Review – Adding Capacity at Heathrow Airport

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1 Executive Summary

1.1 Air Quality Consultants Ltd (AQC) has been commissioned by the London Boroughs of Hounslow and Hillingdon, acting on behalf of the "2M Group", to carry out a critical review of the Consultation Document issued by DfT in November 2007, entitled *Adding Capacity at Heathrow Airport*. Specifically, this report critically appraises the revised air quality modelling work that has been carried out at Heathrow Airport, taking into account the methodologies and underlying assumptions that have been used. This report does not include a detailed appraisal of the Surface Access proposals submitted by DfT. Where appropriate, reference is made to the report prepared by TRL Limited that considers surface access and transport emissions in detail.

1.2 The 2003 White Paper *The Future of Air Transport* (AWP) made it clear that Government would not support the addition of a third runway at Heathrow Airport unless it could be confident that the European air quality limit values could be met. In particular, reference was made to the annual mean limit value (40 $\mu g/m^3$) for nitrogen dioxide (NO_2) which is the critical pollutant around Heathrow.

1.3 DfT subsequently set up the Project for the Sustainable Development of Heathrow (PSDH) which comprised three technical panels related to the three air quality aspects of emissions, monitoring and modelling. PSDH published its report in 2006, which set out a series of recommendations intended to improve the methodology for assessing air quality in future years at Heathrow, including refinements to emissions inventories, new approaches to data evaluation, and a detailed model intercomparison exercise.

1.4 Government now confidently concludes, based on the improved modelling work arising from the PSDH recommendations, that full mixed mode on the existing two runways could be introduced by 2015, and a new third runway could be added at Heathrow by around 2020 without causing exceedences of the air quality limit values.

1.5 The assessment of air quality impacts 10 to 20 years hence inevitably relies on many assumptions. Section 5 of the Consultation Document deals with *Using Sound Science Responsibly,* and states that "the fifth principle for sustainable development calls for *ensuring policy is developed and implemented on the basis of strong scientific evidence, whilst taking into account scientific uncertainty (through the precautionary principle) as well as public attitudes and values*". By definition, if Government is to be confident that the limit values will not be exceeded, it must do so by adopting a precautionary approach to the assumptions that have been made.

1.6 With this precautionary principle in mind, the evidence presented by DfT is considered in respect of the following issues:

- Model verification;
- Potential uncertainties associated with the various future year assumptions;
- The MDL Option; and
- 2015 Full Mixed Mode Option.

General Overview

1.7 The technical evidence that has been provided to support the Consultation Document is generally comprehensive and of a reasonable standard. However, the material is extremely difficult to follow in a logical manner, as elements relating to the same topic are often scattered across a number of different reports. For example, model verification is dealt with in both the CERC and Atkins reports; emissions relating to aircraft and road traffic are dealt with in several AEA reports, the CERC report and the report on surface access.

1.8 In the course of preparing this review, a number of questions relating to air quality matters were identified, where clarification or confirmation of issues was required. Twenty six questions were submitted to DfT on 19 December 2007; a further question, and a request for a meeting with the experts responsible for drafting the technical reports was submitted on 8 January 2008. The final set of responses from DfT was provided on 1 February 2008. DfT also declined the offer of a meeting. This review is therefore necessarily restricted to the written evidence that has been submitted. The delayed response from DfT on some critical issues, and their refusal to allow a meeting between experts, has, in our opinion, significantly hampered this appraisal process.

Model Verification

1.9 Model verification refers to the process by which the model predictions are compared with measured data in order to lend confidence to the performance of the model. The model verification is presented in the CERC *Air Quality Studies for Heathrow Report*, and within the Atkins *Demonstrating Confidence* report.

1.10 Whilst it is accepted that the model performance for the 2002 base year is within the expected band of uncertainty for these types of dispersion models, further analysis of the model performance using the approach recommended by Defra in Technical Guidance Note LAQM.TG(03) suggests

that the model may be systematically underpredicting NOx concentrations by 3.3% and nitrogen dioxide concentrations by 4.4% in 2002. This implies that exceedences of the annual mean objective for nitrogen dioxide could potentially occur at modelled concentrations **above about 38 µg/m^3**.

1.11 The implications of this are best appreciated from the results presented in the Atkins *Population Exposure to Air Pollution Report*. Table 3.7 of this report summarises the number of properties exposed to nitrogen dioxide concentrations above the limit value (40 µg/m^3) for each preferred scheme. These numbers are reproduced as Table 4 in the Consultation Document, and have been used to directly inform Government's conclusions that full mixed mode and a third runway could be introduced by 2015 and 2020 respectively, without causing exceedences of the limit value.

1.12 On request, DfT subsequently provided an expanded version of Table 3.7, showing the number of properties exposed to concentrations above 38 µg/m^3. This table is reproduced below[1].

1.13 There are a number of very important implications arising from this table, which effectively represents a sensitivity test for the predicted future nitrogen dioxide concentrations, taking into account the potential for systematic bias and likely model uncertainty:

- For the 2015 scenarios, the number of properties exposed to concentrations above 38 µg/m^3 significantly increases with the introduction of mixed mode (2015MM) when compared with segregated mode (2015SM). Even with "roads mitigation" (2015MMrd) there are still 116 properties exposed to concentrations above 38 µg/m^3; and
- For the 2030 scenario (2030 R3T6H), there are 115 properties exposed to concentrations above 38 µg/m^3.

Summary of the number of properties exposed to an annual average nitrogen dioxide concentration above each contour band for specified points for each preferred scheme (source DfT response to questions, 01 Feb 2008)

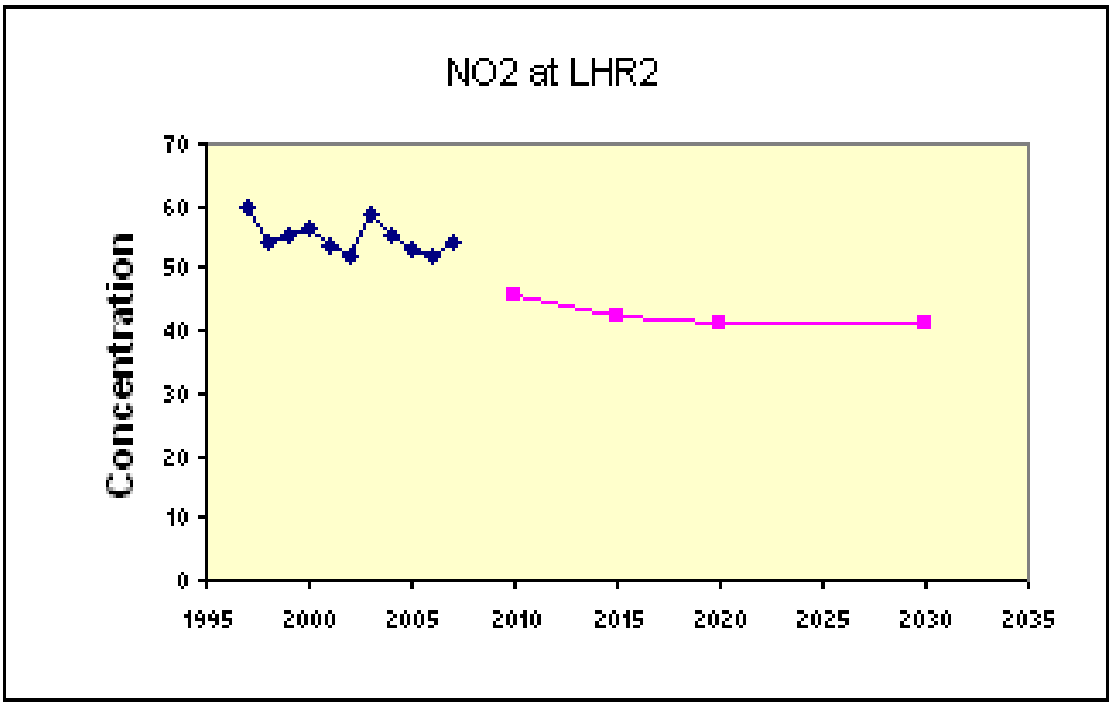
Contour band	2015 SM No Properties	2015 MM No. Properties	2015 MMrd No. Properties	2030 R3T6 H No. Properties
38-38.9	126	144	116	115
39-39.9	75	93	21	21
40-41.9	22	27	0	0
42-43.9	0	0	0	0
44-45.9	0	0	0	0
46-47.9	0	0	0	0
48-49.9	0	0	0	0
50-59.9	0	0	0	0
60-69.9	0	0	0	0
Total Exceeding EU Limit Value	**22**	**27**	**0**	**0**

[1] Data for the 2020 R3T6 H scheme were not provided despite being requested.

1.14 It is also useful to compare trends in measured concentrations with future year concentrations predicted by the model. As an example, the figure below shows the measured annual mean nitrogen dioxide concentrations at the LHR2 site, located just to the north of the northern runway, for the period 1996 to 2007[2]. The figure also shows the predicted annual mean nitrogen dioxide concentrations for 2010, 2015, 2020 and 2030[3].

1.15 The measured nitrogen dioxide concentrations show no strong evidence of a decline over the 11 year period. Indeed, the concentration in 2007 is the same as in 1997. To achieve the predicted concentrations in 2010 and beyond would thus require a substantial "step change" that appears wholly inconsistent with the empirical evidence to date. This disparity is not addressed within the various technical reports.

Measured annual mean nitrogen dioxide concentrations (blue line) and predicted annual mean nitrogen dioxide concentrations (pink line) at LHR2 (µg/m^3)



2 The 2007 data have been extracted from the Heathrow Airwatch site, and include provisional data.

3 The 2010 and 2015 predictions shown are for Segregated Mode whilst the 2020 and 2030 predictions are for the hybrid 3rd runway.

