result of delays or flight inefficiency. This section explores:

- total en-route ATFM delay per flight-hour; and
- horizontal flight-efficiency.

Total en-route ATFM delay per flight-hour

3.6.2 We used as our delay indicator the en-route ATFM delay, taken from the information published by the PRC in its annual Performance Review Report relating to 2007 (PRR 2007). ANSPs' delays are the sum of the respective delays in each of the FIRs they control. Four delay causes are identified, which differ in whether they are within the control of the ANSP:

- ATC Capacity and Staffing. Delay generated by this cause is usually attributable to the ANSP, it is largely within their control.
- ATC Other, which includes delay caused by strikes or equipment failure. Delay generated by this cause is usually attributable to the ANSP.
- Weather. Delay generated by adverse weather conditions is not usually attributable to the ANSP.
- Other, which includes delay generated by military use of airspace and special events. Delay generated by these delay causes is usually outside the control of the ANSP.

3.6.3 On average, according to PRR 2007, ATC capacity related delays and ATC special events account for 78% and 6% respectively, of total en-route ATFM delay. Weather-related delays and other delays account for 12% and 4% respectively of the total. Therefore, the large majority of these en-route ATFM delays are under the control of ANSPs (and under the control of NERL in the particular case of NATS).

3.6.4 Figure 3-21 shows the percentage of the total en-route ATFM delay that arises from various causes, for the airspace controlled by each ANSP.

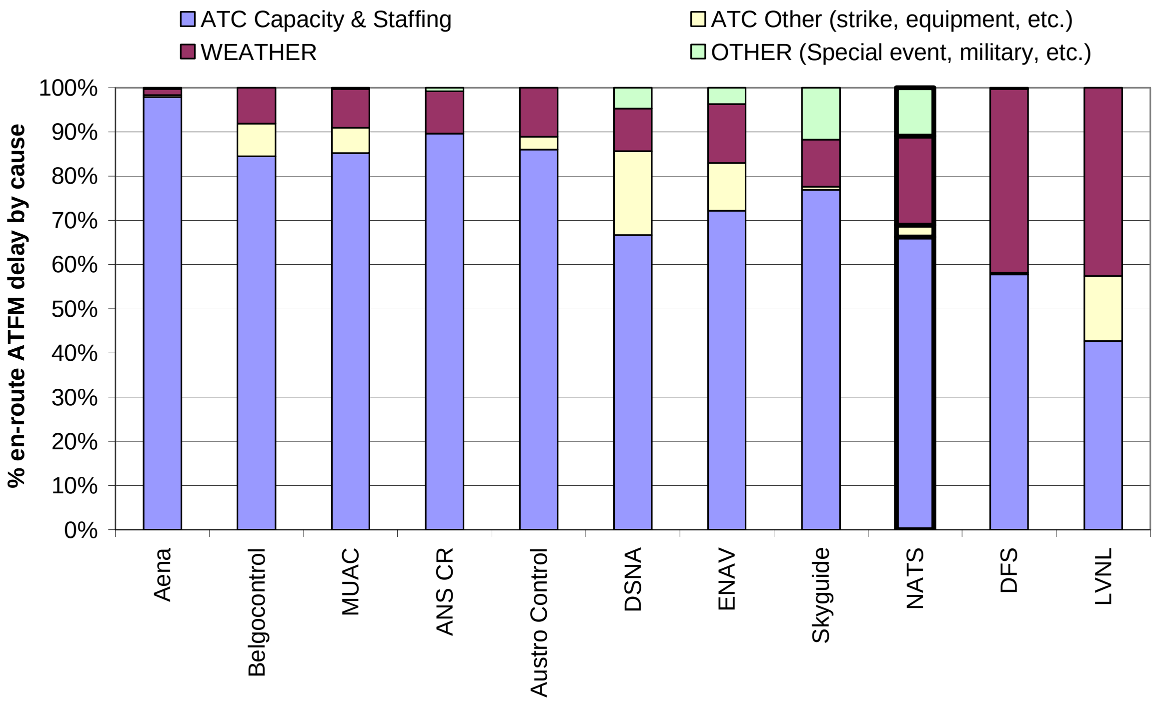


Figure 3-21: Percentage en-route ATFM delay by delay cause

3.6.5 The proportion of ATFM delay in UK airspace that arises from the first two causes listed above is relatively low at under 70%, suggesting that NATS's comparative delay performance may be better than appears in Figure 3-22 and Figure 3-23.

3.6.6 The PRU, however, recommends treating these figures with some caution. The allocation of delay causes is not undertaken in a uniform manner between ANSPs.

3.6.7 The en-route ATFM delay per flight-hour for the sample ANSPs is presented in Figure 3-22. The airspace controlled by NATS generates more delay per flight-hour than the sample average. The sample average is 0.95 minutes of delay per flight-hour compared to NATS's figure of 1.16 minutes per flight-hour.

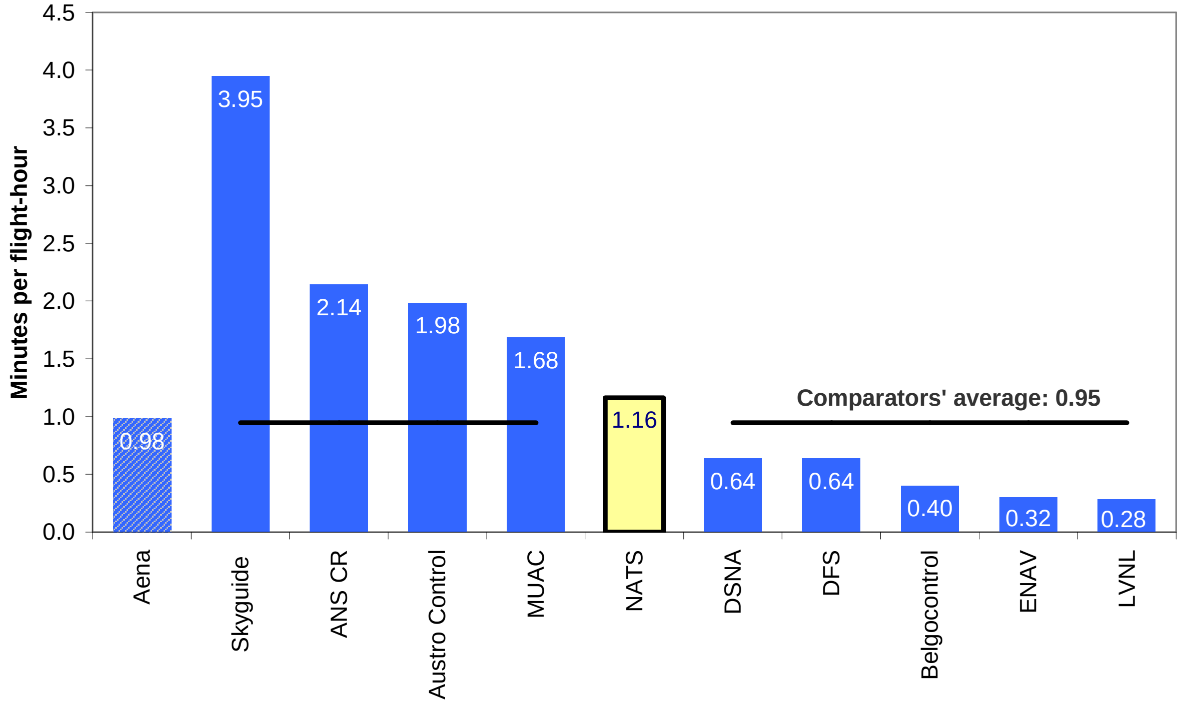


Figure 3-22: En-route ATFM delay per flight-hour

3.6.8 However, Skyguide has a much higher than average delay per flight-hour. This is a combination of high average en-route ATFM delay per flight and a relatively short transit time for aircraft flying through Swiss airspace.

3.6.9 Figure 3-23 presents the change in en-route ATFM delay per flight-hour between 2003 and 2007 for each ANSP in the sample. En-route delay over the time period has remained relatively stable for most ANSPs, with larger variations observed for ANS CR, Austro Control, MUAC and Skyguide.

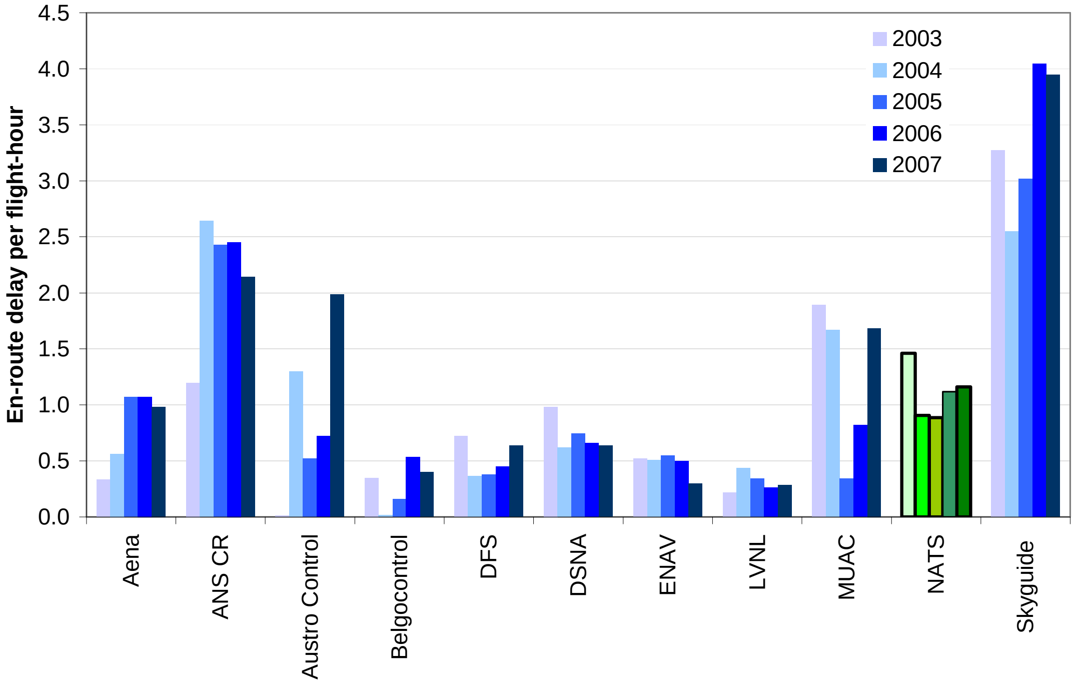


Figure 3-23: 2003-2007 changes in en-route ATFM delay per flight-hour

Horizontal flight-efficiency

3.6.10 Horizontal flight-efficiency is a measure of the actual flown distance compared to the shortest possible, or great-circle distance. The difference between these two values gives the 'excess kilometres flown' by flights in each of the sample ANSPs.

3.6.11 For terminating flights there can also be an additional distance caused by airspace structure and approach procedures in the vicinity of national airports.

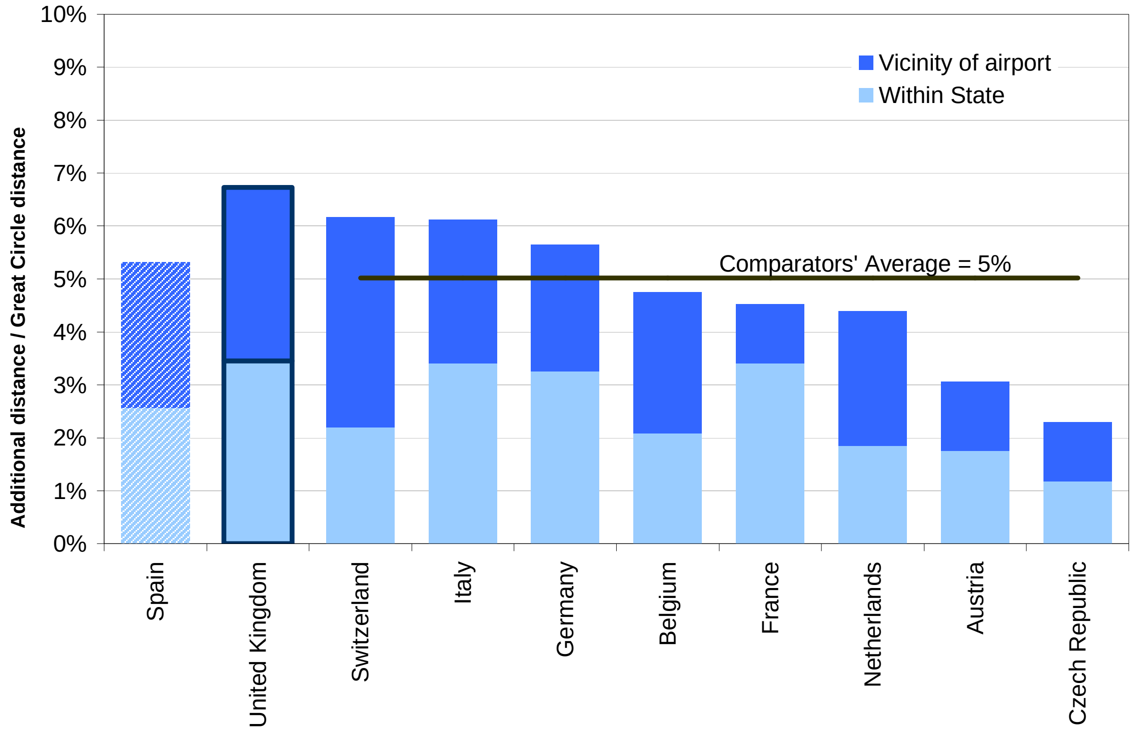


Figure 3-24: Flight-efficiency for the comparators

3.6.12 The UK has the highest horizontal flight inefficiency of the sample, with an excess 6.7 km for every 100 km flown, compared to the average of 5 km.

3.6.13 We emphasise that this figure does not take into account any exogenous factors that influence flight-efficiency nor any trade-offs (for instance, with capacity) that may be inherent in airspace design and operation. Military training areas, for example, are a major cause of flight inefficiencies in the UK, and this is something that is not within the control of NATS.

3.7 Forward-looking performance

3.7.1 Figures for the forward looking projections are those provided to the PRU as part of ACE 2007 and date from November 2008. Inevitably, and to a greater extent than normal, these will be out of date because of the economic crisis and its associated impacts on traffic, pension liabilities, and as well as ANSP's plans to deal with these issues. These may alter the comparisons that flow out of the ACE figures. Nevertheless, for completeness the analysis is shown here.

3.7.2 The projected performance of NATS compared to the selected ANSPs is measured by examining the information disclosed by ANSPs providing projections for 2008 to 2012 for the following items:

- traffic growth;
- en-route costs, excluding cost of capital and exceptional items;
- financial cost-effectiveness; and
- capital expenditure.

3.7.3 Further updates to traffic projections caused by the fast-changing economic situation could have a considerable impact on the projections of financial cost-effectiveness over the period. Reduced demand growth may lead to higher unit costs and therefore a deterioration in performance. ANSPs may differ in their flexibility in cutting operating costs and rescheduling investments to respond to lower expected demand.

Projected traffic growth

3.7.4 The projected traffic growth for NATS is presented in Figure 3-25. It shows the highest and lowest projections of traffic increase amongst the sample ANSPs, ANS CR and Aena, respectively, and also the average of the sample, excluding NATS and Aena.

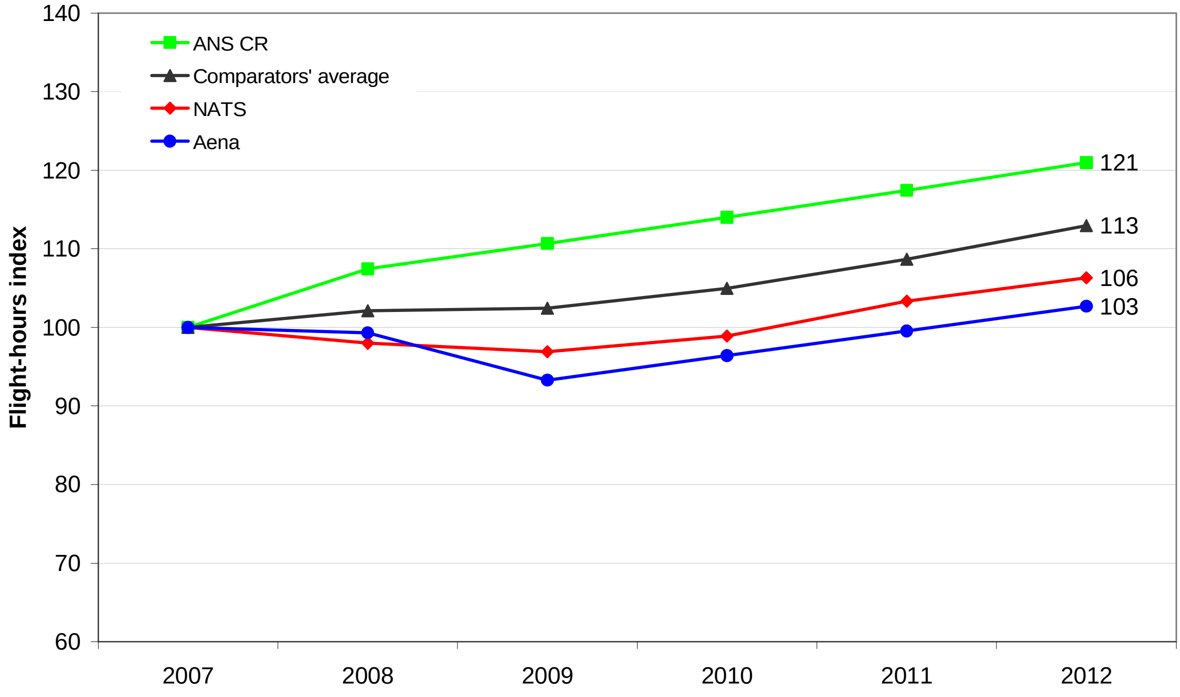


Figure 3-25: Projected traffic growth index

3.7.5 NATS has lower projected traffic growth than the sample average, with traffic expected to be 6% higher in 2012 compared to 2007. The highest projected growth is ANS CR with a rise of 21% compared to 2007. Aena has provided the most conservative figures, projecting that traffic will be 3% higher in 2012 compared to 2007.

