# Kevin Morris

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I think we should move smoothly on to our next speaker and it gives me particular pleasure to introduce Kevin Morris, who spent seven years with BAA at Hatfield on aerodynamics and then he worked initially in British Airways in the aircraft performance and flight test group and he also took on responsibility for aircraft noise and emissions and he's worked in the environmental area developing BA's databases on emissions and on a model and local air quality. Kevin's very actively involved in IKO in two of the working groups. He's also involved in IATA's environmental group and a range of European research programmes. He serves as technical adviser to the airline representatives and the UK government's advisory committee on noise and emissions. Kevin.

Kevin Morris: Thank you, Hugh. What Hugh didn't point out was before six months ago he was my boss as well.

Okay, I'm going to go on from basically Rob did and talk about understanding local air quality and how we've worked together with various stakeholders. I'm going to go a little bit on the modelling and then go onto the monitoring and then what happens next, if you like (slide 2).

So modelling, first of all. We for a long time have been a bit suspicious of the modelling that's been done particularly when you look at the aircraft side of things. It became obvious that people were using the LTO database (slides 3 & 4). One thing I should perhaps have said before I started was that I'm an engineer and unfortunately one of the curses of engineers is we slip into jargon very quickly so I hope to explain some of these things later as we go along.

One of the things about this landing/takeoff – that's what LTO stands for, is that it assumes aircraft operation in a particular way all the same up to 3,000 ft. Now at 3,000 ft some of our jumbos are over High Wycombe, which is quite a long way away. It does seem a bit strange to include those in an inventory of emissions emitted by Heathrow Airport.

The times in mode, the performance is all the same for all types. If you look at an A320 and A340 I think immediately you will see that's not true. Emissions characteristics are not including – the dispersion characteristics are not included in an inventory approach and when you're comparing different modes of transport you've got two dimensional road sources against three-dimensional aircraft sources. You have to do dispersion to get the correct inventory as an input.

One of the things we've found out talking to people, not necessarily just outside the industry but also inside the industry. Aircraft operating procedures aren't really known that well apart from the engineers and the pilots and the people actively involved in them (slide 5).

Takeoff characteristics are a complex modelling challenge. Not only have you got the three dimensions but also there are acceleration, constant speed segments and configuration and power changes. There's one example (slides 6 & 7). That's what a standard takeoff is supposed to look like with one change in power setting up to 3,000 ft, configuration changes and various things going on at the same time. It's actually a lot more complicated than that because of RV's, acceleration and constant speed segments as well. The power setting isn't always the same.

To address these issues of information exchange, if you like, we did set up a steering group (slide 8), it was about two years ago to share this information we had with local authorities to tell them how to do their modelling and to tell them what model to use and everything else. They quickly told us that that was not what they wanted so we progressed by providing them with information, working with them, by listening to them which was quite a challenge for us and I think we've learnt an awful lot from them and I hope they've learnt an awful lot from us about aircraft operations.

These are the bodies involved: Val Bill from Hillingdon, Rob Gibson from Hounslow, Monica from Slough and Tracey from Spelthorn. We do have Roger Garner from the DFT as part of the group, we've had a couple of people from DEFRA, the CAA – Peter Havelock is here who attends our group. The airport operators, BAA, and the Heathrow Airport BAA, Heathrow. We've also had a couple of academics – Helen Absheim and Fernando Ferrius from Imperial College have been useful in bringing in the theoretical side of things and the modelling aspects and Dave Raper from Manchester Metropolitan University. We also send all our data to Lucy at the Greater London Authority.

So what new information have we been able to bring? Contrary to what most people believe aircraft don't take off at 100% power (slide 9) – they don't takeoff at full takeoff power. They're the exceptions rather than the norm and most aircraft takeoff significantly below that. Jock, I'm sure will tell you that Concorde is one of those exceptions.

Identification of actual thrust levels we've actually been able to do from our flight data system and I'll show you what that's like from the 747-400. We've got actual taxi times recorded and we manage to do a lot of survey work along with BAA and a student I had getting ground running data and APU use and working out some data for those.

This is the example of take up thrust uses for 747s – that's our 747 and as you can see if you're going to use 100% power then you're up here all the way. This is weight along the bottom and power up the side. So you can see that's not necessarily the case. Now the Arcia databank uses 100% as the takeoff power and 85% as the climb up power. Now a lot of our 747s are taking off below the 85% and indeed the average thrust levels are about 85%/86% if you take the whole year's survey. What we suggested to be conservative and to be easily justifiable for modelling was say 50% takeoff at 100% power and 50% takeoff at 85% power and that gives you this line here. It's still conservative but it's easy to justify (slide 10).

There is another refinement and this is particularly so of our 747s. This actually shows you what effect that has on the inventory just looking at the takeoff NOX (slide 11). If you look at this side 100% represents 100% takeoff power for the engines on a 747 throughout the year. If you go to the 50/50 split then it actually reduces the total NOX emitted by just over 20%. If you go to the actual recorder so you take each of those points and work out what the takeoff power was and what the NOX relative to that was you drop another 20%. With our 747s we've actually modified a significant number of them with the HT combustor, which also is a low NOX combustor - reduces the NOX even further. So if you looked at the split in 2000 when we did our modelling you actually come down to this level here which is 60% lower than using the LTO cycle.