Potential Uncertainties in Future-Year Assumptions

1.16 To a large extent, the expected attainment of the limit values in future years is driven by the expected reduction in road vehicle emissions, and trends towards the use of cleaner aircraft engines and a greater proportion of twin-engined as opposed to four-engined aircraft. The assumptions made regarding these two issues are therefore crucial. However, the sensitivity tests conducted have been principally limited to a consideration of future primary NO_2 emissions, and the technical reports present no detailed sensitivity tests for many of the other critical assumptions that have been made.

1.17 This is in direct contrast to the assessment documents that accompanied the AWP which included a number of "what if" scenarios. Whilst the Atkins *Demonstrating Confidence* report accurately references the PSDH work, stating that "*uncertainty associated with input parameters will increase as projections are made further into the future*", the Consultation Document suggests that "*insofar as there are remaining uncertainties inherent in modelling, the intensity of NOx emissions may be greater or lesser than predicted….consultees can therefore consider the extent to which uncertainties might affect them*". This is a surprising statement, as in the absence of any quantitative assessment of these uncertainties, it is extremely difficult, if not impossible, for consultees to do this.

1.18 Potential uncertainties associated with the modelling are associated with:

- Meteorology and climate change;
- Future-year assumptions regarding road traffic; and
- Future-year assumptions regarding aircraft

Meteorology and Climate Change

1.19 The modelling predictions in future years are based on meteorological data measured at Heathrow Airport in 2002, consistent with the base year emissions inventory. However, there is no certainty that the weather conditions experienced in 2002 will accurately represent those in future years up to 2030 and beyond, and there is strong evidence to suggest they will not. Changes in meteorology affect both the local dispersion of pollutant emissions from the Airport and the road network, and the contribution to pollutant levels from the regional background.

1.20 There is thus a strong justification for considering alternative meteorological years for the modelling exercises, and as alternative base years from which to forecast regional background pollutant

contributions. In particular, given the unusual meteorological conditions in 2003[4], and associated higher pollutant concentrations, this year should have been considered in detail.

1.21 However, consideration of the effects of meteorology in the Atkins report is confined to a statistical approach, which while not wholly inappropriate, only takes into account emissions of NOx from aircraft (thereby ignoring emissions from all other sources, and the potential for the regional background contribution to be different). The analysis is also based on a single monitoring site (LHR2). This serious deficiency is in fact noted within the Atkins report itself (Finding 30) which states that "*this analysis is solely for LHR2 – the choice of an alternative met year may be different at different CMS (Continuous Monitoring Stations). A wider consideration of Demonstrating Confidence (looking at total concentrations, rather than focussing primarily on within-airport sources as reported here) would have merit in undertaking a modelling sensitivity test of a future case using an alternative year of meteorological data".* In light of this statement, it is very difficult to understand why no additional sensitivity tests were undertaken.

1.22 The Atkins report also recognises the potential additional uncertainty due to the influence of climate change on meteorology (Finding 16). Whilst the effects of climate change are uncertain, there is the potential for windier conditions in the winter months, and higher temperatures in the summer months. As set out within the PSDH report, the former may have significant effects on the contribution that aircraft emissions make to ground level pollutant concentrations. Higher temperatures may potentially give rise to higher background ozone concentrations. Ozone is of particular importance due to the role it plays in the complex atmospheric chemistry, converting NOx emissions (the principal form of emissions from aircraft and road traffic) to nitrogen dioxide (NO_2). Thus, higher background ozone concentrations could potentially result in increased ground level concentrations of nitrogen dioxide.

1.23 Despite recognising this concern, the Atkins report cites the recent AQEG report on air quality and climate change, and work undertaken by CERC on behalf of Defra, and concludes that "*on this basis, no further work on climate change influences has been undertaken*". No assessment or analysis is provided to substantiate the basis of this conclusion. This is inconsistent with Recommendation 1 of the AQEG report that states "*impact analysis of policies or specific development, whether for industry, transport, housing etc., should take account of the interlinkages of emissions of air quality and climate change pollutants*".

[4] Whilst the meteorological conditions in 2003 were "unusual", there is evidence to suggest that such conditions may be "typical" by 2030 due to the effects of climate change.

Emissions - Road traffic

1.24 The information set out in the CERC report indicates that road traffic NOx emissions are predicted to fall by 79% by 2020, and by 82% by 2030, when compared with the 2002 base year. These assumptions regarding future road traffic emissions thus form the cornerstone of the conclusions regarding the expected improvement to nitrogen dioxide concentrations.

1.25 The assumptions made regarding traffic flows and speeds on the local road network are fundamental to these expected improvements. However, as highlighted in the TRL report, the technical reports fail to consider the potential implications for road transport emissions arising from errors in predicted road traffic activity in future scenarios. Such uncertainties will be directly reflected in any future forecasts of nitrogen dioxide concentrations.

1.26 The assessment also includes provision for the introduction of Euro VI emissions standards, but these are not yet finalised, and the proposals cover a wide range. The Atkins report indicates that "*the assessments have used the least optimistic end of this range as agreed with Defra*" but the specific details of this critical assumption have not been provided.

1.27 Inevitably, there must be considerable uncertainty in the forecasts for future traffic flows, speeds, vehicle mix, and take-up of emissions standards when projecting to 2030 and beyond. However, very little detail is provided within the supporting technical reports, and on the basis of the information provided it is very difficult to understand how the assumed reductions in road transport NOx emissions by 2030 will be achieved.

Emissions – Aircraft

1.28 In terms of the future assumptions for aircraft types and engine assignments, there is very little detail provided within the technical reports to support precisely what has been done. For example, the AEA report on *Future LHR Scenarios* states that "*QinetiQ were commissioned by DfT to forecast the engine assignments for future cases*", but no supporting documents were provided.

1.29 The calculation of NOx emissions from aircraft in 2020 and beyond requires that many assumptions are made to assign both aircraft and engine types. This requires assumptions on aircraft and engine rollover to be made for the wide variety of airlines operating from Heathrow, taking account of both economic and regulatory incentives. In terms of the future aircraft fleet assumptions, it is not clear from the technical reports which organisation was responsible for preparing these, and no supporting documentation is provided. On request, DfT has subsequently

provided a note prepared by QinetiQ that sets out the basis of the assumptions for engine assignments.

1.30 In some cases, where the assumed aircraft and engines do not currently exist, QinetiQ created "*completely new engines using the best estimates of the likely technology available…in some cases…there was a good understanding of the expected characteristics of the engine, in other cases there was not, and the best judgement of QinetiQ engine technology experts was used".* Following these assignments the likely NOx performance of the new and derivative engines has to be considered and for this "*a set of expected levels of achievable NOx performance levels relative to the CAEP/4 regulatory limits was used".*

1.31 Whilst the credentials of QinetiQ are not questioned, the PSDH panel report recommended that *"to provide technology forecasts for engine emissions capability through to 2030, a review will be carried out to update the technology assessment carried out for the AWP. The assessment will be carried out by an independent gas turbine technology organisation using the guidance above and informed by input from industry, specifically manufacturers and major Heathrow airline operators. In the case of strongly differing views not reconciled by discussion, the independent organisation will inform DfT of any unresolved differences when making its recommendations.*

1.32 The process described within the technical reports and the supporting note from QinetiQ fails to provide transparency on the input that was provided by industry, manufacturers and airlines, and more critically fails to provide any sensitivity tests for the assumptions that have been made.

MDL Option[5]

1.33 The assessments for the preferred third runway option are based on the hybrid scenario (which assumes mixed-mode on the new third runway, and alternating departures and landings on the existing two runways). However, whilst the Consultation Document notes that this is BAA's assumption, the report also acknowledges that NATS have a "*number of significant airspace and air traffic management issues*" to resolve. The MDL option would restrict departures to the existing northern runway, and would be expected to have much greater air quality impacts at the residential properties to the north west of this runway.

1.34 A direct question was put to DfT on this matter, in which they were categorically requested to confirm whether the MDL option could be excluded. The response only reiterated that "*the intention is to operate the existing two runways in segregated mode*". Given the concerns from

[5] MDL - mixed mode operations on the new third runway, with the existing northern runway used for departures, and the southern runway used for landings.

NATS highlighted above, and in the absence of a categorical statement to guarantee that the MDL option would not be considered, a detailed analysis of this option should have been provided.

2015 Mixed Mode

1.35 It is also proposed to introduce full mixed mode by 2015, which the Consultation Document claims would be compatible with the air quality limit values in the vicinity of the Airport. However, the Document also notes that "*during full mixed mode, there will still be residual areas of exceedence which could be addressed by potential alternative measures*". Such measures could include *"lower speed limits, possible traffic management measures and the use of proprietary photo-catalytic surface treatments which can help absorb NO_2".* However, no detailed information regarding these measures is provided – for example, how much area would need to be covered in these photo-catalytic surface treatments in order to reduce NO_2 concentrations to an acceptable level? The Document leaves such proposals to the airport operator, the Highways Agency, local authorities and other agencies to resolve. In the absence of such details, it is not possible to support the conclusion that the limit values can be confidently achieved.

1.36 Notwithstanding these potential additional measures, the limit value for nitrogen dioxide is to be achieved by 2010, but the New Air Quality Directive (NAQD) (currently under negotiation) allows Member States to seek derogation for a maximum of five years, subject to the establishment of a plan or programme to reduce emissions. The introduction of mixed mode would increase NOx emissions over that which would arise from the existing segregated mode, and by definition would delay the achievement date of the limit value. It is open to interpretation, but this may be in contravention of Articles 20 and 21 of the NAQD.

