THE IMPLICATIONS OF VARIABILITY OF NATIONAL AND REGIONAL AIR QUALITY REGULATIONS ON THE MODELLING OF AIRPORT AIR QUALITY WITHIN GLOBAL AVIATION/ENVIRONMENT MODELS

R E Britter
Department of Engineering, University of Cambridge

ABSTRACT

This paper discusses the variability of the limit values for ambient air NO_2 concentrations internationally and the implications of this variability. The particular concern addressed is the substantial variability (annual average of 40 $\mu g / m^3$ in the UK and Europe generally and 100 $\mu g / m^3$ in the US) on the assessment of air quality in the vicinity of airports. An attempt will be made to assess the economic effects of this difference. Much of the discussion and argument regarding the expansion of Heathrow airport centres on local air quality and would not arise if the US federal regulations were being used. The paper also addresses the topical subject of how these national and regional variabilities can be incorporated in an equitable manner into global models of the impact of aviation on the environment

INTRODUCTION

Aviation has experienced rapid expansion as the world economy has grown and this has produced a number of major environmental and societal challenges. There is urgent need to model the contributions of aviation at local and global levels in order to assess the best aviation policies to be pursued in the future that strike appropriate balances between economic benefits and environmental impact mitigation. Internationally, there are several groups developing global models of the effect of the aviation industry on the environment and society. The Institute for Aviation and the Environment at the University of Cambridge is creating such a policy assessment tool: the Aviation Integrated Modelling (AIM) project and this involves the synthesis of a wide range of models covering aircraft technology and cost, air transport demand, airport activity, aircraft movement, global climate, local air quality and noise and a regional economics model. This paper considers aspects of local air quality that may impact the development of such a policy assessment tool.

In the Summary of Project Heathrow from the UK Department of Transport (DfT, 2006) it is stated that “the White Paper *The Future of Air Transport* (DfT, 2003a) made clear that the Government supports a short third runway at Heathrow- after a second runway at Stansted – subject to compliance with strict conditions on air quality, noise and public transport access.” The summary went on to say that “there is a good case for the further development of Heathrow. The airport is of vital importance to the UK economy, attracting business to London and the South East and supporting 100,000 jobs (direct and indirect). A short third runway would yield net economic benefits of some £6 billion (net present value) – the largest of all the new runway options examined in the run up to the White Paper. However, we recognize that expansion would have environmental consequences and have made clear that further development would be conditional on:

- Compliance with air quality standards, including EU limits for Nitrogen Dioxide that will be mandatory from 2010;
- ………noise …..
- ………public transport access…..

The work that is now being undertaken (the "Project for the Sustainable Development of Heathrow" or "Project Heathrow" for short) fulfils the commitment in paragraph 11.63 of the White Paper to:

"*institute immediately with the airport operator and relevant bodies and agencies a programme of action to consider how these conditions can be met in such a way as to make the most of Heathrow's two existing runways and to enable the addition of a third runway as soon as practicable after a new runway at Stansted*" "

In a report on Aviation, Core Cities and Regional Economic Development (DfT 2003b) from Ove Arup it is argued that aviation is a major sector of the UK economy in its own right and it also contributes to regional economy through savings in delivery travel time and broader catalytic effects. It is also a major contributor to competitiveness through locational advantage and connectivity. In particular "the presence of international air services or even "better" international services may tip the balance in favour of a particular location being suited to modern economic activity because it offers a relative economic advantage, all other effects being equal ……. It is suggested that there is a strong causal relationship between core city aspirations and …. improved international connectivity by air"

Thus, there appears to be both a direct economic gain and the possible countering of an indirect economic loss from improved air services. Of course there are also economic costs and environmental and societal impacts that require consideration.

REGULATORY UNDERPINNING

The principal pollutants of concern in the airport/urban context are NO_2, PM_{10} and ozone. Ozone concentrations local to the airport will likely be dominated by larger scale processes and will not be considered further here. For NO_2, the UK regulatory limit values are 40 $\mu g/m^3$ for the annual mean and 200 $\mu g/m^3$ (18 exceedances allowed) for the 1 hour mean respectively. For PM_{10} the equivalent limit values are 40 $\mu g/m^3$ and 50 $\mu g/m^3$ (35 exceedances allowed) but for a 24 hour mean. These will be fully in force in 2010 for NO_2 and were in force in 2005 for PM_{10}.