3.7.6 To further develop this analysis there is a possibility of exploring the CRCO submissions of June 2009, when the data becomes available.

Projected en-route ATM/CNS costs

3.7.7 The projected en-route ATM/CNS costs for NATS compared to the sample of ANSPs is presented in Figure 3-26. To be consistent with the historical analysis the projected costs exclude the cost of capital and exceptional items.

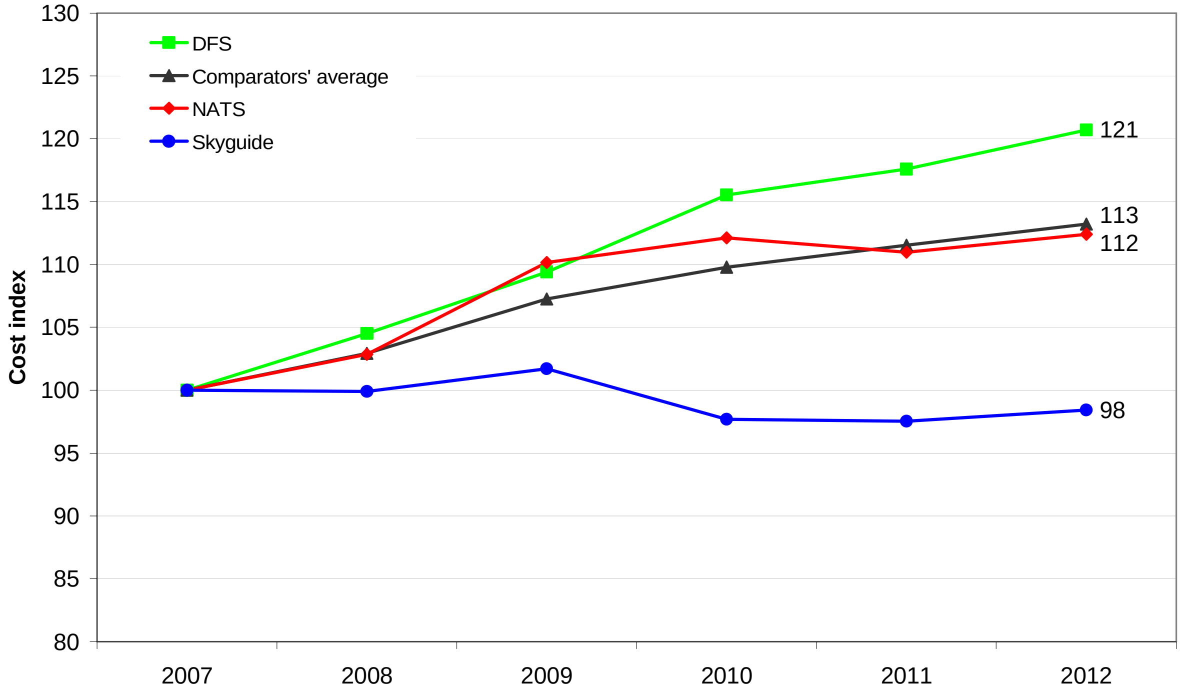


Figure 3-26: Projected en-route ATM/CNS costs index

3.7.8 NATS's projected increase in en-route ATM/CNS costs between 2007 and 2010 is similar to the projected increase for the sample. There is a marked increase for NATS in 2009 compared to the sample.

3.7.9 DFS foresee greater increases than the comparators' average, with a 21% increase in en-route costs between 2007 and 2012, whilst Skyguide foresee a 2% reduction in costs over the same period.

3.7.10 NATS have provided Helios with an updated projection of costs and traffic for 2009 to 2012[14]. We have not obtained updated information from comparator ANSPs, therefore it would be inappropriate to include this update in the benchmarking analysis presented above. It is, however, interesting to see the impact of NATS's latest forecast of the total cost of en-route ATM/CNS provision. This forecast is compared to that submitted to the PRU for ACE 2007 in Figure 3-27, below.

[14] The updated projection of costs that NATS provided is based on the ACE 2008 reporting framework. The PRC has made minor modifications to the reporting requirements, however, we understand that for the forward-looking information the 2008 reporting framework is comparable with that of 2007.

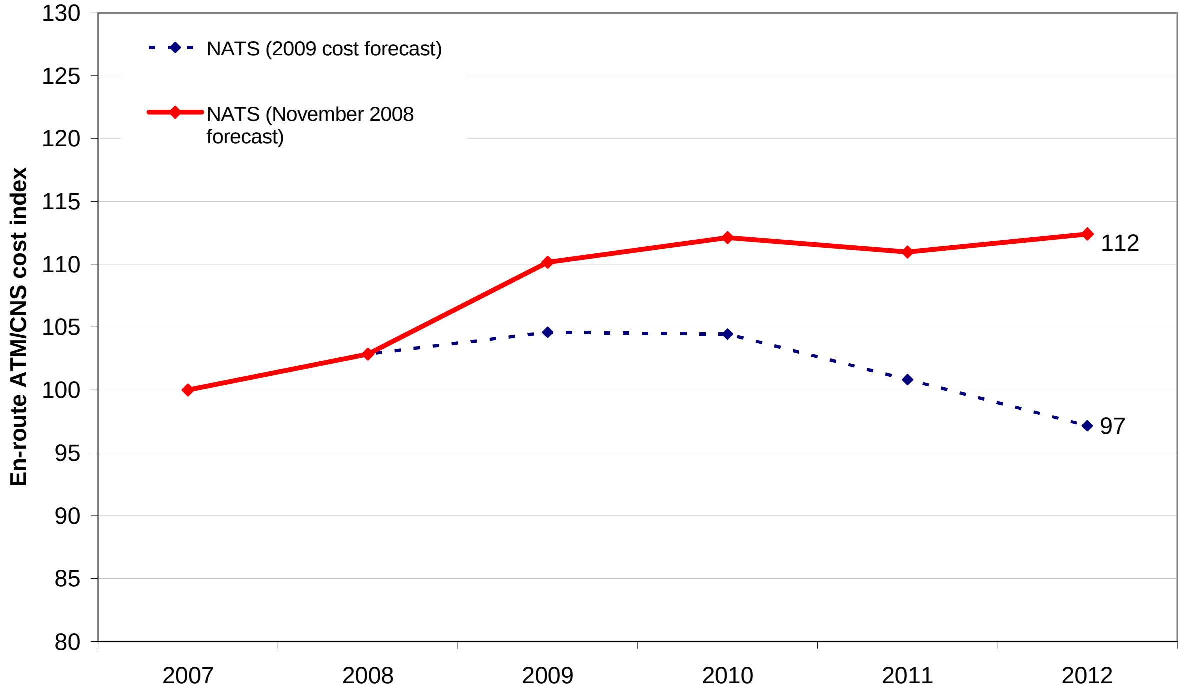


Figure 3-27: Comparison of projected en-route ATM/CNS cost index

3.7.11 The cost projections for NATS that were provided by NATS to Helios show a considerable reduction in the en-route ATM/CNS cost from 2009 onwards, compared to the forecast that was submitted to the PRU for ACE 2007.

Projected en-route financial cost-effectiveness

3.7.12 The projected en-route financial cost-effectiveness for NATS compared to the comparators' average is presented in Figure 3-28. Because of the marked change in the £/€ exchange rate between 2007 and 2009, we have presented the figures calculated at two alternative exchange rates, the 2007 exchange rate and the exchange rate for the first sixth months of 2009. The projected en-route cost per flight-hour excludes cost of capital and the cost of exceptional items.

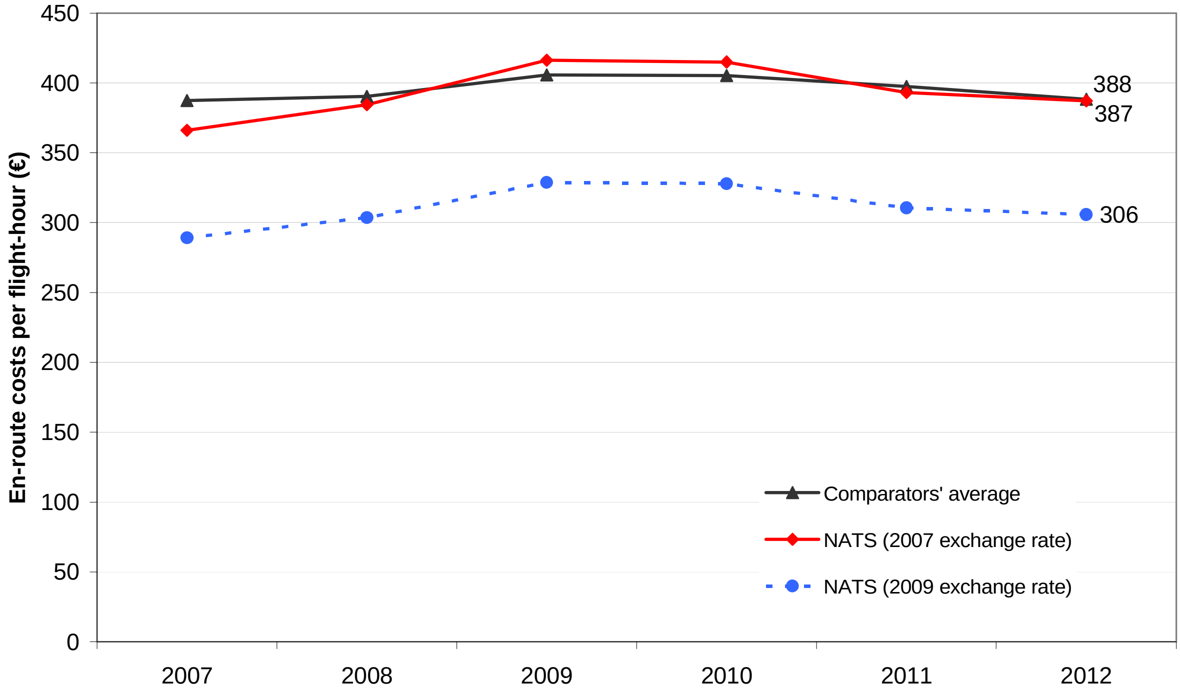


Figure 3-28: Projected en-route cost per flight-hour

3.7.13 When using the 2007 exchange rate NATS is projected to track below the sample average for en-route cost per flight-hour through to 2012, rising above the sample average in 2009 and 2010. This is a result of the low traffic projection (compared to the sample average) and the projected increase in costs in 2009.

3.7.14 When using the 2009 exchange rate the en-route cost per flight-hour is more than 21% lower than the values using the 2007 exchange rates, because of the fall in the value of the pound compared to the euro.

3.7.15 The current economic climate, and downturn in traffic demand, means that the projected performance disclosed in November 2008 is likely to be out of date. Updating this information was possible for NATS as they provided more recent forward-looking projections. It was much more difficult to update this analysis for the comparators, and so the benchmarking was undertaken using the data from November 2008.

Capital expenditure

3.7.16 The forward-looking capital expenditure plans for each of the sample ANSPs is presented in Table 3-1.

ANSP	Cumulative capex for 2004-2007 (4 years)	Cumulative capex for 2008 to 2012 (5 years)	Ratio of capex per year 2008-2012 to capex per year 2004-2007
Aena	€622m	€777m	1.00
ANS CR	€129m	€91m	0.56
Austro Control	€107m	€171m	1.28
Belgocontrol	€142m	€99m	0.56
DFS	€308m	€530m	1.38
DSNA	€648m	€802m	0.99
ENAV	€732m	€738m	0.81
LVNL	€32m	€66m	1.64
MUAC	€75m	€82m	0.88
NATS	€786m	€880m	0.89
Skyguide	€229m	€141m	0.49

Table 3-1: Cumulative capital expenditure for sample ANSPs

3.7.17 We note from Table 3-1 above that NATS planned capital expenditure for the 2008-2012 period is projected to be €880m, which is more than any of the other ANSPs.

3.7.18 The difference in scale of investments is also interesting. In absolute terms, NATS five-year capex is more than ten times that of LVNL or MUAC. It is also higher than the cumulative capex of the six smallest ANSPs in the sample taken together (ANS CR, Austro Control, Belgocontrol, LVNL, MUAC and Skyguide).

3.7.19 The following observations are made regarding ratio of the planned annual capex for ANSPs in 2008 to 2012 to the historical figures for annual capex from 2004 to 2007.

- Aena, DSNA, MUAC and NATS's planned annual capex over the 2008-2012 period is similar to the observed annual capex over the 2004-2007 period;
- LVNL, DFS and Austro Control's planned annual capex over the 2008-2012 period is significantly higher than over the 2004-2007 period;
- Skyguide, Belgocontrol, ANS CR and to a lesser extent ENAV plan annual capex over the 2008-2012 period that is significantly lower than over the 2004-2007 period.

3.7.20 Figure 3-29 presents the ratio of capital expenditure to operating cost for the comparator ANSPs. NATS ratio is at the top end, but this is because it is in the course of restructuring its centres. DFS by contrast has finished its restructuring. We note that the forward-looking information provided by ANSPs in November is likely to be out of date and ANSPs might cut back on capital expenditure more than envisaged last year.

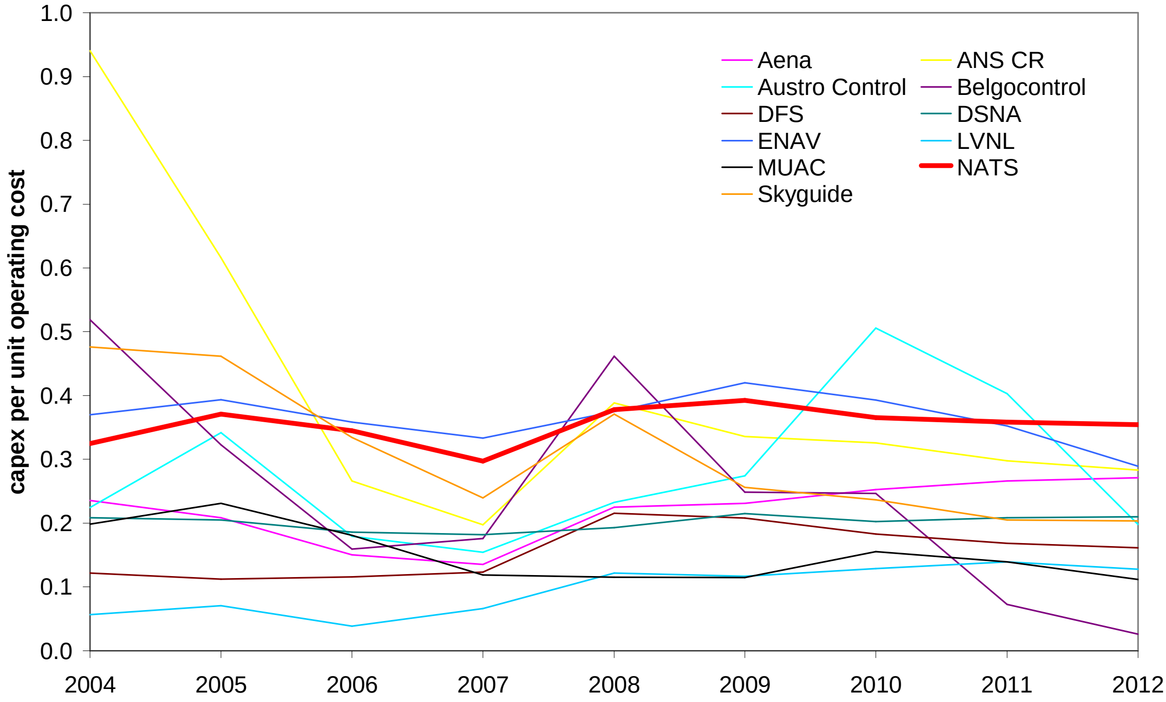


Figure 3-29: Capex/operating cost ratio

4 Descriptive analysis at ACC level

4.1 Introduction to ACC analysis

4.1.1 This chapter presents our analysis of the KPIs for NATS's ACCs compared to the ACCs of the other comparator ANSPs. The characteristics of ACCs within ANSPs can vary greatly: for example two NATS ACCs; Scottish ACC (low traffic complexity and density) and London TC (high complexity and density). Therefore, the results for NATS as an ANSP do not show the variations within the ANSPs, and an analysis at ACC level can provide greater insight. It also enables the performance of NATS's ACCs to be compared with ACCs of similar characteristics from elsewhere in Europe. However, no consistent cost data is available at ACC level, and therefore comparison of ACCs is confined to an analysis of ATCO productivity.

4.1.2 Section 4.2 presents the ATCO productivity of the ACCs, including the changes that have taken place between 2003 and 2007, and then 2006 and 2007.

4.1.3 Section 4.3 presents an analysis of the varying traffic conditions among the sample ACCs and Section 4.4 presents an initial analysis of the impact of exogenous factors on ATCO productivity.

4.1.4 Section 4.5 presents the quality of service at the sample ACCs.

4.2 ATCO productivity

4.2.1 In this section we examine the ATCO productivity (flight-hours per ATCO-hour) in the ACCs of the sample ANSPs selected for comparison as described in the previous chapter.

4.2.2 Figure 4-1 shows the ATCO productivity in the ACCs of the sample ANSPs in 2007. The four NATS ACCs are highlighted. As discussed in the previous chapter, NATS productivity is higher than average, and this is particularly apparent in London Area Control (London AC) and Scottish ACC. Manchester and London TC have lower productivity than London AC and Scottish, and also productivity lower than the sample average. Maastricht, an upper airspace centre, is the most productive.