Conclusions

1.37 The Consultation Document and supporting technical reports provide an assessment of air quality in the vicinity of Heathrow airport in future years, with the introduction of full mixed mode and a new third runway. The assessments presented draw upon many of the recommendations included within the PSDH report, and undoubtedly provide a more robust evidence base than was available at the time of the AWP

1.38 However, the proposals for Heathrow expansion are complex, and require forecasting pollutant concentrations many years into the future. This inevitably requires many complex assumptions to be made. Whilst the technical reports provided by DfT to support the Consultation Document recognise the many uncertainties that are associated with the assessment, the evidence that is presented lacks transparency in many critical areas, and fails to provide plausible scenario tests

that could have been used to demonstrate confidence in the outcomes. Given the reliance that Government has placed upon the expected improvements to emissions from both road traffic and aircraft, this is surprising. In addition, the assessments fail to take full and proper account of one of the principal recommendations arising from the PSDH report, that the sensitivity of the model output should be tested against the likely ranges in model input. This has only been partly achieved in some areas, and disregarded in others.

1.39 Additional model verification work carried out in this report has identified that the model appears to be systematically underpredicting nitrogen dioxide concentrations by about 5%. In addition, the regional background contribution to pollutant concentrations in 2015 and beyond may be significantly higher than that forecast from a 2002 base year, taking into account meteorological variation and the potential effects of climate change. Thus, there is evidence that the limit value for nitrogen dioxide could be exceeded in future years where the model has predicted concentrations above about 38 $\mu g/m^3$. Results provided by DfT confirm that this would result in some 116 properties being exposed to nitrogen dioxide concentrations above the limit value in 2015 (with full mixed mode) and in 2030 (with the new third runway).

1.40 Taking all of these issues into account, it is concluded that the evidence provided by DfT is not sufficiently robust to support the conclusions that the proposed developments to add capacity at Heathrow Airport could be confidently achieved without compromising the air quality limit values.

2 Introduction

2.1 Air Quality Consultants Ltd (AQC) has been commissioned by the London Boroughs of Hounslow and Hillingdon, acting on behalf of the "2M Group", to carry out a critical review of the Consultation Document issued by DfT in November 2007, entitled *Adding Capacity at Heathrow Airport*. Specifically, the objectives of the review have been to critically appraise the revised air quality modelling work that has been carried out at Heathrow Airport, taking into account the methodologies and underlying assumptions that have been used.

2.2 This report does not provide a critical appraisal of the BAA *Surface Access Report*, but draws upon the conclusions of the appraisal carried out by TRL, inasmuch as these are directly relevant to the modelling of future air quality concentrations.

2.3 In the course of this review, the following documents issued by DfT have been considered:

- Adding Capacity at Heathrow Airport – DfT Consultation Document
- Demonstrating Confidence in the PSDH Air Quality Work – Atkins
- Population Exposure to Air Pollution – Atkins
- Air Quality Studies for Heathrow – CERC
- Revised Emissions Methodology for Heathrow 2002 – AEA
- Emissions Methodology for Future LHR Scenarios – AEA
- Heathrow Airport Emission Summaries – AEA

2.4 Consideration has also been given to these additional reports:

- Review – Adding Capacity at Heathrow Airport: Implications for emissions. TRL Limited.
- Modelling Air Quality form Aircraft Sources at London Heathrow Airport with a Lagrangian model LASPORT: 2015 Mixed Mode – MMU
- Airport Studies for Heathrow Case 12 (2015MM LASPORT Sensitivity) - CERC
- The Future of Air Transport (the "Aviation White Paper"), 2003

- Air Quality Assessments Supporting the Government's White Paper 2003
- Panel for the Sustainable Development of Heathrow (PSDH), 2006
- Air Quality and Climate Change: A UK Perspective (AQEG, 2006)

2.5 The first section of this report provides a general overview, and also makes reference to a list of questions that was provided to DfT in order to seek clarification on a number of issues. The following sections then provide a critical review of individual reports, cross-referencing where appropriate. Wherever possible, the paragraph numbers used in the source documents are stated for ease of reference.

2.6 The conclusions are summarised in Section 5. A summary of the questions put to DfT and the response provided is given in Annex 1.

3 Overview

3.1 The Aviation White Paper made it clear that Government would not support the addition of a third runway at Heathrow Airport unless it could be confident that the European Union air quality limit values could be met. These are legally binding upon Member States. Reference was made, in particular, to the annual mean limit value (40 µg/m^3) for nitrogen dioxide (NO_2), which is the critical pollutant around Heathrow.

3.2 DfT subsequently set up the Project for the Sustainable Development of Heathrow (PSDH) which comprised three technical panels related to the three air quality aspects of emissions, monitoring and modelling. PSDH published its report in 2006, which set out a series of recommendations intended to improve the methodology for assessing air quality in future years at Heathrow, including refinements to emissions inventories, new approaches to data evaluation, and a detailed model intercomparison exercise to help select the most appropriate model to use.

3.3 Government now confidently concludes, based on the improved modelling work arising from the PSDH recommendations, that full mixed mode on the existing two runways could be introduced by 2015, and a new third runway could be added at Heathrow by around 2020 without causing exceedences of the air quality limit values.

3.4 The assessment of air quality impacts 10 to 20 years hence inevitably relies on many assumptions. Section 5 of the Consultation Document deals with *Using Sound Science Responsibly,* and states that "the fifth principle for sustainable development calls for *ensuring policy is developed and implemented on the basis of strong scientific evidence, whilst taking into account scientific uncertainty (through the precautionary principle) as well as public attitudes and values*". By definition, if Government is to be confident that the limit values will not be exceeded, it must do so by adopting a precautionary approach to the assumptions that have been made.

3.5 The technical evidence that has been provided to support the Consultation Document is extensive. However, the material is difficult to follow in a logical manner, as elements relating to the same topic are scattered across a number of different reports. As examples, model verification is dealt with by both the CERC and Atkins reports; emissions relating to aircraft and road traffic are dealt with in several AEA reports, the CERC report and the report on surface access.

3.6 There is often a lack of transparency in the information provided in the technical reports. In some cases the information provided has proved to be inaccurate. A number of the reports cite

documents from which critical assumptions have been made, but without providing the detailed information. As an example, the Atkins *Demonstrating Confidence* report contains a total of 42 "Findings", but it is frequently not clear how these have been taken forwards to demonstrate confidence in the model. This report also presents data without specifying the pollutant, the averaging period or the units, as well as including a table that is clearly incomplete and making use of data from monitoring stations with low data capture. In many aspects, the report appears incomplete.

3.7 A principal criticism of the Consultation Document and the supporting technical reports is that they provide minimal sensitivity testing for the many assumptions that have been included in the assessments – in respect of air quality matters these tests have largely been restricted to a consideration of primary NO_2 emissions. This is in direct contrast to the assessment documents that accompanied the AWP, which included a number of "what if" scenario tests.

3.8 Whilst the Atkins *Demonstrating Confidence* report accurately references the PSDH work, stating that *"uncertainty associated with input parameters will increase as projections are made further into the future"*, the Consultation Document suggests that *"insofar as there are remaining uncertainties inherent in modelling, the intensity of NOX emissions may be greater or lesser than predicted….consultees can therefore consider the extent to which uncertainties might affect them"*. In the absence of any quantitative assessment of these uncertainties, it is difficult, if not impossible, for consultees to do this.

3.9 In the course of preparing this review, a total of 27 questions relating to air quality matters were identified, where clarification or confirmation of issues was required. These questions were submitted to DfT between 19 December 2007 and 8 January 2008. The final set of responses from DfT was provided on 1 February 2008. An offer to set up a meeting between technical experts was also made to DfT, but this was declined, and this review is necessarily restricted to the written evidence that has been submitted. There are still matters that have not been adequately clarified. The delayed response from DfT on some critical issues, and their refusal to allow a meeting between experts, has, in our opinion, significantly hampered this appraisal process.

4 Appraisal of Reports

Consultation Document

4.1 Many of the issues set out within the Consultation Document are dealt with in greater detail within the supporting technical documents. However, a number of specific matters are worthy of discussion.

4.2 Issues concerning Airspace are set out in Chapter 3. For the assessment of a three runway airport, two key scenarios were identified:

- MLD – mixed mode operations on the new third runway, with the existing northern runway used for landings, and the southern runway used for departures; and
- MDL - mixed mode operations on the new third runway, with the existing northern runway used for departures, and the southern runway used for landings.

4.3 Para 3.44 notes that *"in practice BAA have assumed that with three runways, use of the two existing runways would alternate, as now"*. This is subsequently referred to as the "hybrid" option, and was the focus of the subsequent assessment work. However, Para 3.45 states that *"NATS acknowledge that a number of significant airspace and air traffic management issues would need to be addressed further before they could submit for approval a design…"*. The MDL and MLD scenarios are not explicitly discounted as potential options, and in response to a direct question on this issue, DfT stated only that "*once a third runway is operational, the intention is to operate the existing two runways in segregated mode, with alternation"*.

4.4 The MDL option, would restrict departures to the northern runway, and would be expected to have much greater air quality impacts at the residential locations to the north-east of the Airport. If the MDL option cannot at this stage be categorically excluded, then the air quality impacts should have been presented in detail.

4.5 It is also proposed to introduce full mixed mode by 2015, which the Consultation Document claims would be compatible with the air quality limit values in the vicinity of the Airport. However, the Document also notes that "*during full mixed mode, there will still be residual areas of exceedence which could be addressed by potential alternative measures*". Such measures could include *"lower speed limits, possible traffic management measures and the use of proprietary photo-catalytic*

surface treatments which can help absorb NO_2". However, no detailed information regarding these measures is provided; for example, it is not stated how much area would need to be covered in photo-catalytic surface treatments in order to reduce NO_2 concentrations to an acceptable level. Their ability to ensure that the limit values are met has not been tested. The Document leaves such proposals to the airport operator, the Highways Agency, local authorities and other agencies to resolve. In the absence of such details, it is not possible to support the conclusion that the limit values can be confidently achieved.