This is the actual contour we got from aircraft alone and this is scaled up to the whole of BA's fleet and the whole of the other airline's fleet operating at Heathrow (slide 12). These are contours of $NO_2$, not NOX but $NO_2$. $NO_2$ is the pollutant actually legislated against. The maximum levels are 40 micro grams. These are in micro grams per cubic meter and the highest one there is 22.9 – 23 say. But it identifies the area which is most affected by aircraft operations. Don't forget this is the aircraft contribution only. It's not all the road traffic or the ground service equipment and everything else.

So, we go onto monitoring (slide 13). Why are we doing monitoring? Well, models are all good but models don't tell you anything if they're not accurate. There's no or very little hard $NO_2$ data across the airport and again into the local communities. All we have is modelling data. If you can't verify what the model is then the model's no use at all. So we wanted to magnify a very finer magnitude of the $NO_2$ concentrations, confirm the drop off rates, which we thought were quite quick from the airport and generally increase our knowledge and understanding of concentrations around the airport of this pollutant (slide 14).

We did two studies. I say we did two studies, we did one study and we're doing another study as we speak (slide 15). We used a one-week monitoring period as a feasibility study. We identified with Imperial College and BAA 15 sites across the airport and up into the local communities. We used diffusion tubes – 3 collocated and one was collocated with a continuous monitor. Diffusion tubes are notoriously inaccurate – you need something to tie them down to for the things to be accurate.

We're currently about half way through a one-year study. We've increased the number of diffusion tubes – 11 are actually on the airport, 7 to the north of the airport and I'm changing them monthly (slide 16). These are the actual locations that we've chosen and again they start right from the south – south of the southern runway and this is actually one of the control posts, at various points across the runway and then up into the local community. The last one is up near the M4 motorway. And again it was to see – this area here is of the greatest interest because that's where the community is and this is the area where our modelling showed the greatest pollution from aircraft in terms of $NO_2$ to come from.

This is what they look like (slide 17) – there are three tubes and they're simple test tubes with a bit of absorbing material that absorbs the NOX or the $NO_2$ in this case. That's how close we got to the runway. It's on a post and that's the tallest thing that's around in that area so that's why we stuck it on that. It's less than 100 yards from the runway. There's another one at the end of one of the piers. This is the continuous monitor – the LHR-2 site that is close to the northern runway, even closer to the northern perimeter road (slide 18 & 19). This is another one at the M4 and again we had a set of three left over so we stuck them in our offices at Waterside.

These are the results so far (slide 20). They're preliminary results because we haven't done the four years and it's the annual average that is important. Forty is the UK level so that's the important one to look at and I guess it confirms what Rob was saying earlier on. Air quality around Heathrow isn't good.

The effects of the runway. This is distance from the runway. This is the M4 up here, this is the runway centre line. These are the ones that are close to the LHR-1 monitor is there. One of the problems with Heathrow is it is surrounded by roads and traffic is an important source as well so you have to be very careful how you look at these but what it does show is this. This is quite a rapid drop off because some of these are the lowest ones on the actual transect monitoring. So what's actually happening? Well, you shouldn't speculate really on where the emissions are coming from until you've got the complete story but other people have been doing it so I will too. Here's our bouncy ball plot (slide 21) – that's technical jargon. The effect of the aircraft appears – this is one interpretation, it happens to be mine but again we should really wait. It seems to be a fairly rapid drop off, which is what our modelling showed us. There's a busy road here, the A4, there's also another slightly less busy one here, the perimeter road. Harlington is a residential area, which is of great interest because that's where the 40 micro grams per cubic meter limit applies and then out here there's the M4, which is another major source. Now that all looks good but there is actually a little bit of justification for putting it like that. One of the members of the group, Monica from Slough noted that it may be possible to look at apportionment from measuring benzene levels. Benzene is present in petrol but not much at all, if any, in kerosene and diesel fuel. So if you have a high benzene signature then that suggests that the emissions are coming from road traffic. We put benzene tubes out on some of the monitors. We haven't got as many measurements as we had for the others but for the NOX but this is what they've come up with (slide 22).

Again, distance from centre of runway out to the M4. This is the M4 signature that shows quite a high concentration. This is actually divided by the $NO_2$ concentration so you get a sort of apportionment, which is what you'd expect from petrol cars. Marylebone Road, which is the other site in London, which is heavily affected by traffic, is up here somewhere.

So in Harlington, and this is where this is, the signature is quite high suggested that the $NO_2$ is coming from petrol driven cars. The airport – it gets lower and we've got one attached to a windsock which is over here somewhere which is affected again mainly by aircraft but there's a few bits with the local transport in this central area. So from this I – again it's preliminary results – I would suggest that Harlington – a lot of it is coming from petrol driven cars.