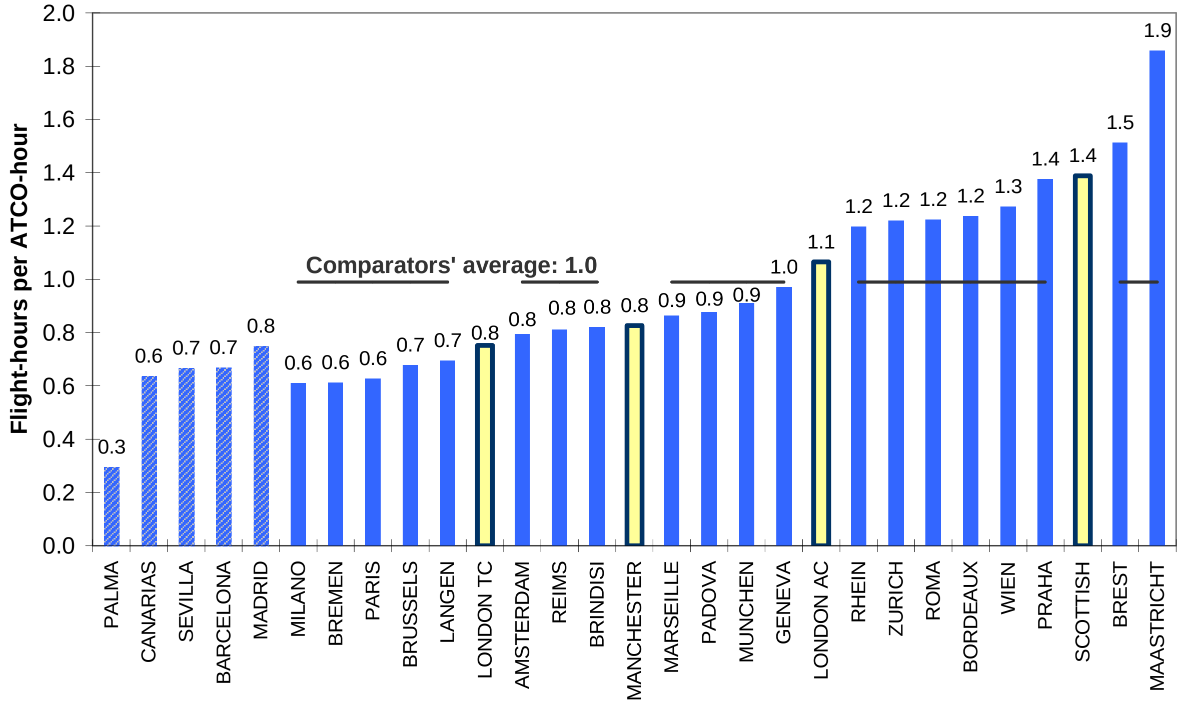


Figure 4-1: ACC ATCO productivity

4.2.3 The changes in ATCO productivity that have been observed, both between 2003 and 2007, and 2006 and 2007 are in some cases substantial. All of NATS's ACCs show a rise in productivity over both periods of time.

4.2.4 Figure 4-2 shows the changes in ATCO productivity for the ACCs in the sample between 2003 and 2007. It shows that London TC has raised productivity by 28% between 2003 and 2007. This results from a 31% rise in flight-hours and a 2% rise in ATCO-hours. The observed rise in flight-hours (+31%) is substantially greater than the overall NATS ACCs traffic increase (+20%).

4.2.5 Langen ACC did not exist in 2003 – it was formed from the merger of Frankfurt and Düsseldorf ACCs – so no result is presented.

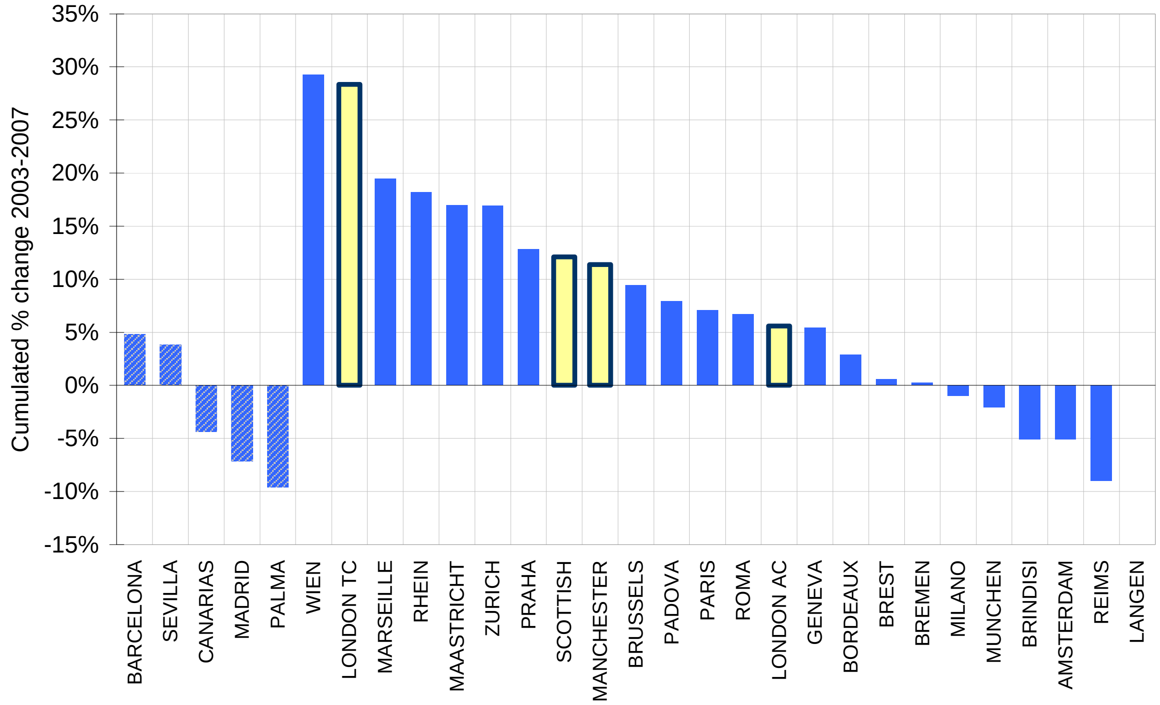


Figure 4-2: 2003-2007 changes in ACC ATCO productivity

4.2.6 All NATS's ACCs raised ATCO productivity between 2006 and 2007, as shown in Figure 4-3. London TC productivity rose by a very substantial 14% between 2006 and 2007; we understand that this was the result of London TC retaining, in the years around the move to Swanwick, an excess of ATCOs, to facilitate the transfer. This excess was substantially reduced in 2007.

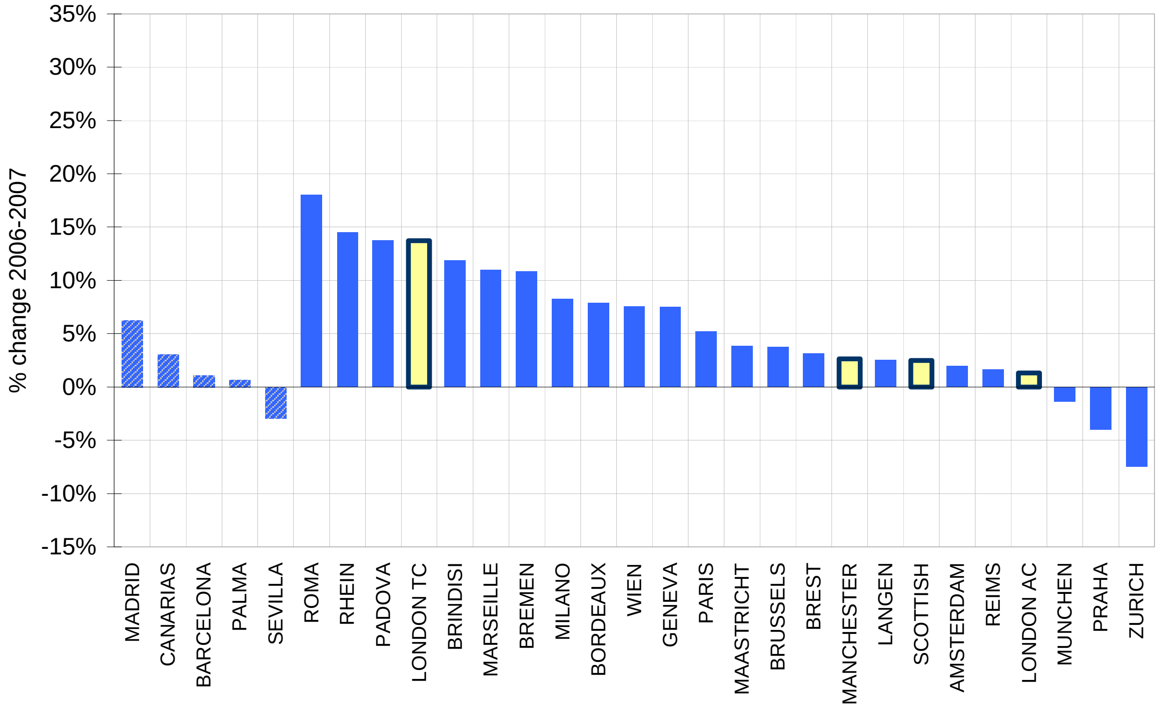


Figure 4-3: 2006-2007 changes in ACC ATCO productivity

4.2.7 We now examine existing indicators of traffic complexity, and show how these indicators may influence ATCO productivity.

4.3 Traffic conditions

4.3.1 The condition of traffic under the control of an ANSP has a considerable impact on the productivity of ATCOs that handle the traffic. There are a number of measures of traffic conditions that have been defined and measured by the PRU[15]:

- Aggregated complexity, which is the product of the adjusted density and the structural complexity:
  - Adjusted density, which measures the volume of traffic in a given volume of airspace taking into account the concentration of the traffic in space and in time.
  - Structural complexity, which reflects the structure of traffic flows. It is defined as the sum of interactions between flights: horizontal interactions (different headings), vertical interactions (climb/descend) and interactions due to different speeds (overtaking).
- Average flight level used is a proxy for traffic complexity; aircraft flying at a higher altitude are less likely to undertake manoeuvres requiring ATCO time to instruct the aircraft and monitor its progress.

4.3.2 Aggregated complexity and its components, and average flight level used are explored in the following sections.

Aggregated complexity

4.3.3 Figure 4-4 shows the aggregated complexity score for the sample ACCs, by presenting the two components of aggregated complexity; adjusted density and structural complexity. It shows that three of NATS's four ACCs have a high aggregated complexity compared to the sample. London TC is an extraordinary outlier, with an aggregated complexity score of forty, over two and a half times the value of the second highest ACC, Langen which has an aggregated complexity score of 14.

4.3.4 Scottish ACC is the only NATS ACC that is lower than the average aggregated complexity of the sample.

[15] As defined in Complexity Metrics for ANSP Benchmarking Analysis, Report commissioned by the Performance Review Commission, April 2006.

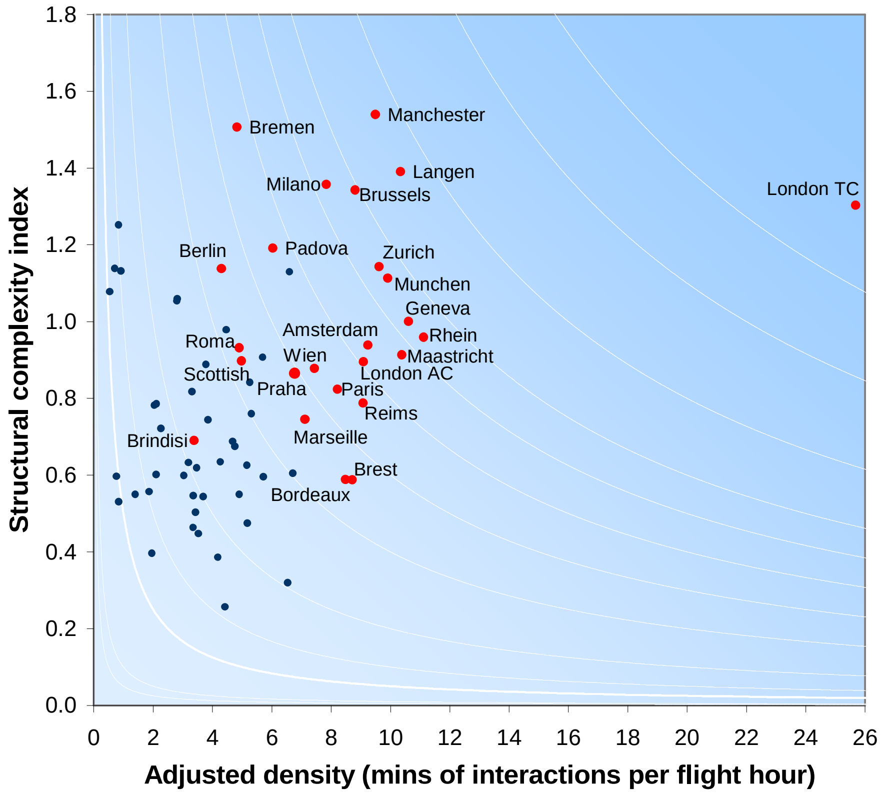


Figure 4-4: ACC aggregated complexity score

Average flight level used

4.3.5 Figure 4-5 shows the average flight level used for the sample ACCs. Two of NATS's ACCs, London TC and Manchester, have a low average flight level used compared to the sample.

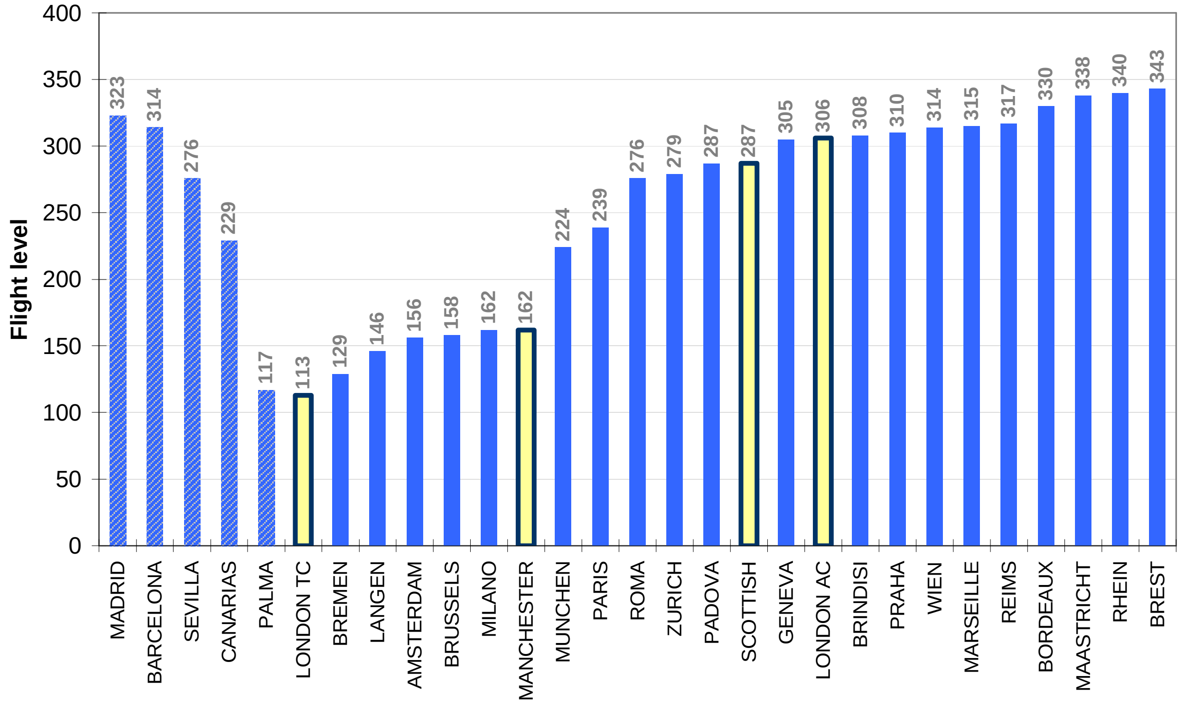


Figure 4-5: Average flight level used

4.4 Influence of exogenous factors on ATCO productivity

4.4.1 This section looks at the possible influence of some exogenous factors on ATCO productivity for the ACCs belonging to the selected ANSPs having two or more ACCs so that possible relationships can be analysed both within and across ANSPs.

4.4.2 The following exogenous factors are assessed:

- § volume of controlled airspace;
- § adjusted density of traffic;
- § structural complexity;
- § aggregated complexity score; and
- § average flight level used.

4.4.3 The following sections review how these exogenous factors vary between ACCs, and how that variation is associated with ATCO productivity. These relationships are explored more formally in the statistical analysis in Chapter 5.

Volume of controlled airspace

4.4.4 The volume of the controlled area is an exogenous factor at ANSP level. However, the volume of airspace controlled by ACCs within an ANSP is not an exogenous factor. The volume of airspace controlled by ACCs within an ANSP may be affected by traffic complexity but it also largely depends on endogenous factors. An exception to this is where ACCs are dimensioned and positioned on grounds other than operational, typically political or economic.