4.6 Notwithstanding these potential additional measures, the limit value for nitrogen dioxide is to be achieved by 2010, but the New Air Quality Directive (NAQD) (currently under negotiation) allows Member States to seek derogation for a maximum of five years, subject to the establishment of a plan or programme to reduce emissions. The introduction of mixed mode would increase NOx emissions over those which would arise from the existing segregated mode, and by definition would delay the achievement date of the limit value. It is open to interpretation, but this may be in contravention of Articles 20 and 21 of the NAQD.

AEA Reports: *Emissions methodology for future scenarios* and *Heathrow Airport Emissions Summaries*

4.7 These reports are concerned with providing the "airport emissions inventories" that were subsequently input into the CERC dispersion model. In general terms, the work has been completed to a high standard, with details of the methodology provided.

4.8 A critical issue with regard to generating future airport emissions inventories concerns the assumptions that have been made for future aircraft fleet mix, and the engines that have been assigned to individual airframes. This work does not appear to have been undertaken directly by AEA.

4.9 In terms of future **aircraft** assumptions the *Emissions Summaries* report states that *"for future cases [of aircraft fleet composition] the table makes use of the type groups introduced by BAA for forecasting purposes."* As far as it is possible to ascertain, future assumptions on aircraft fleet mix were provided by BAA. No independent review of these data appears to have been undertaken, and no scenario tests are provided.

4.10 For future engine assignments, Para 2.27 of the *Emissions methodology* report notes "*QinetiQ were commissioned by the DfT to forecast the engine assignments for the future cases*" . However, no reference to a QinetiQ report is provided, and the details are not set out within the AEA report.

4.11 In response to a direct question, DfT provided a three page report issued by QinetiQ (QinetiQ/07/03179/V2.0) on 18 January 2008. As far as it is possible to tell, this short document was prepared to directly answer the question that was put to DfT, and is not the original report provided to AEA (assuming a report was provided).

4.12 Whilst the credentials of QinetiQ are not questioned, the PSDH panel report recommended that *"to provide technology forecasts for engine emissions capability through to 2030, a review will be carried out to update the technology assessment carried out for the AWP. The assessment will be carried out by an independent gas turbine technology organisation using the guidance above and informed by input from industry, specifically manufacturers and major Heathrow airline operators. In the case of strongly differing views not reconciled by discussion, the independent organisation will inform DfT of any unresolved differences when making its recommendations.*

4.13 The process described within the technical reports and the supporting note from QinetiQ fails to provide transparency on the input that was provided by industry, manufacturers and airlines, and more critically fails to provide any sensitivity tests for the assumptions that have been made.

CERC report: *Air Quality Studies for Heathrow*

4.14 The report presents modelling using ADMS-Airport of air quality around Heathrow Airport, for both the base year and a number of future year scenarios. Issues of concern are noted below.

Meteorology

4.15 The modelling has been carried out using hourly sequential meteorological data for Heathrow Airport for the year 2002, consistent with the year for which the base year emissions inventory was prepared. No scenario tests for other years of meteorological data are provided.

4.16 The model requires the user to input pollutant concentrations arising from sources outside of the model domain i.e. the rural background contribution. Future year rural background concentrations have been derived from the 2002 hourly values, once again consistent with the meteorological data and the emissions inventory. The following approaches were used to calculate future year rural concentrations:

- For NOx, assuming the year-adjustment factors provided by Defra;
- For NO_2, using a correlation polynomial derived from the 2002 NOx and NO_2 concentrations;
- For O_3, using expressions related to the total oxidant in each hour.

4.17 The approach used for 2002 is generally acceptable, but there a strong justification for a least one other meteorological year to have been considered in detail. There is no certainty that the weather conditions experienced in 2002 will accurately represent those in future years up to 2030 and beyond, and there is strong evidence to suggest they will not. Changes in meteorology affect the local dispersion of pollutant emissions from the Airport and the road network, and more importantly, the contribution to pollutant levels from the regional background.

4.18 It is widely accepted that 2003 was a relatively poor pollution year for many areas of the UK, including London. An example of this can be seen from the graphs presented in the Atkins *Demonstrating Confidence* report (Figs 3.3. and 3.4), where significantly higher concentrations of both NOx and NO_2 were recorded in 2003 than in preceding or subsequent years. There is also considerable precedent for considering a number of meteorological years for sensitivity testing *viz* the recent revision to the Air Quality Strategy (AQS) that was published by Defra in 2007, and which considered three meteorological years, 2002, 2003 and 2004. The AQS notes (Para 336, Vol 2) "*modelling the base case for these three years should provide an estimate of the likely range of future air quality outcomes that are influenced by the weather*".

4.19 Further comments relating to meteorological years and potential climate change effects are noted below with reference to the Atkins *Demonstrating Confidence* report.

Emissions

4.20 Emission inventory totals are provided in Section 4.3 of the report, in a series of tables for 2002 and future year scenarios. A summary of these data for airport and road traffic sources is provided in Table 1 below.

Table 1: Summary of Emissions Inventory Totals (NOx, tonnes/yr)

Emission Source	Base Case (2002)	2030R3[a]	2030R3[a]
Aircraft[b]	4131	7746	6762
Aircraft (Ground)[c]	1647	2627	2259
Roads[d]	62406	13247	11060

a The 2020 and 2030R3 emissions inventories have been calculated as the average of the respective MDL and MLD scenarios
b: Aircraft includes all aircraft emissions shown in CERC report
c: Ground aircraft emissions excludes climb out, initial climb and approach. These emissions are included within the total aircraft emissions.
c: Roads includes major roads around Heathrow and rest of Greater London and minor roads

4.21 The data in the table indicate that emissions from aircraft sources are predicted to increase by 21% by 2020, and 18% by 2030, compared with the 2002 baseline. This reflects the increase in aircraft movements and the relatively limited improvement in aircraft NOx emissions expected in future years. Comments related to the potential uncertainties of the assumptions have been discussed above.

4.22 Critically, the data indicate a reduction in road traffic NOx emissions of 79% by 2020, and 82% by 2030. It is these improvements that largely drive the reductions in concentrations predicted in future years. However, as noted in the TRL *Adding capacity at Heathrow Airport: Implications for emissions* report, the technical evidence submitted fails to make any reference to the implications for road transport emissions associated with errors in predicting traffic activity for future scenarios.

4.23 The assessment also includes provision for the introduction of Euro VI emissions standards, but these are not yet finalised, and the proposals cover a wide range. The Atkins report indicates that "*the assessments have used the least optimistic end of this range as agreed with Defra*" but the specific details of this critical assumption have not been provided.

4.24 Inevitably, there must be considerable uncertainty in the forecasts for future traffic flows, speeds, vehicle mix, and take-up of emissions standards when projecting to 2030 and beyond. However, very little detail is provided within the supporting technical reports, and on the basis of the information provided it is very difficult to understand how the assumed reductions in road transport NOx emissions by 2030 will be achieved.

Model verification

4.25 Model verification refers to the process by which the model predictions are compared with measured data in order to lend confidence to the performance of the model. Model verification is presented in the CERC *Air Quality Studies for Heathrow Report*, and within the Atkins *Demonstrating Confidence* report.

4.26 Section 9 of the CERC report presents a statistical comparison of predicted NOx and NO_2 concentrations with measured concentrations at nine Continuous Monitoring Stations (CMS); comparisons of measured versus modelled annual mean NOx and NO_2 concentrations are provided within Tables 9.1 and 9.2 respectively. These tables calculate an average fractional bias, indicating a "*very small mean over-estimate*" for NOx (+0.013) and NO_2 (+0.018). The tables also show the analysis for the data excluding LHR10 (the M25 site, which was acknowledged within the PSDH report to be an outlier), although the accompanying text focuses on the results with LHR10 included.

4.27 These comparisons also include the LHR6 site, which has a significant influence on the calculation of the average fractional bias (this site shows a fractional bias of -0.27 for NOx, and -0.11 for NO_2). LHR6 is the site at Teddington, which lies outside of the principal model domain area, and was not considered in as much detail as the "airport area". It is therefore also appropriate to consider the verification if LHR6 is also excluded, i.e. confining the verification to those sites that have been adequately modelled.

4.28 Tables 2 and 3 below repeat the analysis in the CERC report, but with LHR6 and LHR10 excluded. The measured and modelled values from these tables are then also shown plotted in Figures 1 and 2 for NOx and NO_2 respectively. In each case, the "best fit" regression line is also shown.

4.29 Model verification procedures are discussed in detail within Annex 3 of the Technical Guidance Note LAQM.TG(03) which has been published by Defra. If the approach recommended in this guidance is followed, the slopes of the regression lines in Figures 1 and 2 suggest that the model is under-predicting NOx by 3.3%, and NO_2 by 4.4%.