It is useful to recall here that generally the regulatory control is provided at the "emissions" level and at the "pollutant concentration" level. Somewhat simplistically we can interpret this with the former reflecting the pollutant generating activity while the latter is acting as a surrogate for personal exposure and for the resulting health effects. Currently these two regulatory controls are not necessarily equivalent or even comparable; for example NO_x is used for the emission regulatory control while NO_2 is used as the pollutant concentration control. Thus those engineers and scientists working on the reduction of engine emissions will address NO_x while the meteorologists and atmospheric chemists looking at air quality will be addressing NO_2. This provides scope for misunderstanding and poor provision of complementary mitigation strategies.

It is often unwise to generalize but pollutant monitoring stations near Heathrow indicate that the most difficult regulatory limit value to satisfy is the annual mean NO_2 limit value with the next most difficult being the short term 24 hour PM_{10} limit value. In fact the annual mean NO_2 measurement at the monitoring site LHR2 was close to 60 $\mu g/m^3$ in 2003, already well in excess of the limit value of 40 $\mu g/m^3$ before any airport expansion. The corresponding annual mean PM_{10} concentration was 24 $\mu g/m^3$, significantly below the limit value of 40 $\mu g/m^3$. In fact the White Paper "*The Future of Air Transport*" states specifically that " The most difficult issue confronting expansion of Heathrow concerns the compliance with the mandatory air quality limit values for NO_2 that will apply from 2010 (as set down in the EU directive 1999/30/EC)". Note that the UK national regulations will come fully into force also in 2010.

The difficulty of satisfying the annual mean NO_2 limit value of 40 μg/m^3 is being felt at other European airports and generally within urban areas in large cities throughout Europe. It is felt so strongly in Europe that very many technical experts are engaged in its study. Interestingly, this is not the case in the US with many scientists there being surprised by the scale of work being undertaken in Europe concerning NO_x and NO_2.

One may wonder why this markedly different deployment of expertise has occurred; and what this means if one is looking into global environmental regulations, for example when considering the general area of aviation, that is essentially global. The answer appears to come from these quite different regulatory levels set in Europe (40 μg/m^3) and in the US (100 μg/m^3) for the annual average NO_2 concentration. This is a very marked and influential difference and explains why NO_2 is of great concern in Europe and of relatively negligible concern in the US. Stretching the point slightly it appears that if Heathrow specifically, and London more generally, were transplanted to the US there would be no or insignificant concern over the pollutant that is currently seen to be critical in Europe with regard to local air quality. The consequences of these differences in regulations are likely to have very substantial social and economic impacts.

The source of the EU regulatory limit value on annual mean NO_2 can be traced back to the World Health Organization (WHO) value of 40 μg/m^3 that appeared in their 1996 air quality guidelines. It must be stressed that the WHO value is a guideline and not a standard. This same value is also adopted by China for residential and commercial areas but is doubled for industrial areas.

The EU project Clean Air for Europe (CAFÉ) did ask a WHO working group to review systematically the most recent scientific evidence on the adverse health effects of particulate matter (PM), ozone (O_3) and nitrogen dioxide (NO_2) and this led to a report WHO, 2003. The response to the specific question as to whether there is new scientific evidence to justify reconsideration of the WHO Guidelines for nitrogen dioxide (NO_2) was that "there have been some new epidemiological studies reporting association of longer term exposure with lung function and respiratory symptoms. The former group *(WHO, 1996)* that proposed the annual guideline value of 40 μg/m^3 acknowledged that "although there is no particular set of studies that clearly support the selection of a specific numerical value for an annual average guideline the database nevertheless indicates the need to protect the public from chronic nitrogen dioxide exposures". Because of a lack of evidence the former group *(WHO, 1996)* selected a value from a prior WHO review. The new evidence *(that is, post WHO, 1996)* does not provide sufficient information to justify a change in the guideline value. Given the role of NO_2 as a precursor of other pollutants and as a marker of traffic related pollution, there should be public health benefits from meeting the current guidelines. Thus the present working group did not find sufficient evidence to reconsider the 1-hour and annual WHO guidelines for NO_2".