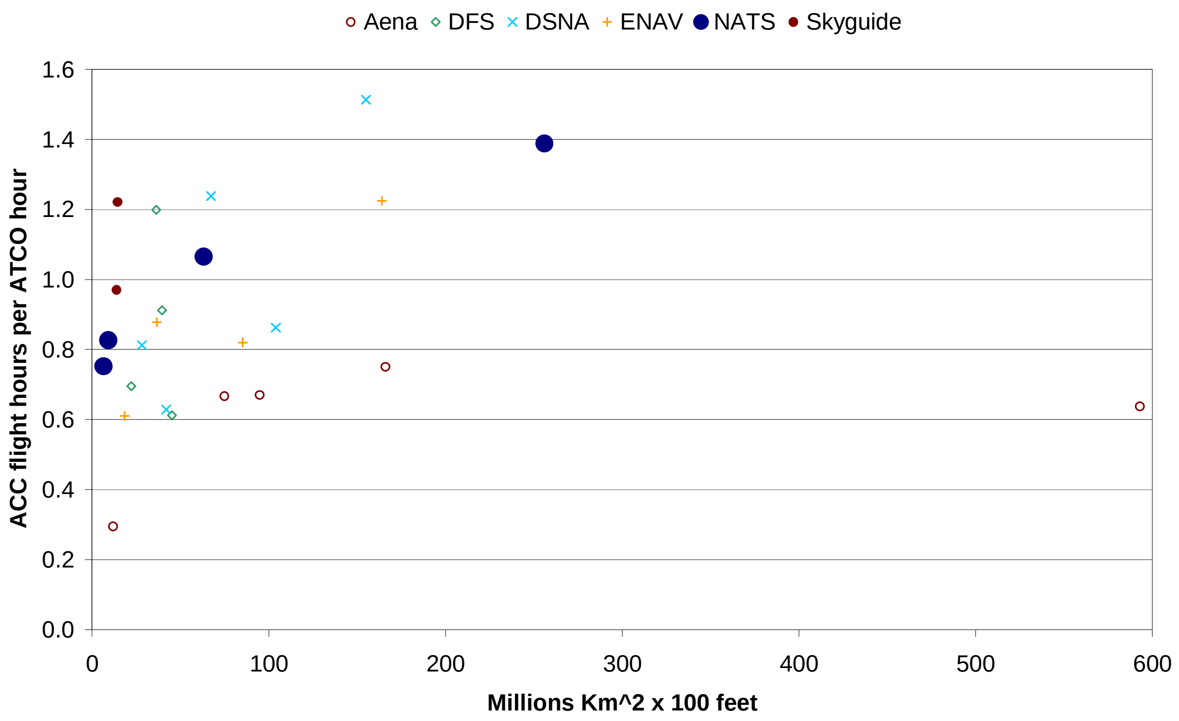


Figure 4-6: ATCO productivity versus volume of controlled airspace

4.4.5 From visual inspection ATCO productivity appears to be associated, albeit weakly, with volume of controlled airspace. It shows that as the volume of airspace increases, so does ATCO productivity. There are a couple of major exceptions to this relationship:

- Canarias is a Spanish ACC (at the far right-hand side of Figure 4-6), which has a volume double that of the next largest ACC.
- For the Skyguide ACCs, Zurich is considerably more productive despite having a similar volume to Geneva. This is a common feature in comparing these ACCs, and may be related to the much greater delays at Zurich, as discussed in Section 4.5.

Adjusted density

4.4.6 Figure 4-7 plots ATCO productivity against adjusted density for the ACCs belonging to the selected ANSPs having two or more ACCs.

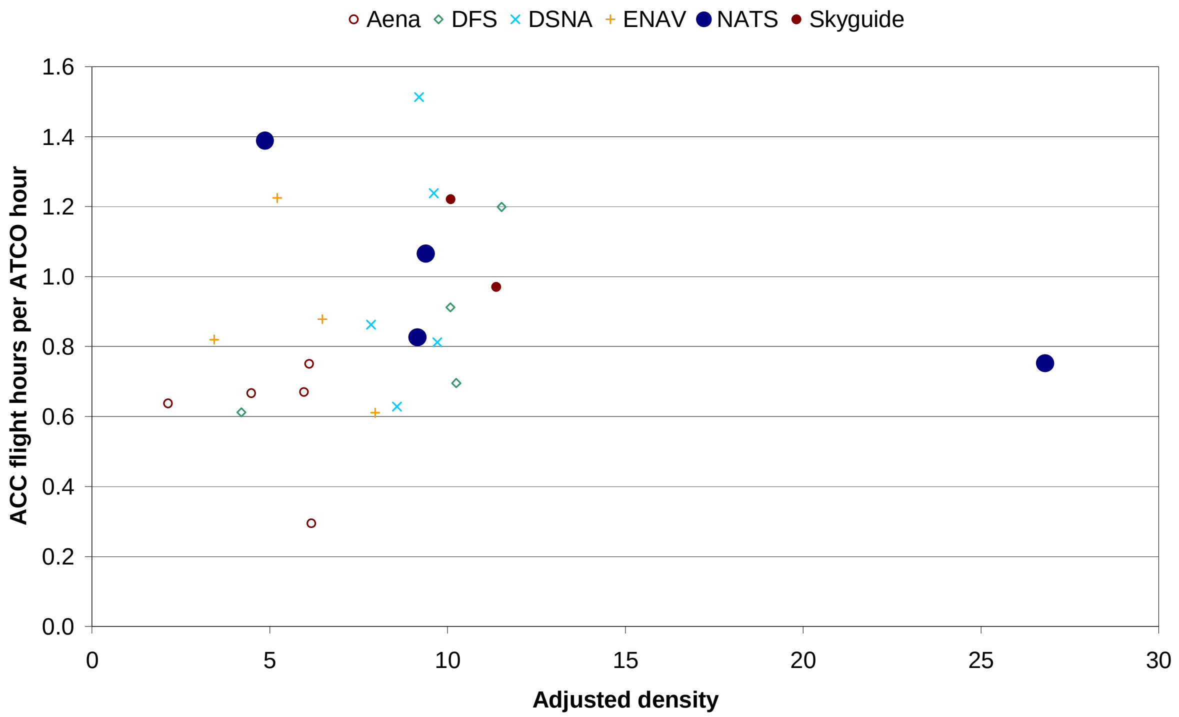


Figure 4-7: ATCO productivity versus adjusted density

4.4.7 From visual inspection ATCO productivity appears to be associated, albeit weakly, with the adjusted density of traffic at ACC level. London TC is an outlier. Within ANSPs the results are less conclusive, with both the Skyguide ACCs and the ENAV ACCs showing a negative association.

Structural complexity

4.4.8 Figure 4-8 plots ATCO productivity against structural complexity for the ACCs belonging to the selected ANSPs which have two or more ACCs.

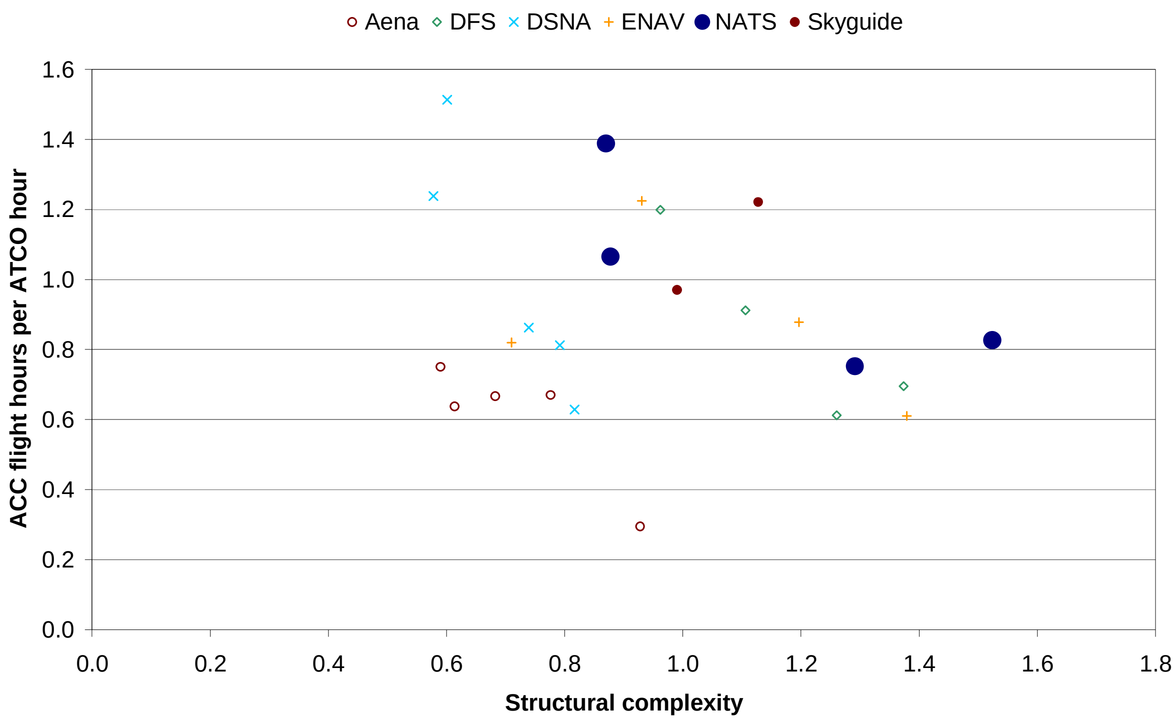


Figure 4-8: ATCO productivity versus structural complexity

4.4.9 From visual inspection ATCO productivity appears to be associated with structural complexity; the more structurally complex an ACC, the lower the ATCO productivity. This negative association contrasts with the positive association between ATCO productivity and adjusted density, as described in paragraph 4.4.7.

4.4.10 Within ANSPs the Skyguide ACCs, Geneva and Zurich, do not follow this correlation, with the more structurally complex ACC (Zurich) having a higher ATCO productivity than Geneva. This may be related to the much greater delays at Zurich, as discussed in Section 4.5.

Aggregated complexity

4.4.11 Figure 4-9 shows that there is no obvious association between aggregated complexity score and ATCO productivity, either for the sample of ACCs or for ACCs within ANSPs.

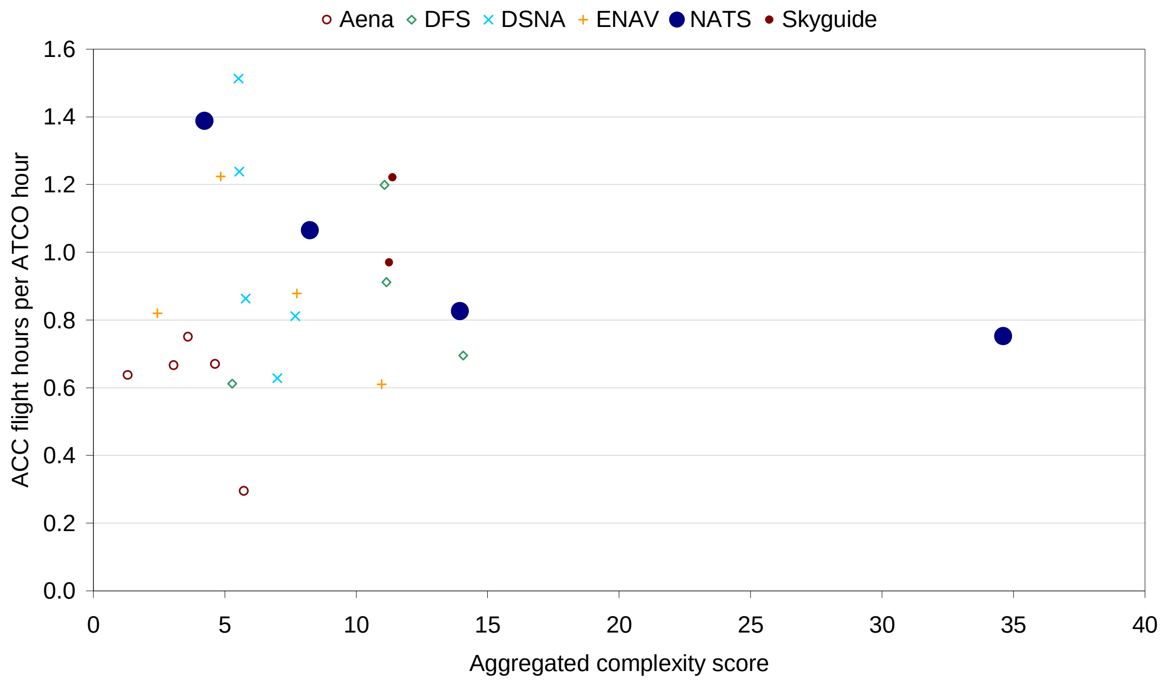


Figure 4-9: ATCO productivity versus aggregated complexity score

Average flight level used

4.4.12 Figure 4-10 presents a plot of ATCO productivity against the average flight level used for the ACCs belonging to the selected ANSPs having two or more ACCs.

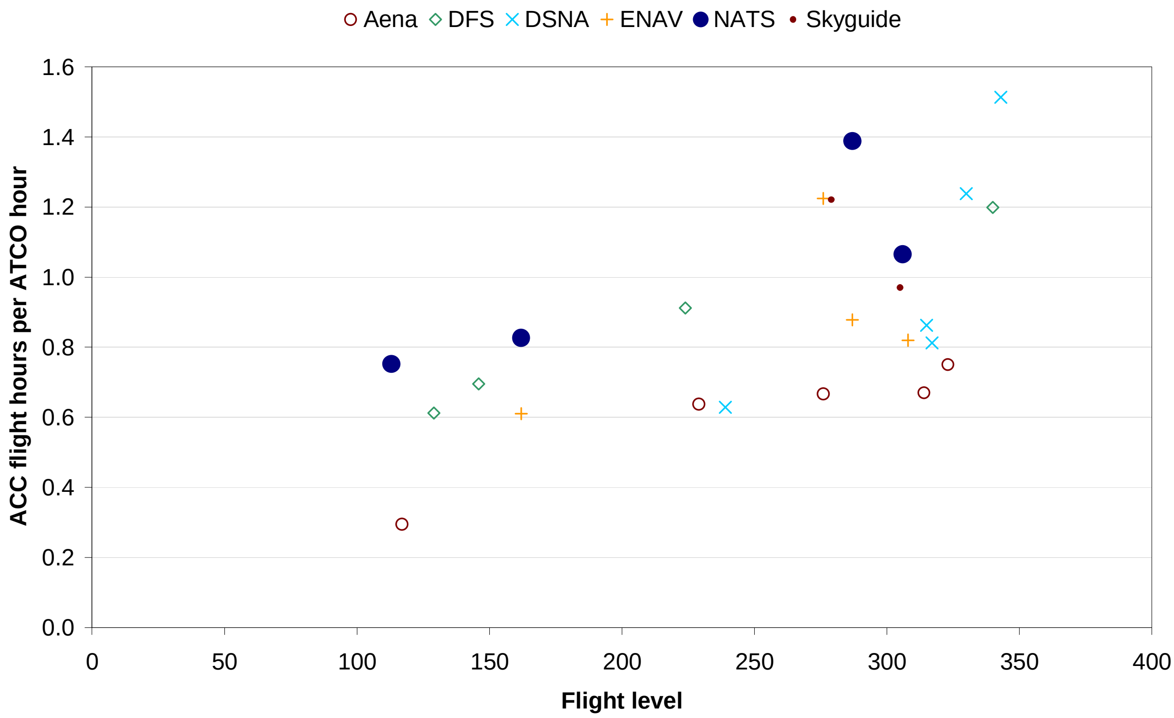


Figure 4-10: ATCO productivity versus average flight level used

4.4.13 ATCO productivity appears to be associated, rather strongly, with average flight level used. The higher the average flight level used the higher the ATCO productivity. This correlation appears to be true both for the sample of ACCs and also the ACCs within ANSPs.

4.4.14 The main exception to this correlation is Skyguide, where the ACC with the lower average flight level shows lower productivity. The Skyguide ACCs have shown the opposite correlation to the overall correlation in a number of the analyses in this section. There may be other exogenous or endogenous factors that account for this. Zurich has very high delays, which may provide an explanation for this opposite correlation, as discussed in Section 4.5, below.

4.5 Quality of service at ACC level

4.5.1 The quality of service for the ACCs in the sample is measured by calculating the total en-route ATFM delay attributed to sectors within an ACC. It includes the delay causes described in Section 3.6. Some delay causes, such as weather, are outside of the control of the ANSP, however, as this is considering en-route ATFM delay we believe that the weather-related delays should not affect one ACC significantly more than another.

4.5.2 A measure of horizontal flight-efficiency within ACCs is not available from the PRU, although it could in principle be calculated from CFMU data.