Table 2: Comparison of mean (µg/m^3) and fractional bias for measured and modelled NOx at CMS (excluding LHR10 and LHR6)

CMS	Measured	Modelled	Fractional Bias
LHR2	119.49	110.27	-0.077
LHR5	73.74	68.39	-0.073
LHR8	63.53	59.10	-0.070
LHR11	74.13	68.32	-0.078
LHR14	71.18	64.32	-0.096
LHR15	66.34	63.15	-0.048
LHR16	113.26	124.44	+0.099
Average			**-0.049**

Table 3: Comparison of mean (µg/m^3) and fractional bias for measured and modelled NO_2 at CMS (excluding LHR10 and LHR6)

CMS	Measured	Modelled	Fractional Bias
LHR2	52.09	48.04	-0.078
LHR5	43.41	36.31	-0.164
LHR8	32.07	31.67	-0.012
LHR11	35.93	35.16	-0.021
LHR14	36.3	34.57	-0.048
LHR15	32.43	34.15	+0.053
LHR16	45.26	47.18	+0.042
Average			**-0.032**

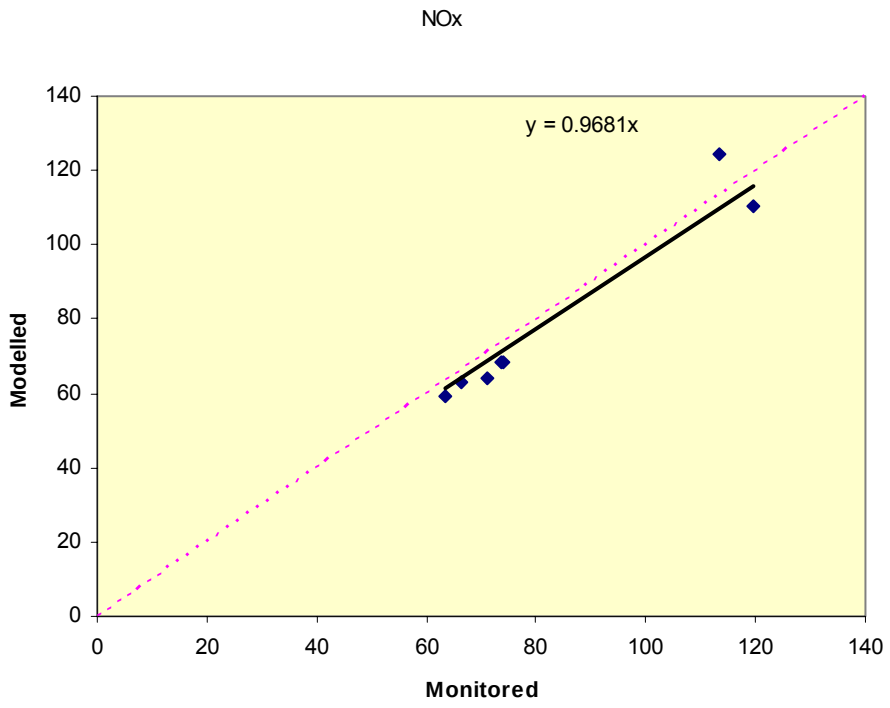


Figure 1: Plotted values from Table 2. Dotted line is 1:1. Solid line is best fit.

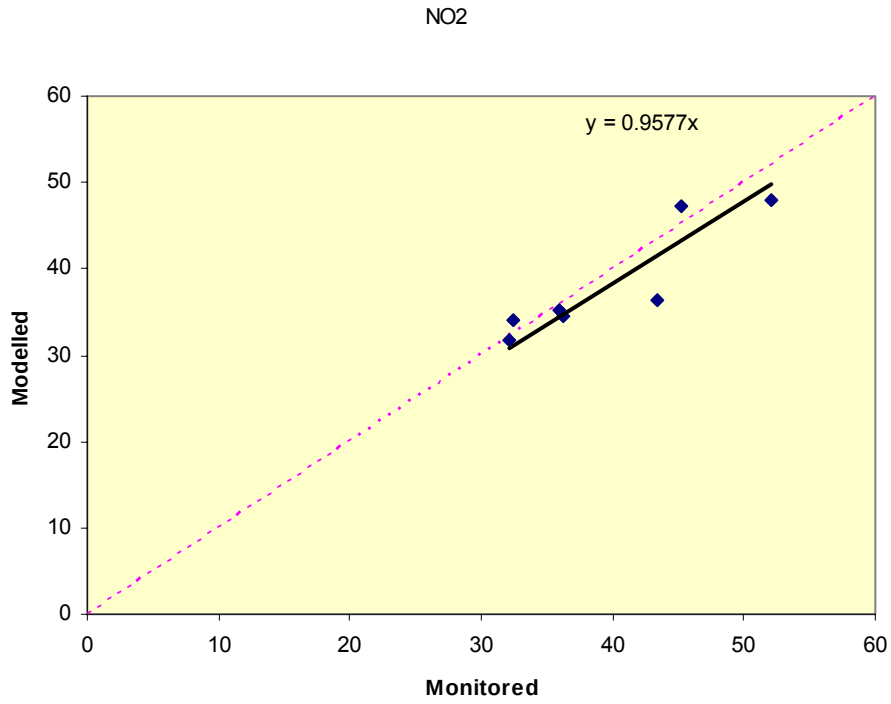


Figure 2: Plotted values from Table 3. Dotted line is 1:1. Solid line is best fit.

4.30 The outcome of this analysis is that there is potential that exceedences of the limit value (40 µg/m^3) could realistically occur **where predicted annual mean concentrations of nitrogen dioxide exceed about 38 µg/m^3.**

Atkins *Demonstrating Confidence* report

4.31 The Atkins *Demonstrating Confidence* report is intended to "*provide the evidence base for demonstrating confidence (showing robustness) in the air quality modelling undertaken for PSDH*" (section 1.1). The report is confusing to read, and as identified below, it contains a number of incomplete tables and figures. The report sets out a total of 42 *"findings"*, but the relevance of these is not always clear in terms of fulfilling the principal objective, which is to demonstrate confidence in the model. In many aspects, the report appears to be unfinished.

4.32 The scope of work undertaken in the report is set out in section 1.2. This cites Recommendation 4 of the PSDH Panel 1 report, and notes that the "*modelling should include substantial analysis to test the sensitivity of the model output to the likely ranges of uncertainty in model input, especially that related to emissions, future meteorology, the behaviour of jet plumes, and future changes to primary NO_2 and background ozone*".

4.33 It is also useful to refer to Chapter 1 of the PSDH report, which sets out a synthesis of the key issues and findings. Para 101 notes that "*analysis of the sensitivity of the model output to likely ranges of uncertainty in model input, especially that related to emissions, to the future meteorology, to the behaviour of the jet plumes and to future changes in primary NO_2 and background O_3, **will be essential**".* It is therefore surprising that the Atkins report then abjectly fails to apply **substantial analysis** to any of these **essential** issues, and fails to address some of them at all.

4.34 The lack of sensitivity testing is considered to be a major weakness in the assessment. For example, where is the evidence to show that the sensitivity of the model has been tested against the likely ranges of uncertainty with regard to NOx emissions arising from both aircraft and road traffic? There is no analysis provided in respect of future changes to background ozone. The analysis provided in respect of future meteorology is useful, but insufficient in detail. These issues are discussed in more detail below.

4.35 Section 2.3 of the report describes how the various PSDH panel recommendations have been incorporated into the assessment. A series of tables is also provided, setting out the recommendations and a response to each of the recommendations. It is noted that Table 2.1 makes reference to reports prepared by CERC and CATE regarding the LASPORT model, but these documents were not listed in Annex D of the Consultation Document. It is further noted that Table 2.4, which deals with Surface Access, only lists 10 PSDH recommendations, when in fact the PSDH report contains 19 recommendations. On request, DfT provided the missing reports and updated Table 2.4 to include the missing items.

4.36 Finding 6 notes that "*the full (in an ideal world) recommendations have not been carried out*". Likewise, Finding 7 states that "*Panel 3 surface access sources were implemented where the work programme for PSDH allowed*". The implications of these are not explored further, and it is not clear whether they are important or not.

4.37 Section 3 of the report deals with model verification, and several aspects are covered. Comparisons of measured and modelled concentrations are shown in Figures 3.3 and 3.4, for NOx and NO_2 respectively. The measured values provided have been updated since the PSDH report was completed, but the Atkins report does not provide these data, nor any information on data capture. On specific request, this information was provided by DfT. Important issues to note are:

- Data capture at some sites (LHR5, LHR17 and LHR18) was low data in some years, and in some cases below 50%. The data reported in the PSDH report used a threshold of 75%. It is

not clear why this has been changed in the Atkins report. Considerable caution should be applied to annual mean concentrations derived from less than 75% data capture.

- The figures also include "annual mean" concentrations for 2007, but only data for the period up until 21/05/07 were included. This should have been made explicitly clear, and once again, caution must be applied to these values.

4.38 Consideration of the data in these figures is then essentially restricted to NOx "*for LHR2 there seems to be a downward slope over time*.", which is agreed. For NO_2, this is not the case, but the issue is not explored further. The report provides no conclusions from the data in these figures that lends any confidence to the performance of the model.

4.39 To take this analysis further, Figure 3.4 from the Atkins report has been reproduced, and is shown in Figure 3 below. In this case it was possible to obtain a full 12 months data for 2007, although some provisional data are included. The predicted annual mean nitrogen dioxide concentrations for 2010, 2015, 2020 and 2030 have been derived from the CERC report[6].

4.40 It is evident that the measured nitrogen dioxide concentrations show no strong evidence of a decline over the 11 year period from 1996 to 2007. Indeed, the concentration in 2007 is the same as in 1997. To achieve the predicted concentrations in 2010 and beyond would thus require a substantial "step change" that appears wholly inconsistent with the empirical evidence to date. This disparity is not addressed at all within the Atkins report. It is though consistent with the under-prediction of the model discussed above.

4.41 Finding 14 of the report states that *"separate evaluations would be needed for the aircraft contribution, the performance very close to roads and the background contribution; given that the relative magnitudes of these components varies strongly between locations"*. Clarification of this issue was sought from DfT, but it still remains unclear as to how this has been taken forwards to lend confidence in the model performance. If separate evaluations are needed, then where are they provided in this report?

[6] The 2010 and 2015 predictions shown are for Segregated Mode whilst the 2020 and 2030 predictions are for the hybrid 3rd runway.