One of the follow-up questions from CAFÉ to the WHO (WHO, 2004) asked what was the basis for maintaining the WHO NO_2 annual specific guideline value of 40 μg/m^3, and this essentially queries the argument in the WHO, 2004 report "that there was no new evidence to warrant changing the current guideline". The question essentially reinterprets the approach adopted in WHO, 2003 as one of "The current guideline is based on limited evidence and there is no newer evidence to make it more robust" and goes on to say "Consequently WHO should assess how confident it is in the current guideline." In response WHO argues that "There is evidence from toxicological studies that long-term exposure to NO_2 at concentrations higher than current ambient concentrations has adverse effects. ….. However, we are unable to establish an alternative NO_2 guideline from these studies. We therefore recommend that the WHO annual specific Guideline value of 40 µg/m^3 should be retained or lowered". Thus it is concluded that "NO_2, as a marker of a complex mixture of traffic-related pollution, is consistently associated with adverse effects on health at relatively low levels of long-term average exposure." It is also noted that the associations cannot be completely explained by co-exposure to $PM_{2.5}$.

Overall there is great complexity here, with NO_2 acting as a pollutant of concern and as a surrogate for other concerns (such as ozone and particulates and as a marker of a complex mixture of traffic-related pollution). But it is clear that Europe and the US have developed different approaches to address these complexities leading to markedly different weightings being given to the annual average NO_2 concentrations and this has led to markedly different research interests and programmes.

Although the statutory annual mean NO_2 limit value was currently being exceeded at some locations around Heathrow there were no breaches of the PM_{10} statutory annual mean limit value. Of particular interest was the observation that around the airport annual mean concentrations of PM_{10} were around 24-25 µg/m^3 (compared with the statutory limit value of 40 µg/m^3) however the bulk of this figure 21-23 µg/m^3 could be attributed to regional background concentrations as measured in similar parts of London away from the airport. The airport-related contribution to the annual mean PM_{10} concentration was measured to be close to negligible. Some preliminary mathematical modelling of PM_{10} annual mean concentrations near to Heathrow, undertaken during the PSDH study, produced similar conclusions. Furthermore, very limited measurements of annual mean $PM_{2.5}$ near the airport also produced an equivalent observational conclusion that the airport-related annual mean $PM_{2.5}$ contribution was close to negligible in comparison with estimated annual mean background concentrations (DfT, 2006). For particulates the regulatory problem is with exceedances of the short term (24 hour) limit value.

To summarize the position, we have markedly different regulations in the US and in Europe for a pollutant of concern. The European regulations are inhibiting (rightly or wrongly) various developments for which some societal and monetary cost and benefit could and should be attributed. This has caused substantial differences in research and development programmes (at least when comparing US and European activities). Not the least of these is when developing mitigation strategies to assist compliance with regulatory limit values. As a specific example the reduction of NO_X emissions is one mitigation strategy in reducing NO_2 concentrations near airports. However, at Heathrow it was also apparent that over the period from 1993 to 2004 " there has been a highly significant downward trend in the annual mean NO_X concentrations (over 6 µg/m^3 per year), but only a minimal (but proven) downward trend in annual mean NO_2 concentrations (0.5 µg/m^3 per year)." By suitable background concentration subtraction it was also possible to conclude airport NO_X and NO_2 have not reduced over time. Further to this, if NO_2 was to be principally a "marker of a complex mixture of traffic-related pollutants) then it is not at all clear that a mitigation strategy for a reduction in NO_X and/ or a reduction in NO_2 would transfer across to a reduction in health effects on the population. These issues, together with the international differences in regulatory limit values require addressing and clarifying if they are to form part of global aviation/environment modelling.

CONCLUSIONS

- The regulatory limit values for annual average nitrogen dioxide concentrations vary considerably on a global scale, up to a factor of 2.5 between Europe and the USA.
- This limit value has been difficult to meet in Europe in urban areas and near to many airports, but not within the USA
- Consequently there is a marked difference in the efforts in the US and Europe regarding NO_2 as a pollutant, in research funding and, consequently, in national commitment of scientific expertise
- There is evidence that NO_2 is being used as a marker for a complex mixture of traffic related pollutants
- It is not at all clear that mitigation efforts to reduce NO_2 concentrations will be transferred to reductions in the health effects on the population
- The large national or regional variability in some regulated pollutants and the implied health effects on the population may lead to difficulties in developing equitable monetisation within global aviation/environment models.

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