So what can we conclude (slide 23) from the work we've done so far? Well, working together with the local councils, BAA and other political and scientific bodies has been a real boon. What we've discovered, and this is British Airways as well as me personally is that the dialogue has been at least as important as the modelling. Building up the trust, being able to share the information has been a two-way thing and it's so much better than what it used to be before, as Rob said, we threw bricks at each other.

We've tried to put the focus on getting the correct inputs for the dispersion modelling rather than the actual modelling itself. Everyone has their own favourite model. We chose EDMS, which is the US model because it was cheap basically. So that was our reason. Other people have different reasons for choosing their model because it does it in a particular way. Modelling effects are important and Imperial College has shown just how important they can be but they're not the be all and end all. The old adage of garbage in, garbage out works very well here.

Okay, so what we're doing in the future? Well, we just started the modelling. We're still refining the inputs (slide 25). There are a few things that we still need to know about. Taxi power settings, although they don't have a great effect on NOX because it's at the low end of the power range – are generally thought to be too high for the IKO data bank so we're going to look a little bit at those.

Engine out taxi is not included with some engines not engines going. We know some aircraft do taxi on a reduced number of engines.

We've been working at refining the takeoff power setting philosophy and that's fed its way into the BAA inventory. We don't include any effects of reverse thrust, which is a big omission. Main engine start we haven't looked at. Refinement of the APU cycle – at the moment we just assume a particular level of APU use but it does go up and down with power requirements.

We haven't – and this is BAA – we haven't modelled GSE, that's ground service equipment, air side road vehicles or land side vehicles although thanks to hard work of the local authorities and in particular the Greater London Authority that data is available and we shall be using it.

We're going to complete the monitoring. We're about half way through. We've got about another five to six months to go. The BTX that measure benzene and they're now located at most sites to the north of the airport and that is on-going as well and that could be quite an important thing.

We're looking at possible additional sites although again getting the money for them might not be so easy as it has been in the past. And we continue to work with other groups as well. The Germans have come across from the Franhoff Institute as part of the campaign to measure emissions on the airport.

We're continuing to work with the steering group that is what this is all about really with the local authorities and BAA and academia. The website that Rob mentioned is being jointly funded by themselves, the BAA and ourselves so that's a great cooperative effort and there it is again, Heathrowairwatch.org.uk so look out for it in the future (slide 27). It's not up and running yet but we're promised in eight weeks it will be. And we're working on dissemination of information to other groups. ICAO CAEP, Working Group 3 and the AERONET process in the European Union have both had presentations made to them as well as the Heathrow Airport consultative committee. And just to emphasise that's the end of my talk but it's not the end of the process. Thank you.

Chairman: Thank you Kevin. I'm sure that some of that material is new to some people in the audience and I believe it's a very important study, as I suppose you would expect me to say having been working with Kevin beforehand.

I do think that we are 15 minutes schedule. I'm quite willing if anybody has a quick question for Rod, Rob or Kevin to take one quick question but I think what we really should do is move to coffee and try and get back by a quarter to 12 so that we give the later speakers adequate time to make their presentations.

New speaker: Just one quick question. Have the airlines looked at the environmental cost of the tankering fuel? It's one of the processes we go through two reasons being that commercial your next destination your fuel might be 20% more expensive than your base fuel and also the other reason airlines themselves are carrying centre fuel for return flights. Amsterdam and Glasgow they're all carrying return fuel especially with the fast turnarounds the reason being they cannot guarantee the operations at that airport.

Chairman: Do you want me to answer, Kevin? I think the quick answer is certainly British Airways looks at tankering fuel. The incentive to tanker fuel is very largely based on the cost of fuel at different parts of Europe. For example, in Spain there's a national monopoly on fuel and the price tends to be high and we have at various stages calculated the amount of extra fuel burned as a result of this exercise. That's a quick answer. Kevin, do you want to add anything?

Kevin Morris: Yes, can I add a few things. First of all it's not just those reasons there's also the safety argument as well. Fuel quality varies throughout the world and in some places in the world it's not safe, to be honest and we've had incidences of that – not on British Airways aircraft but on other operator's aircraft where I think it was mainly APUs have run down because of water contamination for instance. Yeah, we do look at tankering of fuel. If everybody sold their fuel at the same price we wouldn't do it. Certainly British Airways wouldn't, it would be a lot less in other countries of the world but you have to look at it logically. On a long haul flight if you're taking an extra 20 tons or whatever, you burn half of that going just by taking it so it's often not very efficient to do that on very long flights. Short haul flights – the extra weight of the fuel has an effect then so does holding and so does re-routing so perhaps it's a much less of an important fact than what people make out.

The other thing of course is that we're trying, well certainly British Airways is part of the Emissions Trading Scheme so it's in our interest to reduce fuel as much as possible. If you load fuel on then you do burn a bit extra, certainly on domestic sectors.

Chairman: Okay, well thanks very much, Kevin. We'll try and be back – we'll now have to make it ten to twelve I think.