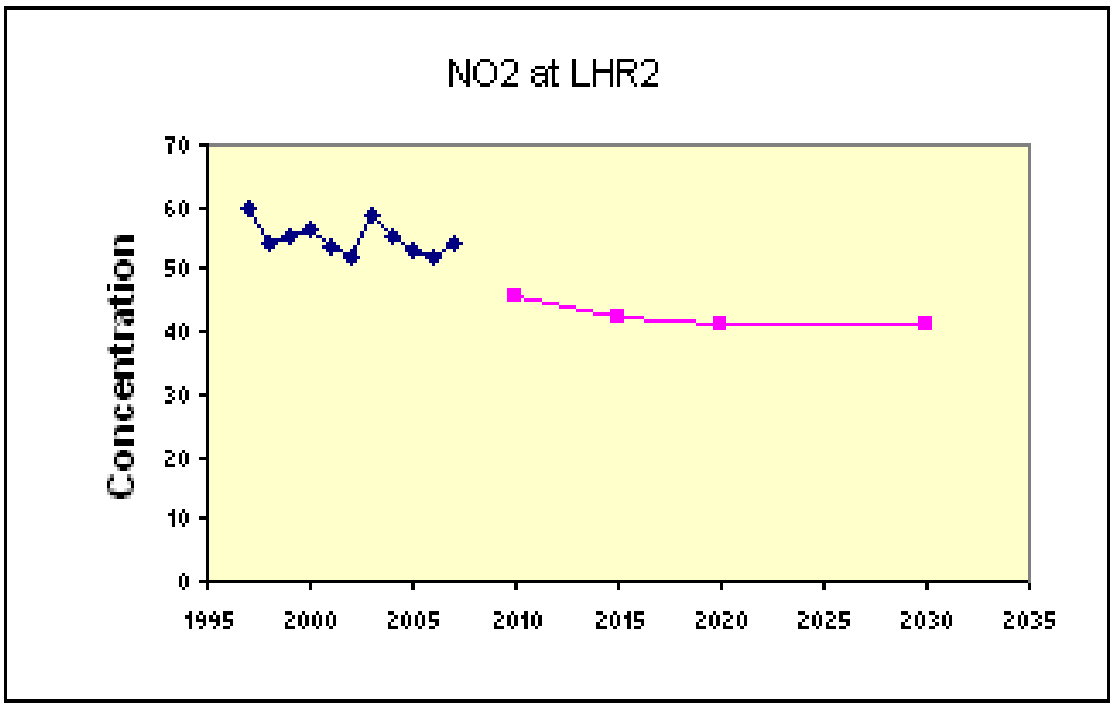


Figure 3: Measured annual mean nitrogen dioxide concentrations (blue line) and predicted annual mean nitrogen dioxide concentrations (pink line) at LHR2 (µg/m^3)

4.42 Issues related to meteorology have previously been discussed with regard to the CERC, report. The Atkins report also discusses this issue, but confines the assessment to a statistical approach. While this is not wholly inappropriate, the analysis only takes into account emissions of NOx from aircraft (thereby ignoring emissions from all other sources, and the potential for the regional background contribution to be different). The analysis is also based on a single monitoring site (LHR2). This serious deficiency is in fact noted within the Atkins report itself (Finding 30) which states that "*this analysis is solely for LHR2 – the choice of an alternative met year may be different at different CMS (Continuous Monitoring Stations). A wider consideration of Demonstrating Confidence (looking at total concentrations, rather than focussing primarily on within-airport sources as reported here) would have merit in undertaking a modelling sensitivity test of a future case using an alternative year of meteorological data".* In light of this statement, it is very difficult to understand why no additional sensitivity tests were undertaken.

4.43 The Atkins report also recognises the potential additional uncertainty due to the influence of climate change on meteorology (Finding 16). Whilst the effects of climate change are uncertain, there is the potential for windier conditions in the winter months, and higher temperatures in the summer months. As set out within the PSDH report, the former may have significant effects on the contribution that aircraft emissions make to ground level pollutant concentrations. Higher temperatures may potentially giving rise to higher background ozone concentrations. Ozone is of particular importance due to the role it plays in the complex atmospheric chemistry, converting NOx emissions (the principal form of emissions from aircraft and road traffic) to nitrogen dioxide

(NO_2). Thus, higher background ozone concentrations could potentially result in increased ground level concentrations of nitrogen dioxide.

4.44 Despite recognising this concern, the Atkins report cites the recent AQEG report on air quality and climate change, and work undertaken by CERC on behalf of Defra, and concludes that "*on this basis, no further work on climate change influences has been undertaken*". This is inconsistent with Recommendation 1 of the AQEG report that states "*impact analysis of policies or specific development, whether for industry, transport, housing etc., should take account of the interlinkages of emissions of air quality and climate change pollutants*".

4.45 No assessment or analysis is provided to substantiate the basis of this conclusion, and the CERC report is neither referenced, nor its' conclusions summarised. However, it is assumed that reference is being made to the study that was carried out by CERC and the Met Office to investigate the impact of climate change on air quality in London and Glasgow, as summarised in the 2007 AQS (Section 1.6.1). The study considered the effects of changing the meteorology associated with climate change on urban air quality in London and concluded that there was only a small change in NO_2. However, as the following section of this report highlights, there is only a very small margin for error, in terms of exceedences of the limit value. It would have been appropriate to have carried scenario tests with both changed emissions and meteorology for this study.

Atkins *Population Exposure to Air Pollution* report

4.46 This report takes the calculated dispersion model results from the ADMS-Airports model, and uses them to determine the number and location of properties that would be exposed to annual mean concentrations of nitrogen dioxide above the limit value. The report lacks adequate descriptions of what has been done, and is, in parts impenetrable. For example, Table 3.3 provides an analysis of source apportionment, showing the "*max % roads NOx*" in 2002 to be 113%. Subsequent explanatory text is equally unhelpful.

4.47 The critical part of the report is Section 3.2 , which provides the analysis based on specified points for the preferred schemes. Table 3.7 within the report provides this analysis for contour bands above 40 µg/m^3. However, this does not allow the sensitivity of the predictions to be considered i.e. what margin of error **would** give rise to predicted exceedences?

4.48 On request, DfT subsequently provided an expanded version of Table 3.7, showing the number of properties exposed to concentrations above 38 µg/m^3. This table is reproduced below. It is noted that results for the 2020 R3T6 H scheme were not provided, despite a direct request.

4.49 There are a number of very important implications arising from this table, which effectively represents a sensitivity test for the predicted future nitrogen dioxide concentrations, taking into account the potential for systematic bias and likely model uncertainty:

- For the 2015 scenarios, the number of properties exposed to concentrations above 38 µg/m^3 significantly increases with the introduction of mixed mode (2015MM) when compared with segregated mode (2015SM). Even with "roads mitigation" (2015MMrd) there are still 116 properties exposed to concentrations above 38 µg/m^3; and

- For the 2030 scenario (2030 R3T6H), there are 115 properties exposed to concentrations above 38 µg/m^3.

Summary of the number of properties exposed to an annual average nitrogen dioxide concentration above each contour band for specified points for each preferred scheme (source DfT response to questions, 01 Feb 2008)

Contour band	2015 SM No Properties	2015 MM No. Properties	2015 MMrd No. Properties	2030 R3T6 H No. Properties
38-38.9	126	144	116	115
39-39.9	75	93	21	21
40-41.9	22	27	0	0
42-43.9	0	0	0	0
44-45.9	0	0	0	0
46-47.9	0	0	0	0
48-49.9	0	0	0	0
50-59.9	0	0	0	0
60-69.9	0	0	0	0
Total Exceeding EU Limit Value	**22**	**27**	**0**	**0**

4.50 This conclusion is of particular importance if reference is then made back to the model verification analysis presented within this report, where it was concluded that *"there is potential that exceedences of the limit value (40 µg/m^3) could realistically occur* ***where predicted annual mean concentrations of nitrogen dioxide exceed about 38 µg/m^3.*** "

Conclusions

4.51 The Consultation Document and supporting technical reports provide an assessment of air quality in the vicinity of Heathrow airport in future years, with a) the introduction of full mixed mode and b) a new third runway. The assessments presented draw upon many of the recommendations included within the PSDH report, and undoubtedly provide a more robust evidence base than was available at the time of the AWP.

4.52 However, the proposals for Heathrow expansion are complex, and require forecasting pollutant concentrations many years into the future. This inevitably requires many complex assumptions to be made. Whilst the technical reports provided by DfT to support the Consultation Document

recognise the many uncertainties that are associated with the assessment, the evidence that is presented lacks transparency in many critical areas, and fails to provide plausible scenario tests that could have been used to demonstrate confidence in the outcomes. This is a critical weakness, given the reliance the Government has placed upon the expected improvements in emissions from both road traffic and aircraft. In addition, the assessments fail to take full and proper account of one of the principal recommendations arising from the PSDH report, that the sensitivity of the model output should be tested against the likely ranges in model input. This has only be partly achieved in some areas, disregarded in others.

4.53 Additional model verification work carried out in this report has identified that the model appears to be systematically under-predicting nitrogen dioxide concentrations by about 5%. In addition, the regional background contribution to pollutant concentrations in 2015 and beyond may be significantly higher than those forecast from a 2002 base year, taking into account meteorological variation and the potential effects of climate change. Thus, there is evidence that the limit value for nitrogen dioxide could be exceeded in future years where the model has predicted concentrations above about 38 $\mu g/m^3$. Information provided by DfT confirms that this would result in some 116 properties being exposed to nitrogen dioxide concentrations above the limit value in 2015 (with full mixed mode), with the same number being exposed above the limit value in 2030 (with the new third runway).

4.54 Taking all of these issues into account, it is concluded that the evidence provided by DfT is not sufficiently robust to support the conclusions that the proposed developments to add capacity at Heathrow Airport could be confidently achieved without compromising the air quality limit values.