Total en-route ATFM delay per flight-hour at ACCs

4.5.3 Figure 4-11 shows the percentage of the total en-route ATFM delay that arises from various causes, for each ACC.

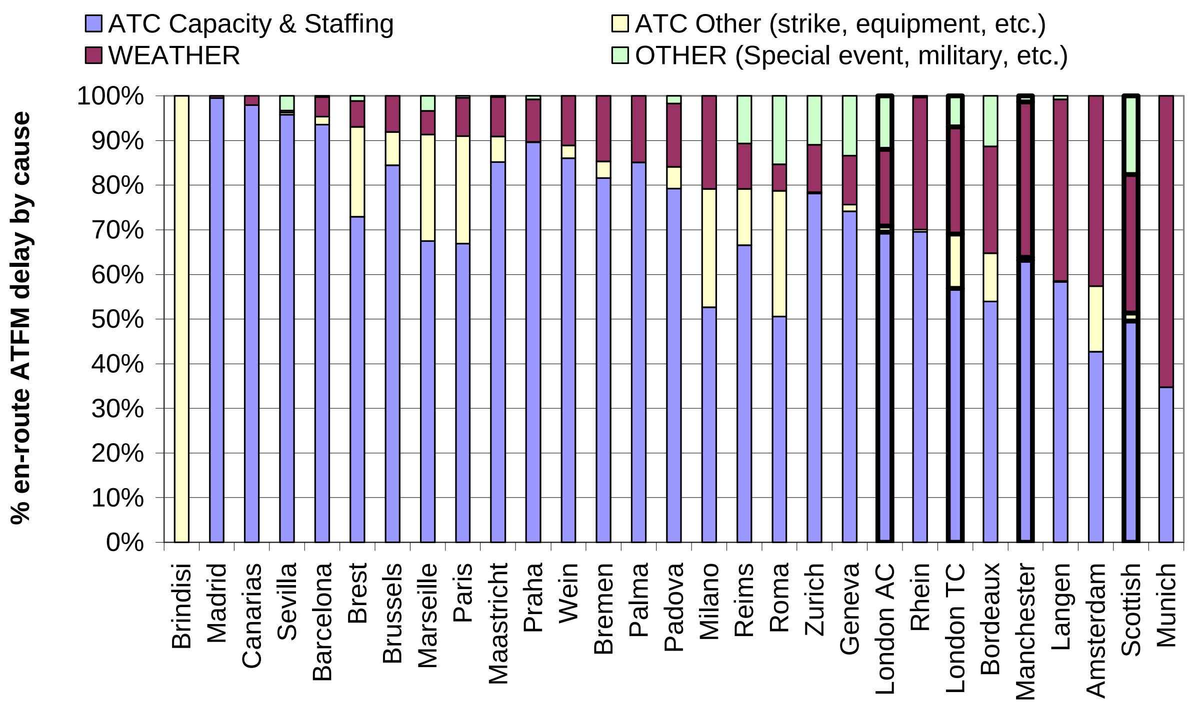


Figure 4-11: Percentage en-route ATFM delay by delay cause

4.5.4 The proportion of ATFM delay that arises from the first two causes, which is usually under the control of the ANSP (see Section 3.6), is relatively low for each of NATS's ACCs. This suggests that the delay performance for NATS's ACCs, including London AC which has above average en-route delay per flight-hour may be better than appears in Figure 4-12.

4.5.5 Figure 4-12 presents the total en-route ATFM delay per flight-hour at the sample ACCs. The average en-route AFTM delay for this sample of ACCs is 1.09 minutes per flight-hour.

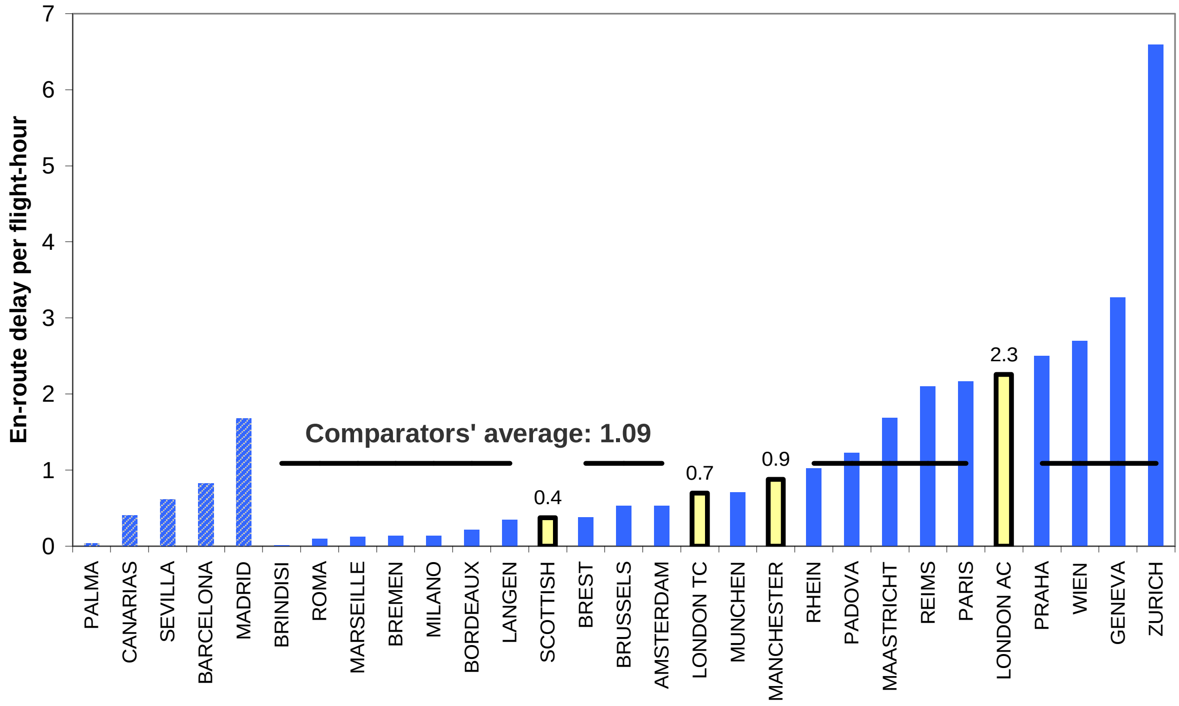


Figure 4-12: Total en-route ATFM delay per flight-hour at ACCs

4.5.6 London AC is significantly above the average, generating 2.3 minutes of en-route ATFM delay per flight-hour. Following discussions with NATS, it is understood that London AC is more constrained than London TC in terms of staffing. We also understand that when demand exceeds capacity, London AC uses ATFM regulations more frequently than London TC, which can rely on other means than ATFM regulation to optimise their operations, for example, by holding some inbound traffic in London AC (when London TC stacks are likely to be full). This has an adverse effect on London AC delay per flight-hour and partially explains the difference between London AC and TC.

4.5.7 Zurich has very high delays - over 6 minutes per flight-hour.[16] This is likely to distort the ATCO productivity values for Zurich ACC. This is because the ACC is

[16] We understand that the high delays in Zurich have been a result of the Skyguide project to create a Swiss UAC controlling the whole of the Swiss upper airspace, based in Geneva. This project required ATCOs to move from Zurich to Geneva between 2005 and 2006, and this move is visible in the ACE data. This project was cancelled, but not all ATCOs that transferred to Geneva were transferred back to Zurich in 2007. This resulted in a relative ATCO shortfall in Zurich in 2007, explaining the higher productivity and higher delays.

unlikely to have sufficient ATCO-hours on duty to handle the traffic, hence the high delays. The number of flight-hours passing through Zurich ACC remains, albeit with flights suffering a delay. Hence, high delays can result in unusually high ATCO productivity. This is one possible explanation why Zurich ACC and Geneva ACC do not conform to the associations between ATCO productivity and exogenous factors observed between ACCs from one ANSP in Section 4.4.

4.6 Conclusions of ACC analysis

4.6.1 NATS ACCs perform well in terms of ATCO productivity when compared to similar ACCs. London TC and Manchester, which operate in lower airspace, have a similar productivity to Amsterdam, and a higher productivity than Brussels, Langen and Milano, which also operate in lower airspace. We also note that Scottish ACC has a similar productivity to Brest, and a higher productivity than Bordeaux.

4.6.2 ATCO productivity at the different NATS ACCs ranges from 0.8 (London TC) to 1.2 (Scottish) ACC. Higher productivity was achieved in ACCs where the structural complexity was lower, and where the average flight level used was higher. We observed similar situations for ACCs within other ANSPs.

4.6.3 For all NATS ACCs except London AC, ATFM delays were lower than the average of other ACCs. London AC delay per flight-hour was 2.3 minutes, well above the sample average of 1.09 minutes.

5 Statistical analysis

5.1 Our approach

5.1.1 Following discussions with the CAA and similarly to the benchmarking of NATS relative to selected ANSPs conducted in 2004-2005, it was decided to adopt a “bottom-up” approach exploring specific issues for the main components of total costs. This approach does not result in an integrated model but is consistent with the KPI breakdown shown in Figure 2-5.

5.1.2 We explore two separate models. One seeks to explain ATCO productivity in terms of the exogenous variables discussed in Section 4.4. This is accomplished by developing a model of the number of ATCO-hours required at different levels of traffic, using observations from each ACC. A second explores the factors that influence support costs, at ANSP level.

5.1.3 As discussed in the ACE 2007 report (see Chapter 4), a number of other exogenous factors than those identified in our models, as well as endogenous factors, will affect performance. The statistical analysis developed in the context of this study investigates some of the factors that appear to play an important role. It cannot, however, capture all of them. Our analysis is an exploration of issues and is not sufficiently mature to be used in a normative manner.

5.2 Scope of the analysis

5.2.1 The statistical analysis was performed on two years’ data (2006 and 2007). Additional years (2003-2005) could have been included in the sample. However, this would have required an investigation of any material changes in ANSPs’ and ACCs’ operational and technical organisation affecting productivity and support costs during this period.

5.2.2 The statistical analysis comprises observations for 36 ANSPs and 66 ACCs. The reason for enlarging the sample of ANSPs and ACCs compared to the descriptive analysis in Chapters 3 and 4, respectively, is to cover a wider variety of situations and test the statistical model’s ability to capture those.

5.2.3 However, since the primary focus of this analysis is to explore NATS performance relative to its comparators (DFS, DSNA, ENAV, Austro Control, ANS CR, Belgocontrol, Skyguide, LVNL and MUAC) we also look at the impact of limiting the sample to these ANSPs on the statistical models and results.

5.2.4 Our investigation of the relationships between exogenous factors and ATCO productivity is done at ACC level. An investigation at ANSP level would unnecessarily discard interesting information, since ANSPs have ACCs operating in radically different traffic environments (for example Scottish and London TC; or Brest and Paris).

5.2.5 Our investigation of the relationship between exogenous factors and support costs is done at ANSP level. It would have been valuable to do this at ACC level, however support cost data is only available at ANSP level and is not broken down into ACC, en-route or terminal. This analysis therefore looks at gate-to-gate support costs.

5.3 ACC ATCO productivity

5.3.1 ACC ATCO productivity, as measured by the PRU, is defined as the ratio of ACC flight-hours to ACC ATCO-hours on duty.

5.3.2 However, this definition of ATCO productivity does not allow for the use of a constant term in the regression model. Moreover, with a measure of output being part of the definition of ATCO productivity, it is difficult to have the output as an explanatory variable since output would be part of both endogenous and exogenous variables. Therefore, we have made **ACC ATCO-hours** our dependent variable in the regression analysis.

5.3.3 From discussions with the CAA, NATS and PRU and our own industry knowledge, we decided to test the following explanatory variables as key drivers of ACC ATCO-hours:

- the scale of operations (quantity of output);
- the size of airspace controlled by the ACC;
- the characteristics of the traffic controlled by the ACC; and
- the delays incurred by users using the ACC airspace.

5.3.4 From the PRU's ACE information disclosure data, we collected the following list of variables to test.

Data name	Source	Calculation
Scale variables		
Flight-hours	ACE data	ACC flight-hours controlled
IFR movements	ACE data	ACC IFR movements controlled
Size variables		
Average transit time	ACE data	ACC flight-hours / ACC IFR movement controlled
Area controlled	ACE data	ACC area of airspace (km^2)
Volume controlled	ACE data	ACC volume of airspace (km^2 x 100 feet)
Traffic characteristics variables		
Density	ACE data	ACC flight-hours / ACC volume of airspace (km^2 x 100 feet)
Adjusted density	ACE data	ACC hours of interaction per flight-hour
Structural complexity	ACE data	Sum of horizontal, vertical and speed interactions per flight-hour
Aggregated complexity	ACE data	Adjusted density x Structural complexity
Flight level	ACE data	Average flight level used in the ACC
Variability	ACE	(ACC traffic in the peak week / ACC traffic in an average week) - 1
Delay variable		
Delay	ACE data	ACC minutes delay / ACC flight-hour

Table 5-1: List of variables to test for ACC ATCO productivity

5.3.5 We tested the cross correlations of the variables we aimed to use to undertake the ACC productivity analysis and confirmed the strong correlation between the numbers of flight-hours controlled and the ATCO-hours on duty.

5.3.6 For our size variables, we note a strong correlation between area controlled, volume and average transit time. Only one of those three should be kept in the model. Since average transit time shows a higher correlation with the variables describing traffic characteristics, we decided not to use this variable, to reduce the risk of multicollinearity. This leaves area controlled and volume as two possible alternatives.

5.3.7 For traffic characteristics we note that density, adjusted density and aggregated complexity are strongly correlated, and only one of those three should be kept in the regression. We also note that those three variables are to some extent positively correlated with the number of IFR movements, introducing a risk of multicollinearity with our output metric.

5.3.8 Structural complexity and average flight level used are negatively correlated, indicating that flight level used could be a proxy for structural complexity, with higher flight levels being associated with lower structural complexity.

5.3.9 Seasonal variability does not show any clear correlation with any of the other variables which makes it a good candidate for inclusion in addition to other variables describing traffic characteristics.

5.3.10 Delay is positively correlated with flight-hours, but to a limited extent. No strong correlation is observed with other candidate explanatory variables.

5.3.11 The detailed cross correlation results are presented in Table 5-2 below.

	ATCO-hours	Flight-hours	IFR movements	Average transit time	Area controlled	Volume	Density	Adjusted density	Structural complexity	Aggregated complexity	Flight level	Variability
Flight-hours	0.85	1.00										
IFR movements	0.78	0.86	1.00									
Average transit time	0.31	0.40	-0.05	1.00								
Area controlled	0.30	0.40	0.09	0.72	1.00							
Volume	0.19	0.27	-0.03	0.69	0.98	1.00						
Density	0.36	0.31	0.60	-0.38	-0.27	-0.31	1.00					
Adjusted density	0.46	0.48	0.73	-0.31	-0.22	-0.27	0.92	1.00				
Structural complexity	0.10	0.04	0.31	-0.53	-0.23	-0.25	0.51	0.36	1.00			
Aggregated complexity	0.38	0.34	0.64	-0.42	-0.26	-0.29	0.97	0.94	0.60	1.00		
Flight level	-0.02	0.18	-0.07	0.48	0.20	0.18	-0.46	-0.27	-0.75	-0.49	1.00	
Variability	-0.28	-0.33	-0.41	-0.06	-0.22	-0.21	-0.27	-0.26	-0.36	-0.32	0.18	1.00
Total ERT delay	0.43	0.55	0.65	-0.05	0.03	-0.04	0.25	0.38	0.15	0.30	0.16	-0.31

Table 5-2: Correlation matrix for ACC ATCO-hours candidate explanatory variables

5.3.12 We investigated both a linear and a quadratic functional form (adding the square of flight-hours as an explanatory variable). We found that the quadratic form provided better results in terms of overall explanation of the variance (that is, a higher R^2). We also noted that the statistical significance of seasonal variability and delay were substantially improved in presence of the square of flight-hours.

5.3.13 We tested the impact of adding candidate variables to or removing them from the quadratic model. We found that the best model of ACC ACTO-hours was obtained by combining:

- a constant term;
- flight-hours;
- the square of flight-hours;
- the area controlled by the ACC;
- the average flight level used;
- seasonal variability; and
- delay per flight-hour.

5.3.14 The retained model is shown by the equation below:

$$\begin{aligned}\text{ACC ATCO hours}_{\text{ACC}} = \alpha \;+\; & \beta_1(\textit{flight hours}_{ACC}) \;+\; \beta_2\,(\textit{flight hours}_{ACC})^2 \\ & + \beta_3(\textit{AreaControlled}_{ACC}) + \beta_4(\textit{flightlevel}_{ACC}) \\ & + \beta_5(\text{var}\,\textit{iability}_{ACC}) + \beta_6(\textit{delay}_{ACC})\end{aligned}$$

5.3.15 We wished to explore the possibility that the model was unduly influenced by small ACCs that were rather dissimilar to those of NATS. Starting with the complete sample of observations (two years' data and 66 ANSPs) we analysed the impact of removing the 10 observations associated with the lowest ATCO-hours. The overall quality of the model was similar, and more importantly the signs of estimated coefficient for all our explanatory remained unchanged. However, the significance of the area controlled, variability and delay variables remained weak both with and without the observations from the ACCs with the lowest number of ATCO-hours.

5.3.16 We also analysed the residuals (the difference between observed and predicted values) for all ACCs and identified some outliers. We found that the model did not produce realistic results for those ACCs having very low traffic density (low traffic for their size). We also noticed that some of the Aena ACCs were outliers and had a significant impact on the estimated coefficients. We decided to test our model on a sample excluding all ACCs belonging to UkSATSE, Aena, Oro Navigacija, MoldATSA, MATS, Finavia, and ROMATSA. We also excluded Bodo and Stavanger ACCs but kept Oslo. The objective of excluding these ACCs was to obtain a model relevant for NATS and its comparators. We tested the sample composition by excluding these ACCs that were either outliers (without any further judgment about their comparability to NATS ACCs) or had a traffic density too far from the ACCs of main interest.

5.3.17 This left us with 94 observations out of 132. This improved the model, as all the explanatory variables were statistically significant (including the area controlled, variability and delay variables) and the value of the coefficient of determination (R^2) increased.

5.3.18 The results of the model based on this reduced sample are shown in Table 5-3 below:

Dependent variable: ACC ATCO-hours on duty Adjusted R^2: 0.87		
	Estimated coefficient	Significance
Constant	99,882	Yes (100%)
Total flight-hours controlled	1.85	Yes (100%)
SQR(Total flight-hours controlled)	-1.53 E-06	Yes (100%)
Area controlled	-0.18	Yes (100%)
Flight level	-589	Yes (100%)
Variability	144,565	Yes (99%)
Total ERT delay per flight-hour	-10,575	Yes (98%)

Table 5-3: Summary statistics for ACC quadratic regression model

5.3.19 Interpreting these results we find the following characteristics:

- The constant term implies that a certain minimum number of ATCOs (corresponding to around 100,000 hours a year) are required on duty in ACCs irrespective of the number of flights controlled.
- For every extra flight-hour controlled additional ATCO-hours are required, but economies of scale mean that the incremental number of ATCO-hours required to serve additional flight-hours declines as the number of flight-hours increases.
- All other things being equal, fewer ATCO-hours are required in ACCs that are larger, in terms of area controlled. This could indicate economies of scope whereby ATCOs could be more productive when controlling flights over larger areas.
- All other things being equal, fewer ATCO-hours are required in ACCs where the average flight level used is higher. This confirms the idea that upper airspace areas are relatively less complex and therefore support higher productivity.
- All other things being equal, ACCs where the seasonal traffic variability is higher need more ATCO-hours and will have a lower productivity than those ACCs where traffic is evenly distributed throughout the year.
- All other things being equal, the greater the delay per flight-hour, the lower the number of ATCO-hours on duty.