5 Annex 1: Summary of Questions to DfT and Answers Provided

Table 1: Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

Question	DfT Response	Comment
Consultation Document – Adding Capacity at Heathrow		
It is understood that the data provided in Table 4 are derived from the Atkins report *Population Exposure to Air Pollution*. It is further understood that the data in Table 4 represent the preferred options for the future year scenarios. ***Q1: Please provide an explanation for the derivation of the number of properties shown to exceed the Limit Value in 2020, given that these data do not appear to be provided in the Atkins report.***	No properties are predicted to exceed the Limit Value with a third runway in 2020 and alternation on the existing runways - see main consultation document (Table 4) and Atkins Population Exposure Report (Table 3.2)	Table 3.2 of the Atkins report sets out the population exceeding 40 µg/m^3 NO_2 by contour band using the Grid-Based results. The numbers in this table are not consistent with Table 4 in the Consultation Document. The analysis based on Specified Points results is reported in Section 3.2. The relevant table (Table 3.7) does not provide information for the 2020 two and three runway cases shown in Table 4 of the Consultation Document.
Para 3.75 states that "modelling has taken account of all aircraft-related technical panel recommendations (and gone beyond them in some cases)". ***Q2: Please provide a summary of where the modelling assessment has "gone beyond" the technical panel recommendations, including a specific reference to Tables 2.1 to 2.4 of the Atkins report.***	The statement made clearly refers only to aircraft-related recommendations, and so only table 2.2 is pertinent. There are areas of the aircraft emissions inventory where data were available in a better form than assumed at technical panels stage, and such data has been used in the consultation document work. As shown in table 2.2 page10 of DemCon, an example of this is for reverse thrust operation, where panels recommended a single value based on Foo, but further data allowed reverse thrust values dissagregated by aircraft types.	Accepted

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

AEA Report – Emissions Methodology for Future LHR Scenarios		
Q3: Please confirm why one-day schedules were used for all scenarios other than 2030MM (Para 2.2)	The work on a 2015 mixed mode scenario at 540,000 annual movements showed that this was achievable - both operationally for NATS, and within the noise and air quality limits. Since mixed mode on the existing runways in 2030 (which is anyway a somewhat artificial concept, given that a third runway by 2030 would preclude it) would involve no additional movements, it was not felt necessary to draw up a full detailed schedule for a 2030 case in order to illustrate the likely impacts.	Accepted.
Para 2.25 states that "the fleet fractions for each future case are not given here but are provided in the case-specific information provided in separate documents". ***Q4: Please confirm where this information is provided.***	The data is in the AEA supporting technical report: Heathrow Airport Emission Summaries.	Noted, but the AEA report that is referenced does not set out how these future fleet fractions were derived, nor which organisation was responsible for them. There is a complete lack of transparency in the supporting documentation on this critical issue.
Para 2.27 states that "QinetiQ were commissioned by DfT to forecast the engine assignments for future cases." ***Q5: Please provide the documents and reports prepared by QinetiQ to support the engine assignments for the future cases.***	I am attaching a summary note from QinetiQ explaining the approach that was used.	Noted, but it is not clear as to whether the document that has been provided is the QinetiQ report that was provided to DfT and AEA. The document provides no evidence of input from airline operators and industry, in line with the PSDH recommendation, stakeholder review, or sensitivity testing of the assumptions.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

AEA Report – Emissions Methodology for Future LHR Scenarios		
Para 2.51 states that "hold times for the mixed-mode two-runway and R3 cases were based on the results of NATS runway-occupancy modelling using the HERMES model". ***Q6: Please confirm where the times-in-mode for all scenarios are provided, including runway hold times.***	A separate note on this, prepared by AEA, is attached.	Accepted.
Atkins Report – Population Exposure to Air Pollution		
Q7: Please provide an explanation as to how have the percentage figures in Table 3.3 (and all subsequent tables) have been derived?	Data in Tables 3.3 and 3.6 refer to source apportionment work. The methodology for deriving total NOx, roads NOx and airports NOx concentrations at properties is outlined in section 2.2.1.2. The percentage contribution of roads NOx and airport NOx was derived for each property in the study area by dividing the source contribution concentrations at a given property by the total NOx concentration at that property. The results presented in the tables are only for those properties exceeding the EU annual mean Limit Value for NO2 on a case by case basis. Due to interactions between the different NOx emission sources once emitted into the atmosphere it is possible that an individual source concentration may exceed the total NOx concentration when all the sources are modelled together, as seen for the 2002 scenario roads NOx contribution.	The explanation provided is unclear and fails to adequately describe what has been done.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

Atkins Report – Population Exposure to Air Pollution		
The report provides no assessment for the Preferred Scheme in 2020 (2020 R3T6). In addition, the assessment only considers the hybrid option in 2030 (2030 R3T6 H). ***Q8: Please confirm whether the MLD and MDL scenarios are also under consideration as potential viable future options.***	It was necessary to model separately the MLD and MDL scenarios in order to replicate a 'hybrid' case (with alternation). As the consultation document makes clear (para 3.11), once a third runway is operational, the intention is to operate the existing two runways in segregated mode, with alternation.	It is accepted that it is the Intent to operate the two existing runways in segregated mode, but given the concerns of NATS, as noted in the Consultation Document, it does not appear to be guaranteed. If the MDL option on the northern runway cannot be explicitly discounted then results for this scenario should be presented.
Atkins Report – Demonstrating Confidence in the PSDH Air Quality Work		
Q9: For the Specified Points Results set out in Section 3.2, please provide an analysis of properties exposed for the 2020 R3T6 MDL, 2020 R3T6 H, and 2030 R3T6 MDL scenarios (unless the MDL scenarios can be fully discounted as viable options).	See response above to Q8.	See response above to Q8.
For all of the Specified Points Results, it is difficult to determine how sensitive the analysis is to the predicted NO_2 concentrations. ***Q10: Please expand the results presented in Table 3.7 to include two lower contour bands i.e. 38-38.9, and 39-39.9 µg/m^3.***	Data for 38-38.9 and 39-39.9µg/m3 bands are presented in the table below along with the data (above 40□g/m3) presented in Table 3.7 of the Population Exposure to Air Pollution Report.	Noted. Comment on these results is provided in the main text.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

Atkins Report – Demonstrating Confidence in the PSDH Air Quality Work		
Section 1.1 and 2.3 makes reference made to the "PSDH modelling group" and "reviewed by sub-groups of the technical panels". ***Q11: Please confirm the membership of these sub-groups and technical panels and how they were appointed.***	Section 1.1 refers to the PSDH modelling group. This is the progress reporting group for the air quality work carried out under PSDH public consultation. The main group members included DfT AED, BAA plc (for data purposes), Atkins Limited, AEA Technology plc, and Cambridge Environmental Consultants Ltd. Section 2.3 states that "the major changes on aircraft representation, and the effects on model validation (including diagnostic tests), have been reviewed by sub-groups of the technical panels." The former was focused on jet modelling, and a special meeting (by DfT invitation) was held to discuss these issues, focused on those with technical experience in the area. This included Cranfield IT (Ian Poll), University of Cambridge (Rex Britter), University of Surrey (Alan Robbins), University of Manchester (Angus Graham), University of Leeds (Mike Pilling), CERC and DfT. The latter on validation was a sub-group of Panel 1, and included David Carslaw (ITS Leeds), Mike Pilling (University of Leeds), and Bernard Fisher (University of Greenwich).	Noted.
Table 2.1 makes reference to CERC "Air Quality Studies for Heathrow (2015 LASPORT Sensitivity" and CATE "Model Comparison for PSDH". These reports do not appear in Annex D of the Consultation Document. ***Q12: Please provide copies of these technical reports.***	Documents provided.	Noted.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

Atkins Report – Demonstrating Confidence in the PSDH Air Quality Work		
Table 2.1 (Aircraft): The recommendation regarding Future Aircraft is not an accurate reproduction of the PSDH panel report. This stated (para 72 of Ch3) *"To provide technology forecasts for engine emissions capability through to 2030, a review will be carried out to update the technology assessment carried out for the AWP. The assessment will be carried out by an independent gas turbine technology organisation using the guidance above and informed by input from industry, specifically manufacturers and major Heathrow airline operators. In the case of strongly differing views not reconciled by discussion, the independent organisation will inform DfT of any unresolved differences when making its recommendations.* ***Q13: Please provide evidence to demonstrate that this recommendation was taken forwards, and provide all reports and communications from the independent organisation and inputs from all stakeholders.***	See Q5 above.	See comment in relation to Q5 above.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

Atkins Report – Demonstrating Confidence in the PSDH Air Quality Work		
Table 2.4: Table contains 10 recommendations from Ch3 of the PSDH panel report related to Surface Access. It is noted that the PSDH report contains19 recommendations on Surface Access. ***Q14: Please expand Table 2.4 to fully address all of the recommendations on Surface Access provided in the PSDH panel report.***	The additional 9 items are provided, in the same format as table 2.4, in the attached file "PSDH surface access panel recommendations - extra breakdown.pdf".	Noted.
Q15: Please confirm the summary data in Table 2.6. What pollutant do these data refer to, what was the averaging period assumed, what units are the data expressed in?	The summary data in Table 2.6 is for NOx concentrations from aircraft only, at discrete receptors (as listed in the CERC Air Quality Studies for Heathrow report). This data refers to annual mean NOx concentrations measured in µg/m3. Cases reported are the LASPORT model run (CATE LASD2015 MM), the ADMS-Airport model run in LASPORT equivalent mode (CERC LASD2015MM), and the ADMS-Airport model run (CERC D2015MM) for the equivalent option test using the main model setup.	Noted.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

Atkins Report – Demonstrating Confidence in the PSDH Air Quality Work		
Q16: Please confirm the data provided in Figure 3.1. What label should be assigned to the y axis of this graph?	Figure 3.1 is a map. I assumed the question is intended to refer to Figure 2.1. Figure 2.1 presents NOx concentrations from aircraft sources only, at discrete receptor points for the LASPORT model (CATE LASD2015MM) and the ADMS-Airport model run in LASPORT equivalent mode (CERC LASD2015 MM). The x-axis labels refer to the 'names' of the discrete receptor points used in comparisons. The y-axis label represents annual average NOx concentrations from aircraft sources in µg/m3.	Noted.
Finding 14: *"separate evaluations would be needed for the aircraft contribution, the performance very close to roads and the background contribution; given that the relative magnitudes of these components varies strongly between locations"*. I ***Q17: Please confirm how Finding 14 has been taken into account with the modelling assessment, to lend confidence to the results arising from pollutant emissions from these different sources.***	The finding refers to the care needed in evaluating validation as an average across site types. Results are provided by CMS site, which encapsulate a range of site types, in both the report on Demonstrating Confidence in the PSDH Air Quality Work, and in the report on Air Quality Studies for Heathrow: Base Case, Segregated Mode, Mixed Mode and Third Runway Scenarios modelled using ADMS-Airport. This includes comparisons based on long-term averages and based on hourly results. For example, LHR2 is clearly close to aircraft sources, LHR10 to road sources, and LHR6 for background sites.	Noted, but the response provided does not confirm how this finding has been used to demonstrate confidence in the model. If separate evaluations were needed, then why were they not carried out?