5.3.20 Figure 5-1 below shows the observed ACC ATCO-hours versus the ACC ATCO-hours predicted by the statistical model.

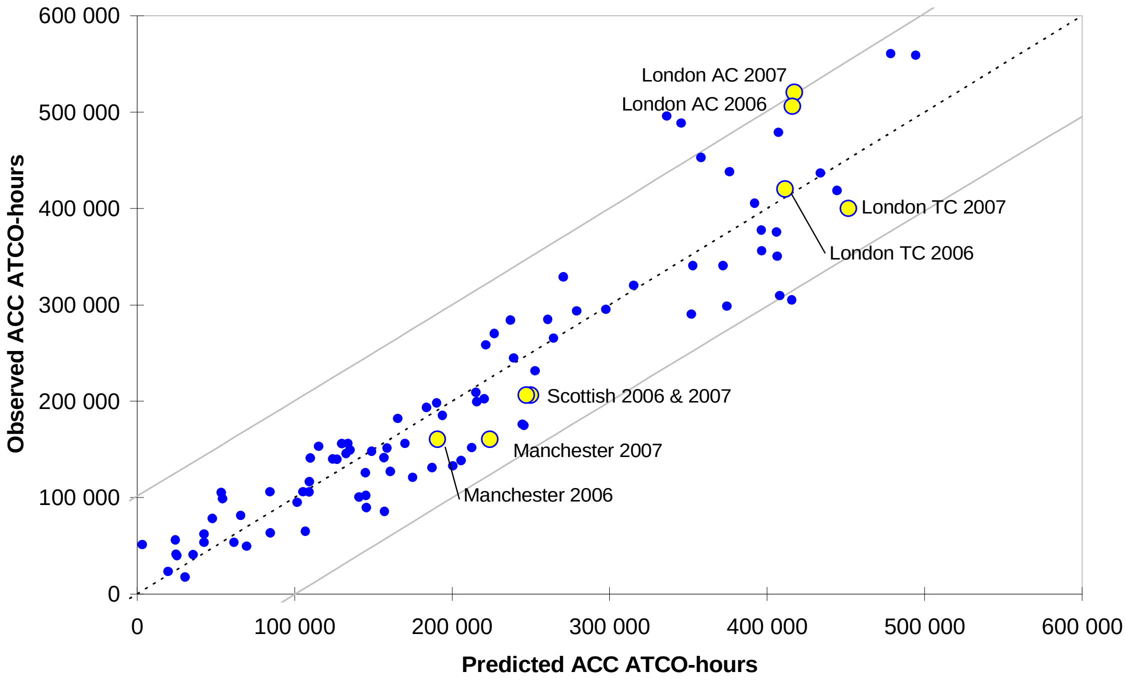


Figure 5-1: Observed versus predicted ACC ATCO-hours

5.3.21 London AC uses significantly more ATCO-hours than predicted by the model. It is however close to the performance of Reims ACC and significantly better than Paris ACC.

5.3.22 On the other hand, London TC, Scottish and Manchester ACCs use fewer ATCO-hours than predicted by the model.

5.3.23 The range of differences between observed and predicted values is large (from -30% to +41%). These results should be interpreted with caution. The observed differences may result from several factors. Additional exogenous factors not captured in the model, endogenous factors, and pure statistical errors might be present, and it is difficult to draw conclusions on the level of intrinsic performance of ACCs.

5.3.24 As a validation exercise, we also estimated the model coefficients from a sample only composed of NATS and the comparators used in Chapter 3, reducing the number of observations from 94 to 49. With the resulting model, R^2 was lower (0.81 compared with 0.87) and the delay variable became insignificant. The significance of the coefficients of area controlled and variability fell very slightly but remained above 95%.

5.3.25 The signs of all coefficients remained the same. The estimated coefficients gave a higher weight to flight-hours, the square of flight-hours, the average flight-level used and variability, and a lower weight to the constant and the area controlled variables. The results for NATS ACCs are only marginally different from those shown in Figure 5-1, while the results for Geneva, Brussels and Amsterdam ACCs are more sensitive to using a model based on a reduced number of observations.

5.4 ANSP support costs

5.4.1 Non-ATCO operating costs are the sum of the gate-to-gate non-ATCO staff costs, non-staff operating costs and depreciation costs. Exceptional costs and cost of capital are not part of the support costs as defined in this study.

5.4.2 From discussions with the CAA, NATS and PRU and our own industry knowledge, we decided to test the following explanatory variables as key drivers of ANSP support-costs:

- the scale of the ANSP's operations;
- the area of the airspace controlled;
- the average income per head in the ANSP's country of origin;
- the average age of assets; and
- the impact of whether all or part of the ANSPs upper airspace is controlled by Maastricht and the ANSP still incurs CNS infrastructure costs.

5.4.3 We also tested the hypothesis that ATCO productivity, or total ATCO-hours on duty is a principal or complementary driver to support costs.

5.4.4 From the PRU's ACE information disclosure data, we collected the following list of variables to test.

Data name	Source	Calculation
Scale variables		
Composite flight-hours	ACE data	ANSP flight-hours controlled x 0.25 IFR airport movements
IFR movements	ACE data	ANSP IFR movements controlled
ATCO-hours	ACE data	ANSPs operational ATCOs-hour on duty
Size variables		
Area controlled	ACE data	ANSP area of airspace (km^2)
Cost of living / labour price		
GDP per head	IMF	GDP / population
Average age of assets		
Age of assets	ACE data	Depreciation / Net Book Value of assets in operation
MUAC variable		
MUAC	ACE data	Share of ANSP contribution to MUAC costs. MUAC values are 44 for DFS, 31 for Belgocontrol, 25 for LVNL, -100 for MUAC, and 0 for all other ANSPs

Table 5-4: List of variables to test for ANSP support costs

5.4.5 We tested the cross correlations of the variables we aimed to use to undertake the ANSP support cost analysis. We found a very high positive correlation between support costs and composite flight-hours, ATCO-hours and IFR movements. Since the three scale variables are also strongly correlated with each other, only one should remain in the model. We retained composite flight-hours as they showed the highest correlation with support costs.

5.4.6 We note that area controlled is positively correlated with support costs. However, it is even more strongly correlated with composite flight-hours and ATCO-hours, resulting in a high risk of multicollinearity.

5.4.7 The GDP per head is a proxy for labour costs and the general level of price in the countries in which ANSPs operate, and does not show a clear correlation with any of the other variables.

5.4.8 Similarly, the average age of assets and the MUAC variables seem to be statistically independent from the other variables.

5.4.9 The detailed cross correlation results are presented in Table 5-5 below:

	Support costs	Composite flight-hours	IFR movements	ATCO-hours	Area controlled	GDP per capita	Age of assets
Composite flight-hours	0.99	1.00					
IFR movements	0.93	0.95	1.00				
ATCO-hours	0.93	0.95	0.84	1.00			
Area controlled	0.63	0.71	0.53	0.83	1.00		
GDP per capita	0.31	0.33	0.40	0.23	0.27	1.00	
Age of assets	-0.18	-0.16	-0.16	-0.11	-0.10	0.02	1.00
MUAC	0.17	0.09	0.00	0.13	-0.02	-0.03	0.21

Table 5-5: Correlation matrix for ANSP support cost candidate explanatory variables

5.4.10 It should be noted that a simple regression of support cost on composite flight-hours and a constant already explains a very large part of the variance (adjusted R^2=0.97). However, this strong statistical relation is not fully satisfactory on an economic ground since the constant is negative (indicating negative costs in absence of traffic) and since other factors are obviously playing a role. Therefore, we judged our model on the significance of additional variables rather than on the improvement to the adjusted R^2.

5.4.11 We investigated a linear functional form and tested the impact of adding or removing our candidate variables. We found that the best model of ANSP support costs was obtained when combining:

- a constant term;
- composite flight-hours;
- the area controlled by the ANSP;
- the average age of assets; and
- the MUAC variable.

5.4.12 The retained model is shown by the equation below:

$$Support\ costs_{ANSP} = \alpha + \beta_1(\ CompositeFlightHours_{ANSP}) + \beta_2\ (AreaControlled_{ANSP}) + \beta_3(AgeOfAssets_{ANSP}) + \beta_4(MUAC_{ASNP})$$

5.4.13 We estimated the model from 72 observations (36 ANSPs over the 2006-2007 period) and found that all explanatory variables were significant at at least 95%. However, this model raised a number of issues:

- The sign of the coefficient of area controlled was negative, although intuitively the ATM and CNS infrastructure and the associated running and maintenance costs should increase with area controlled. This may well result from the high correlation between area controlled and flight-hours.
- The plot of the residuals indicated that the larger the support costs, the larger the residuals.
- One observation (DFS 2007) was suspect to have a particular influence in the estimation of the model coefficients (Cook distance > 1). This could be explained by DFS making large reductions in support costs in 2007.
- There is clearly a difference of scale between the five largest ANSPs and the others. This was less of a problem when working at ACC level but might be a limitation when investigating ANSP support costs.

5.4.14 Given that NATS is of central interest in this analysis, we decided to estimate the same model keeping only NATS and the comparators from Chapter 3. This reduces the number of observations from 72 to 20 and therefore limits the confidence we can have in the model results.

5.4.15 The results of the model estimated from data from NATS and the comparators from Chapter 3 are shown in Table 5-6 below.

Dependent variable: ANSP support costs Adjusted R^2: 0.99		
	Estimated coefficient	Significance
Constant	87,742,680	No
Composite flight-hours	184	Yes (100%)
Area controlled	171	Yes (100%)
MUAC	1,237,241	Yes (100%)
Age of assets	-9,280,072	No

Table 5-6: Summary statistics for ANSP regression model 1

5.4.16 We note that the constant and the age of assets are not statistically significant in this model, and that the area controlled variable which had a negative sign when estimated from the 36 ANSPs has a positive sign when only NATS and its comparators are retained.

5.4.17 We also tested the hypothesis that higher support costs would be the counter-part of higher ATCO productivity. We did this by adding the ratio of composite flight-hours per ATCO-hour as an additional explanatory variable. We tested the model on both the complete sample of ANSPs and the sample reduced to NATS and its comparators. The resulting models did not provide any evidence of a clear relationship between ATCO productivity and support costs.

5.4.18 As an alternative means to incorporate productivity in our support costs model, we replaced the composite flight-hours variable by the ATCO-hours variable. The corresponding model is shown by the equation below:

$$Support\ costs_{ANSP} = \alpha + \beta_1(ATCO\ Hours_{ANSP}) + \beta_2\ (AreaControlled_{ANSP}) + \beta_3(AgeOfAssets_{ANSP}) + \beta_4(MUAC_{ASNP})$$

5.4.19 We estimated this model from a sample composed of NATS and its comparators (20 observations) which allows for a direct comparison with the model results shown in Table 5-6. The model results are shown in Table 5-7 below.

Dependent variable: ANSP support costs Adjusted R^2: 0.99		
Source	Estimated coefficient	Significance
Constant	163,515,438	Yes (99%)
ATCO hours	133	Yes (100%)
Area controlled	192	Yes (100%)
Age of assets	-17,311,076	Yes (95%)
MUAC	1,219,906	Yes (100%)

Table 5-7: Summary statistics for ANSP regression model 2

5.4.20 Interpreting the results we find that the following features:

- While ATCO-hours are slightly less correlated with support costs than composite flight-hours, we note that its combination with other explanatory variables provides better statistical results. Compared to Model 1 shown in Table 5-6, the adjusted R^2 remains at the same level and the constant and the average age of assets show a significance level higher than 95%.
- The constant term indicates the existence of fixed costs, which are independent of the level of traffic and the area controlled by the ANSP.
- The positive value of the area controlled variable indicates that all else being equal, larger ANSP have additional fixed costs that vary in proportion to their size.
- The negative value of the age of assets variable indicates that, all else being equal, the support costs fall with the average age of assets in operation. Since depreciation costs are part of the support costs, this is in line with our expectation.
- Comparing Model 1 and Model 2 results, we note that the values of the constant and of the coefficient of the average age of assets are much higher in the second model. However, we note that in both cases, the constant is about 10 times higher than the coefficient of age of assets variable. All other things being equal, it indicates that for an ANSP with an average asset age of 10 years, the fixed costs estimated from the constant term of the model are cancelled out by the “Age of assets” variable.

- For each additional ATCO-hour on duty, some €133 of support would be required. Although wages could not be captured in our model, it is obvious that this value will not be the same for all ANSPs and will depend on the employment cost of support staff.
- The MUAC variable was always statistically relevant in the various models we tested. The coefficient estimated for the MUAC variable could be interpreted in terms of the CNS support cost borne by Belgocontrol, LVNL and DFS used for the airspace controlled by MUAC. However, the size of the coefficient suggests that it may be representing additional effects that are keeping MUAC support costs low.

5.4.21 Figure 5-2 shows the difference between observed support costs and support costs predicted by the statistical model.

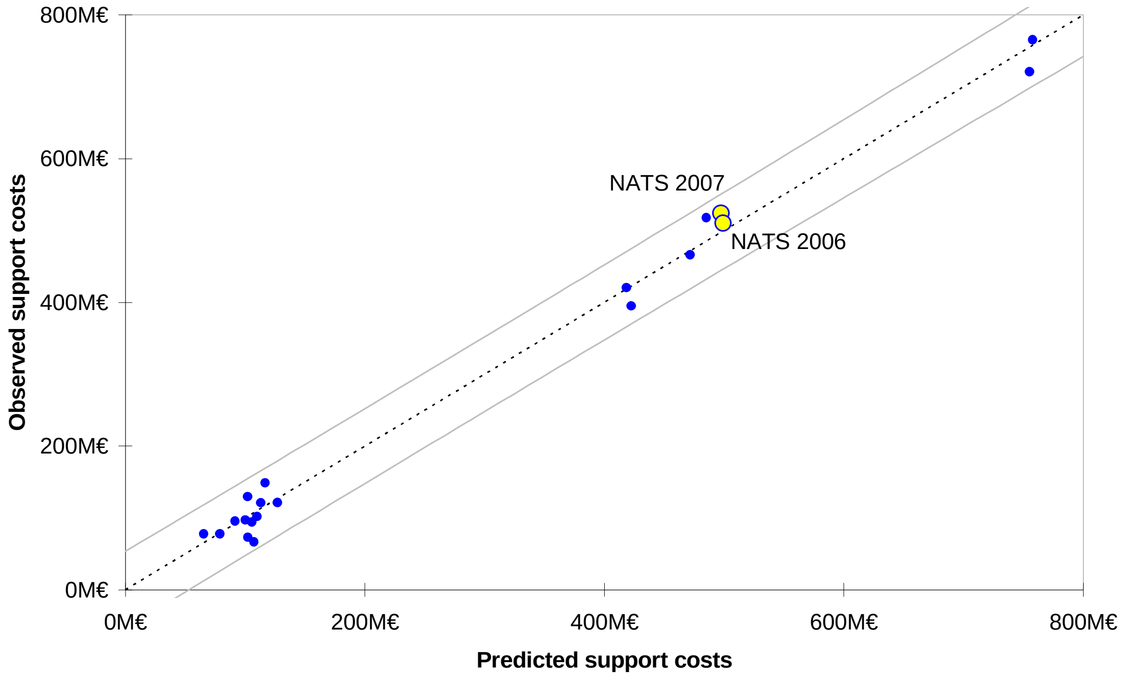


Figure 5-2: Observed versus predicted ANSP support costs

5.4.22 NATS support costs are slightly more than the support costs predicted by the statistical model based on its number of ATCO-hours, its area, and the average age of its assets.

5.4.23 Given the model sensitivity to sample composition, and to combination of various explanatory variables, the interpretation of these results should remain very cautious. Although NATS position always remained within plus or minus 5% compared to predicted support costs, its position relative to other ANSPs (particularly MUAC) was not always the same.

5.5 Conclusions of the statistical analysis

5.5.1 Emerging results from our investigation of ATCO productivity indicate the likely presence of economies of scale. We also found that the number of ATCO-hours required was sensitive to the area controlled by the ACC, the seasonal traffic variability, the average flight level used in the ACC (this being a proxy for traffic complexity) and the quality of service (measured by delays).

5.5.2 We found no evidence that either density or adjusted density affected the number of ATCO-hours required.

5.5.3 Numerical results indicated that Manchester, Scottish and London TC performed relatively well compared to the model predictions. On the other hand, we noted that London AC observed ATCO-hours were much higher than predicted.

5.5.4 Emerging results from our investigation of support costs show that composite flight-hours are closely correlated with support costs. We noticed however a high sensitivity of the model to changing the composition of the sample.

5.5.5 Although explanatory variables significance was also unstable, we found indications that fixed costs are required and vary as a function of ANSPs area controlled. We also noticed that the average age of assets has an impact on support costs, through depreciation.

5.5.6 We found no statistical evidence that input prices are playing a significant role in determining support costs. Although ATCO-hours are slightly less correlated with support costs than composite flight-hours, we found that its combination with other explanatory variables provides better statistical results.

5.5.7 Numerical results indicated that NATS support costs were more or less in line with the model predictions. However, it would be premature to put much emphasis on these numerical results, given the range of uncertainty surrounding the statistical analysis.

6 Insights from outside Europe

6.1 The CANSO benchmarking study

6.1.1 The only recent benchmarking exercise that we are aware of that could contribute towards the CAA's purposes is that undertaken by the CANSO Benchmarking Working Group.

6.1.2 The confidentiality of the CANSO exercise to participating ANSPs made it very unlikely that we would obtain useful information through CANSO themselves. Our approach was therefore to ask some of the non-European ANSPs participating in the CANSO exercise if they would be willing to allow us to use the data for the purposes of the CAA's work.

6.1.3 We received a positive response and data from two ANSPs, one of which was able to provide the full set of information required by CANSO. The second provided all of the information they provided to CANSO, but were unable to fulfil CANSO's requirements so there were some important pieces of information missing.

6.1.4 There are difficulties in drawing comparisons even in Europe between ANSPs with very different operating characteristics - and even more so outside. There are few areas in the world in which traffic is as dense or as complex as in Europe, and therefore the results from most non-European ANSPs may represent what is achievable in rather different operating environments.

6.1.5 In addition, the PRU undertakes extensive validation of the European data, which provides a more robust basis for benchmarking. We understand that there has been no similar validation of the non-European data.

6.1.6 For all these reasons, comparisons between European and non-European ANSPs should be treated with caution.

6.1.7 Non-European ANSP data provides us with some insight into oceanic ANS, which is not available from the PRU's data. Both non-European ANSPs that have disclosed their data are responsible for providing oceanic ANS, in addition to continental ANS.

6.2 Analysis of non-European ANSPs

6.2.1 The two Key Performance Indicators that we were able to analyse using 2007 data were:

- Financial cost-effectiveness (gate-to-gate) for one of the non-European ANSPs.
- ATCO productivity (gate-to-gate) for both of the non-European ANSPs.
- ATCO productivity and financial cost-effectiveness (gate-to-gate) for oceanic operations.

Financial cost-effectiveness (gate-to-gate)

6.2.2 Figure 6-1 shows the financial cost-effectiveness indicator for NATS compared to the European sample of comparators and also a non-European ANSP. To be consistent with our work in Chapter 3 we have **excluded** the cost of capital from this analysis.

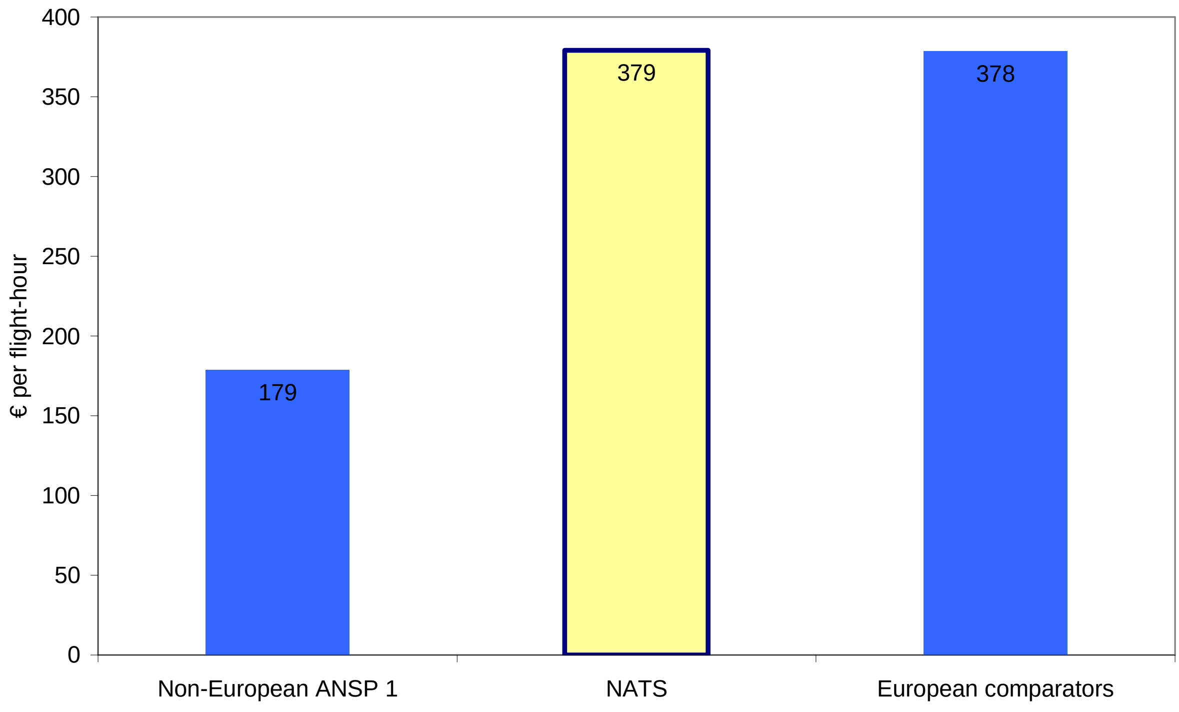


Figure 6-1: Financial cost effectiveness including non-European ANSP

6.2.3 NATS gate-to-gate financial cost[17] per composite flight-hour (excluding the cost of capital) is very slightly above the average of the selected European ANSPs, but that of the non-European ANSP is substantially lower – less than half.

ATCO productivity (gate-to-gate)

6.2.4 Figure 6-2 shows the ATCO productivity of NATS compared to the European sample of comparators and also two non-European ANSPs. It shows that whilst NATS has an ATCO productivity above the average of the European comparators those of the two non-European ANSPs are considerably higher.

[17] The gate-to-gate indicator presented in Figure 6-1 includes costs and flight-hours related to both NATS's en-route and terminal air navigation services. Figure 3-1 showed that for NATS's en-route business the cost per flight-hour was lower than the average of the European comparators.

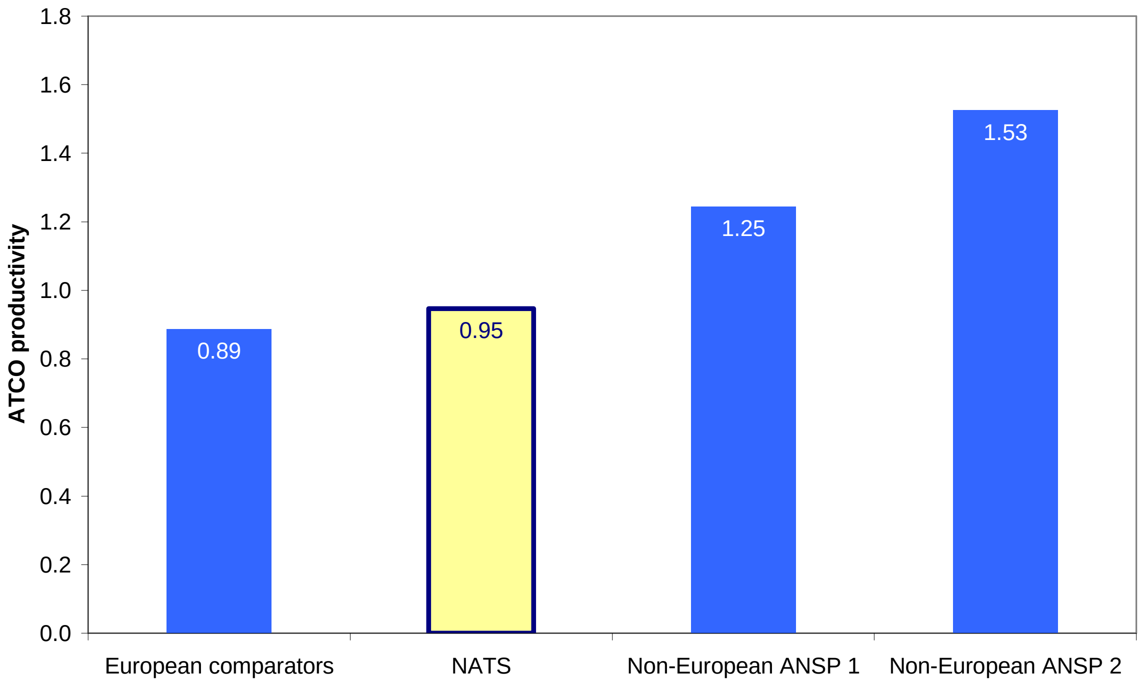


Figure 6-2: ATCO productivity including non-European ANSP

Oceanic operations

6.2.5 The data provided by the participants in the CANSO benchmarking exercise enables us to compare NATS's oceanic operations with both non-European comparators.

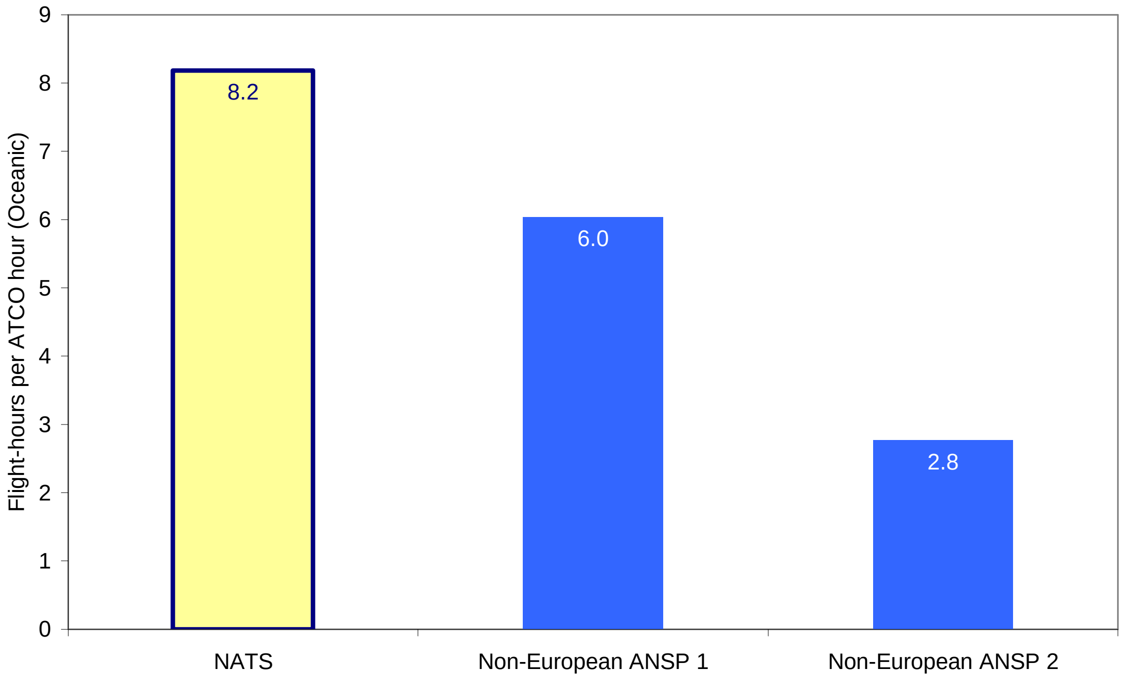


Figure 6-3: ATCO productivity for oceanic operations

6.2.6 The productivity of NATS's oceanic ATCOs appears to be significantly higher than that of the two non-European ANSPs.

6.2.7 Figure 6-4 shows the financial cost effectiveness indicator for NATS's oceanic operations compared to one non-European comparator. The costs per flight-hour for the two operations appear to be comparable. Given the substantially higher ATCO productivity in NATS, this suggests that either ATCO employment costs or support costs per flight-hour are substantially lower in the non-European comparator.

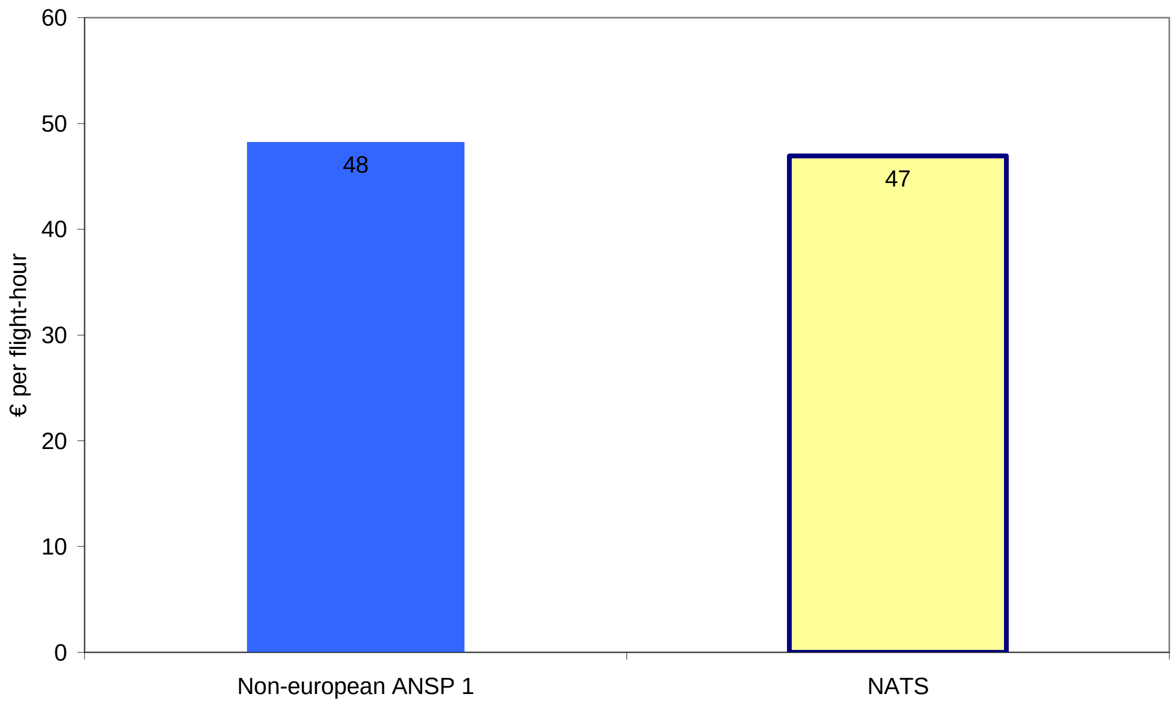


Figure 6-4: Financial cost effectiveness for oceanic operations

7 Conclusions

7.1 NATS position compared to the selected ANSPs

7.1.1 The analysis shows that NATS's performance has improved over the last five years, and is close to, and in many cases better than, the average of the sample in most aspects of performance. NATS en-route financial cost per flight-hour is €365 compared to €383 for the sample average.

7.1.2 NATS has 5% lower ATCO employment costs per unit output and its ATCOs are 7% more productive than the sample average. However, between 2003 and 2007, NATS average ATCO employment costs grew faster than the sample average, while the ATCO productivity rose at a slower rate than the sample average.

7.1.3 NATS has lower non-ATCO staff costs and lower depreciation costs than the sample average but considerably higher non-staff operating costs. The higher non-staff operating costs reflect the high amount of outsourcing employed at NATS.

7.1.4 At ACC level, we note that NATS ACCs perform well in terms of ATCO productivity. Within NATS we observe that higher productivity is achieved in ACCs where the structural complexity is lower. We observed similar situations for ACCs within other ANSPs. For all NATS ACCs except London AC, ATFM delays were lower than the average of other ACCs.

7.1.5 The forward-looking information suggests that NATS is projected to remain below the sample average for en-route cost per flight-hour through to 2012, rising above the sample average in 2009 and 2010. Given the current economic climate, there is considerable uncertainty regarding the forward-looking plans since they were prepared before the full impact of the current recession had been perceived and do not therefore take account of recent revisions. These projections should be viewed with appropriate caution.

7.2 The influence of exogenous factors

7.2.1 The statistical models that have been developed show encouraging results. Further work to test other functional forms and longer time series might add to its usefulness.

7.2.2 The results of a statistical model of ATCO-hours at ACC level show that there are economies of scale in ANS provision, and that structural complexity appears to affect ATCO productivity adversely.

7.2.3 The model suggests that London AC does not perform as well as predicted by the model, requiring more ATCO-hours than the model predicts. There may well be other exogenous factors that account for this. Also, the level of performance is not significantly below that predicted.

7.2.4 The model suggests that all other NATS's ACCs perform well.

7.2.5 A statistical model of support costs at ANSP level indicated that NATS support costs were more or less in line with the model predictions. However, it would be premature to put much emphasis on these numerical results, given the range of uncertainty surrounding the statistical analysis of support costs.

7.3 Insights from outside of Europe

7.3.1 The difference between operating environments within Europe compared with outside Europe make comparisons between ANSPs difficult. Benchmarking within Europe is facilitated by the collection and validation of data that is undertaken by the PRU. Whilst CANSO collects data from members for their benchmarking study we understand that they do not undertake extensive validation.

7.3.2 Therefore, it is difficult to draw firm conclusions from this analysis. We do however present the results for information purposes, and these results should be considered with caution.

7.3.3 From these results it appears that although NATS's en-route financial cost effectiveness and ATCO productivity are higher than the average of the selected European ANSPs there are non-European ANSPs that perform better. Mitigating factors for the differences in performance have not been analysed.

7.3.4 NATS appears to have higher ATCO productivity for oceanic operations, than the non-European ANSPs observed. However, the financial cost-effectiveness of NATS's oceanic operations is similar to that of the single non-European ANSP is included in the analysis, suggesting that its support costs or ATCO employment costs are higher.