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

Atkins Report – Demonstrating Confidence in the PSDH Air Quality Work		
Finding 26 states that medium aircraft become relatively more important with increasing distance from the runway. ***Q18: Please provide a detailed justification to support this argument.***	Finding 26 is under the caveat that there is some evidence from the data mining undertaken. This can be seen in pages 40-41. Figure 4.10 clearly shows some of the effects, whilst also highlighting that the confidence intervals around the data is often larger for medium aircraft, which includes that the number of events within some flights per hour groupings are small. The analysis within the Defra study referred to, and the analysis in the report on Demonstrating Confidence in the PSDH Air Quality Work, were both undertaken by the same organisation. Heavy aircraft departing on 27R are statistically more significant than medium aircraft departures, which is entirely expected from knowledge of the emissions. However, for 27L departures there is some indication from the statistical modelling that medium aircraft become more important for NOX concentrations than heavy aircraft. This finding was also confirmed by analysing the data at Harlington for 27R departures, where medium aircraft were shown to be more important than heavy aircraft.	Noted, but the evidence to support this conclusion is limited.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

Atkins Report – Demonstrating Confidence in the PSDH Air Quality Work		
Q18(a) As a matter of urgency, could the DfT clarify the data capture rates for all of the monitoring data used in the DemCon data pack. These need only be provided for those data highlighted in green or magenta, or shown in red, in the data tables provided by DfT on 13th December 2007 i.e. new data included since PSDH was published.	Data capture rates provided.	Noted. Data capture rates for some sites in some years was well below the 75% threshold used in the PSDH report. The Atkins report should have made this clear and drawn the readers attention to the need to treat these data with caution.
CERC Report – Air Quality Studies for Heathrow		
Para 3.2.1: Future hourly NOx concentrations were obtained by using the year-adjustment factors published by Defra. ***Q19: Please confirm which factors were used for these calculations.***	The factors come from the DEFRA LAQM website (link provided) as detailed in the report. The relevant factors, taken directly from this spreadsheet, are given in the Table below (provided) together with the factor calculated relative to 2002 concentrations and the resulting annual average NO_x concentrations.	Noted.
Para 3.2.1: "Factors for 2030 were calculated by linear extrapolation of the 2015 – 2020 factors" ***Q20: Please provide a justification to support this assumption regarding a further reduction in background NOx post 2020, setting out the measures that are expected to reduce emissions.***	The DEFRA factors (above) for future background concentrations relative to 2004 were extrapolated from the 2015 and 2020 values and used to calculate a 2030 concentration. The annual average background concentrations of NO_x and NO_2 used for 2030 were 9.2µg/m³ and 8.0µg/m³ respectively, compared to 9.5µg/m³ and 8.2µg/m³ for 2020. Tables 4.13 and 4.15 show that total emissions of NO_x from London decrease by 4.4% between 2020 and 2030 while the assumed change in background NO_x concentrations is 2.7%. The figure below shows the annual average background NO_x concentrations used in the modelling.	Noted.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

CERC Report – Air Quality Studies for Heathrow		
Table 4.2 shows NOx emissions from rail declining by 62.6% between 2002 and 2105. ***Q21: Please provide a justification for this assumption.***	Emission factors for 2002 are taken from the London Atmospheric Emissions Inventory. Emission factors for future years were supplied by the DfT based on the re-engining of high-speed trains. Note that these figures are emission factors, not emission rates, ie they do not include the growth in train movements in future years which are detailed in the report.	Noted, but reference is made to the TRL report which states that the extent to which these reductions are realistic are dependent on the programme of HST replacement and changes in train franchises.
Para 8.1 states that the height of the centre of the road source has been reduced from 2m to 1 m above the given source height and the initial σ_z of the plume has also been decreased from 2m to 1m. ***Q22: Please provide a justification for these changes, and indicate what effect this is likely to have had on predicted concentrations close to the roads.***	The changes to the height of the road centre and initial plume spread were made to the model as part of the study Modelling of Current and Future Concentrations of PM, NO_x and O_3 in London using ADMS-Urban which CERC carried out for DEFRA (web link provided). Model verification at the AURN sites in London showed improved agreement between measured and modelled concentrations using these new values. The changes tend to increase modelled concentrations close to roads, while having little effect further away.	Noted, but given these changes were made, it is surprising that no reference was made in the Atkins *Demonstrating Confidence* report.
Table 9.1 indicates that LHR10 was acknowledged in the MIC to be an outlier ***Q23: It is understood that LHR10 was identified as an outlier within the PSDH MIC study, as there was considerable uncertainty surrounding the precise location of the monitoring station in 2002. Given the importance of verifying model performance close to busy roads, please confirm what steps were taken to confirm the location of LHR10 so that the data could be included in this assessment.***	The location of the LHR10 monitoring site was investigated and it was found to have moved since 2002 and the road configuration has also changed. The exact location of the site relative to the road in 2002 could not be identified accurately (it was identified for 2006-2007 using GoogleEarth), however, the modelled annual average NO_x concentration is only 14% higher than the measured value. The measured and modelled NO_2 concentrations show greater differences because the NO_2/NO_x ratio at the site is very different from other sites in the area and nationally; see the Demonstrating Confidence the PSDH Air Quality Work report, Section 3.2.	It is not clear from this response whether the Highways Agency or TRL were contacted to verify the location of the monitoring site in 2002.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

CERC Report – Air Quality Studies for Heathrow		
Figure 9.4 provides an analysis of measured NOx concentrations with wind speed. A similar graph was included in the PSDH panel report (Fig 2.19). ***Q24: Please provide an assessment of the differences between these two Figures:*** • Why are the measured NOx concentrations (LHR2 – LHR8) during departures on the northern runway different between the two Figures? • Why are the profiles different? • How have the data for wind speeds of 0 m/s been derived?	Figure 9.4 in the CERC report is mislabelled; it compares measured and modelled LHR2 concentrations, not (LHR2-LHR8) concentrations. Figure 10.9 in the final CERC PSDH report (December 2005) gives equivalent data for LHR2-LHR8. The PSDH report graph was not produced by CERC and different assumptions could have been made such as the categorising of hours into arrivals and departures. Note that the data labelled 0m/s in the CERC figures represent all data for wind speeds between 0m/s and 1m/s. If the wind speed at 10m is less than 0.75m/s, the dispersion is modelled assuming it is equal to 0.75m/s, so that a dispersion calculation is carried out even for the hours when the recorded wind speed is zero.	Noted.
Figure 9.8 provides transects of NOx and NO_2 concentrations. Similar graphs were included in the PSDH panel report (Fig 4.10 and 4.11). ***Q25: Please provide an assessment of the differences between these two sets of Figures. In particular, why are the NO_2 concentrations near to roads different between the two Figures?***	The NO_x concentrations along the transect agree well between Figure 9.8 and the PSDH panel report, apart from some variation due to changes in the alignment of the modelled roads. The NO_2 concentrations are lower in Figure 9.8 due to improvements made to the ADMS chemistry scheme, in particular the chemical reaction times, before the release of ADMS-Urban version 2.2 in January 2006. The studies reported in the CERC November 2007 report use model versions 2.2.3.4-2.2.3.9 and therefore include the changes to the chemistry module.	Noted, but given these changes were made, it is surprising that no reference was made in the Atkins *Demonstrating Confidence* report. There is no detailed description of the ADMS chemistry scheme within the technical reports, nor how changes have been implemented since the PSDH report.

Table 1(contd): Summary of questions provided to DfT, together with response and AQC comment (where appropriate)

AEA Report – Heathrow Airport Emissions Summaries		
Section 4 of this report provides tables showing NOx emissions/movement in 2002 and future years. In many cases the emissions/movement decline (in some cases substantially) in future years for the same aircraft type e.g. B747-400 (10.52 kg/mvt in 2002, declining to 8.95 kg/mvt in 2010). ***Q26: Please provide a full justification for the reduction in NOx emissions/movement in future years***	A short description of the evolution of engine fit is given in para 2.28 of the supporting technical report by AEA on Emission Methodology for Future LHR Scenarios. Many aircraft types, and in particular the B747-400, can be fitted with a variety of engine models from various manufacturers, each of which has different emissions characteristics. The distribution of engines fitted in 2002 is known from data. In the QinetiQ methodology the distribution of engines on a particular aircraft type will evolve (a) as aircraft are retired from the Heathrow fleet on age grounds typically after 20 years and (b) as new individual aircraft of that type are brought into the fleet with particular engine fits (and in later years these engines could be improved versions from an emissions perspective). For the B747-400, the latter mechanism is unlikely, given that the total number of movements of this aircraft type at LHR is forecast to fall (distinguishing this aircraft from the B747 Advanced), although there could still be some replacement with better performing variants. In relation to (a), the older aircraft will be retired first, which could lead to a bettering of the emissions performance.	Noted.