A Statistical models

A.1 ACC ATCO-hours model

A.1.1 Model equation:

$$\text{ACC ATCO hours}_{ACC} = \alpha + \beta_1(\textit{flight hours}_{ACC}) + \beta_2(\textit{flight hours}_{ACC})^2 + \beta_3(\textit{AreaControlled}_{ACC}) + \beta_4(\textit{flightlevel}_{ACC}) + \beta_5(\textit{variability}_{ACC}) + \beta_6(\textit{delay}_{ACC})$$

A.1.2 Summary statistics for the ACC ATCO-hours model:

Number of observations: 94

Degree of freedom: 87

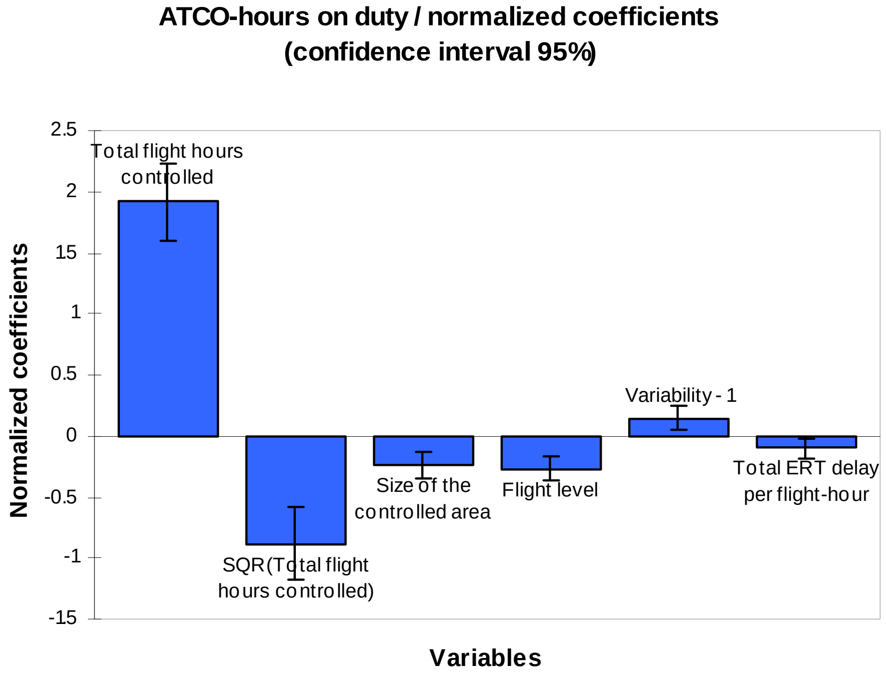
Adjusted R^2: 0.87

	Estimated coefficients	t	Pr > |t|
Constant	99,882	3.47	0.00
Total flight-hours controlled	1.85	12.00	< 0.0001
(Total flight-hours controlled)^2	-1.53 E-06	-5.96	< 0.0001
Area controlled	-0.18	-4.75	< 0.0001
Flight level	-589	-5.66	< 0.0001
Variability	144,565	2.86	0.01
Total ERT delay per flight-hour	-10,575	-2.35	0.02

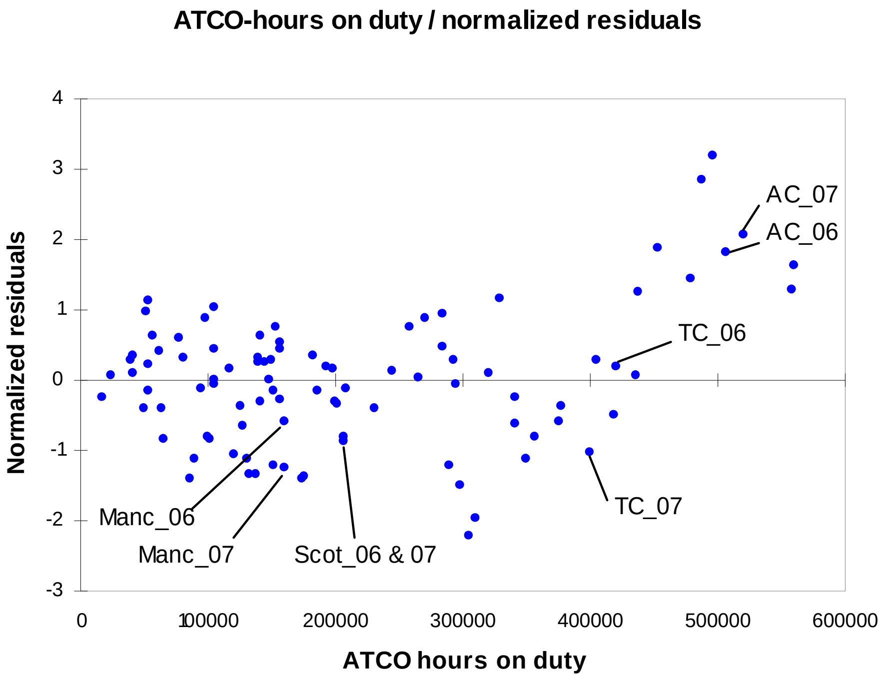
A.1.3 Confidence intervals for the estimated coefficients:

	Estimated coefficients	Lower bound (95%)	Upper bound (95%)
Constant	99,882	42,637	157,127
Total flight-hours controlled	1.85	1.54	2.16
(Total flight-hours controlled)^2	-1.53 E-06	-2.04E-06	-1.02E-06
Area controlled	-0.18	-0.26	-0.11
Flight level	-589	-796	-382
Variability	144,565	44,253	244,877
Total ERT delay per flight-hour	-10,575	-19,521	-1,629

A.1.4 Normalized coefficients:



A.1.5 Normalized residuals:



A.2 ANSP support costs model 1

A.2.1 Model equation:

$$Support\ costs_{ANSP} = \alpha + \beta_1(\ CompositeFlightHours_{ANSP}) + \beta_2\ (AreaControlled_{ANSP}) + \beta_3(AgeOfAssets_{ANSP}) + \beta_4(MUAC_{ASNP})$$

A.2.2 Summary statistics for the ANSP support costs model 1:

Number of observations: 20

Degree of freedom: 15

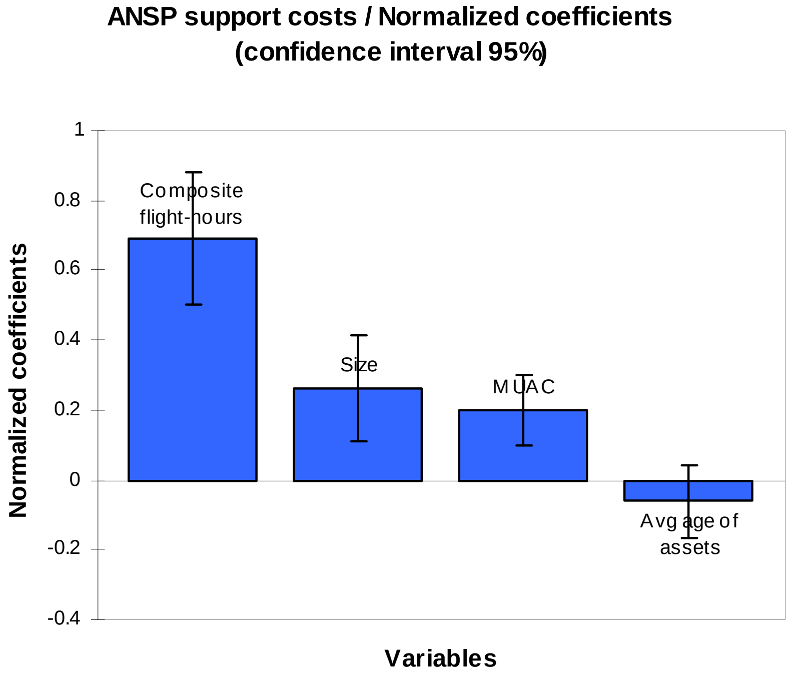
Adjusted R^2: 0.99

	Estimated coefficients	t	Pr > |t|
Constant	87,742,680	1.54	0.14
Composite flight-hours	184	7.75	< 0.0001
Area controlled	171	3.74	< 0.01
MUAC	1,237,241	4.11	< 0.01
Age of assets	-9,280,072	-1.23	0.24

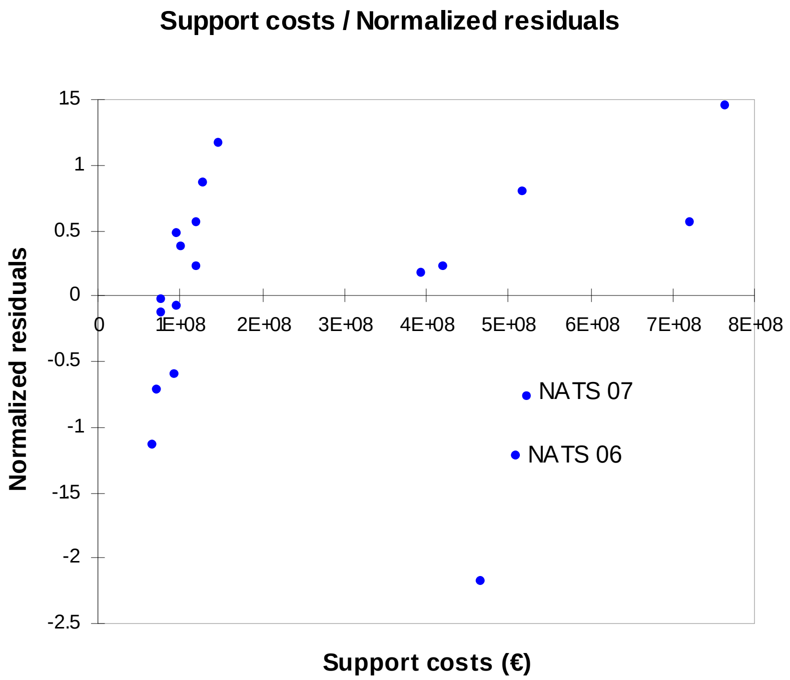
A.2.3 Confidence intervals for the estimated coefficients:

	Estimated coefficients	Lower bound (95%)	Upper bound (95%)
Constant	87,742,680	-33,660,539	209,145,900
Composite flight-hours	184	134	235
Area controlled	171	73	268
MUAC	1,237,241	595,862	1,878,620
Age of assets	-9,280,072	-25,391,680	6,831,536

A.2.4 Normalized coefficients:



A.2.5 Normalized residuals



A.3 ANSP support costs model 2

A.3.1 Model equation:

$$Support\ costs_{ANSP} = \alpha + \beta_1(\ ATCO\ Hours_{ANSP}) + \beta_2\ (AreaControlled_{ANSP}) + \beta_3(AgeOfAssets_{ANSP}) + \beta_4(MUAC_{ASNP})$$

A.3.2 Summary statistics for the ANSP support costs model 2:

Number of observations: 20

Degree of freedom: 15

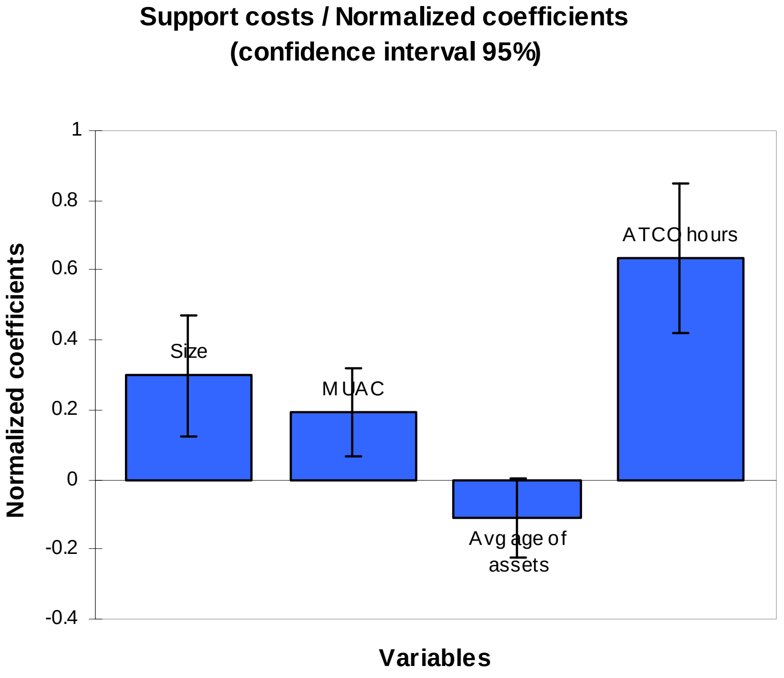
Adjusted R^2: 0.99

	Estimated coefficient	t	Pr > |t|
Constant	163,515,438	2.73	0.02
ATCO-hours	133	6.26	< 0.0001
Area controlled	192	3.64	< 0.01
Age of assets	-17,311,076	-2.11	0.05
MUAC	1,219,906	3.31	< 0.01

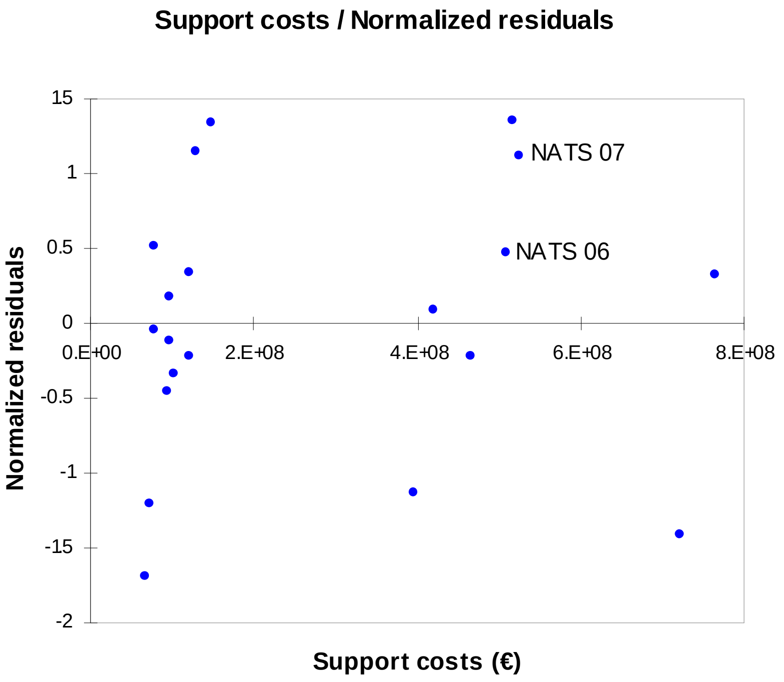
A.3.3 Confidence intervals for the estimated coefficients:

	Estimated coefficient	Lower bound (95%)	Upper bound (95%)
Constant	163,515,438	35,990,945	291,039,930
ATCO-hours	133	88	178
Area controlled	192	80	305
Age of assets	-17,311,076	-34,790,174	168,022
MUAC	1,219,906	434,198	2,005,614

A.3.4 Normalized coefficients:



A.3.5 Normalized residuals:



B ANSP information

	ANS CR	Austro Control	Belgocontrol	DFS	DSNA	ENAV	LVNL	MUAC	NATS	Skyguide
Exchange rate max/min ratios	1.14	1	1	1	1	1	1	1	1.04	1.08
Cumulated inflation 2003-07	10%	8%	9%	8%	8%	9%	6%	6%	8%	4%
Accounting standards in 2007	IFRS	Nat.	Nat.	IFRS	Nat.	National	Nat.		IFRS	Nat.
Irrecoverable VAT	no	no	no	no		no	yes	no	no	no
ANSP status	State-enterprise 100% state-owned	Private limited company 100% state-owned	Public autonomous enterprise 100% state-owned	Limited liability company 100% state-owned	Division of the DGAC 100% state-owned	Joint-stock public corporation 100% state-owned	Corporate entity 100% state owned	Operated by the EUROCONTROL Agency	PPP 49% state-owned and 51% private-owned	Joint-stock company 99.91% state-owned
Civil/Military				Integrated						Integrated
ACC ATCOs contractual annual working hours (2007)	1,569	1,555	1,500	1,441	1,413	1,609	1,742	1,485	1,464	1,445

C Glossary

ACC	Area Control Centre
ACE	ATM Cost-Effectiveness benchmarking programme of the PRU
Aena	Aeropuertos Españoles y Navigación Aérea (the Spanish ANSP)
ANS	Air Navigation Services
ANS CR	Air Navigation Services of the Czech Republic (the Czech ANSP)
ANSP	Air Navigation Service Provider
ATCO	Air Traffic Control Officer
ATFM delay	En-route Air Traffic Flow Management (ATFM) delay is the duration between the last take-off time requested by the aircraft operator and the take-off slot given by the Eurocontrol Central Flow Management Unit as a result of flow restrictions imposed in en-route airspace
ATM	Air Traffic Management
ATSA	Air Traffic Service Assistant
Austro Control	The Austrian ANSP
Belgocontrol	The Belgian ANSP
CAA	Civial Aviation Authority
CANSO	Civil Air Navigation Services Organisation
CNS	Communications, Navigation and Surveillance
CP3	Third Price Control Period of CAA's regulation of NATS
DFS	Deutsche Flugsicherung GmbH (the German ANSP)
DSNA	Direction des Services de Navigation Aérienne (the French ANSP)
ENAV	Società Nazionale per l'Assistenza al Volo (the Italian ANSP)
ERG	Economic Regulation Group of the CAA
Finavia	The Finnish ANSP
FIR	Flight Information Region
GDP	Gross Domestic Product
ICAO	International Civil Aviation Organisation
KPI	Key Performance Indicator
London AC	London Area Control
London TC	London Terminal Control
LVNL	Luchtverkeersleiding Nederland (the Dutch ANSP)
MATS	Malta Air Traffic Services (the Maltese ANSP)
MoldATSA	The Moldovan ANSP
MUAC	Maastricht Upper Air Control Centre
NATS	National Air Traffic Services (the UK ANSP)
NERL	NATS en route plc
Oro Navigacija	The Lithuanian ANSP
PRR	Performance Review Report
PRC	Performance Review Commission
PRU	Performance Review Unit
QoS	Quality of Service
ROMATSA	Romanian Air Traffic Services Administration
Skyguide	The Swiss ANSP
UK	United Kingdom of Great Britain and Northern Ireland
UkSATSE	The Ukrainian ANSP