Phil Ruffles

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Introduction

The last speaker before we break for coffee and come back for the discussion is Philip Ruffles. Does anyone not know Phil ?

First class honours from Bristol, joined Rolls Royce and eventually became a main board member and although he retired in 2001 is still a technical advisor. He's served on many government committees and presently is a member of the Advisory Committee for Aeronautical Research in Europe, reporting to the European Commission.

You've seen his titles; CBE, FRS, FREng – it speaks for itself and I think that we've had a marvellous range of speakers here today and, of course, more tomorrow and we've heard right from the 50 year, 60 year plus timescales right down to short-term things. Within that continuum some people at some stage have to stop and say – that's what we're actually going to do, and on engines on Rolls Royce that was Phil. He had to say that he's heard all this, he knows the compromises, he knows what the different requirements are, but that's what we've got to do.

Philip Ruffles

Thanks very much, Jock, for that glowing introduction. Good afternoon ladies and gentlemen. I realise that there is a distinct disadvantage in appearing last in the afternoon because everything you were going to say has already been said at least once or twice and, in some cases, three times. You'll have to treat what I say as a summary of the day rather than an individual input.

Firstly, I'd just like to introduce you to ACARE, which stands for the Advisory Council for Aeronautical Research in Europe. Its background goes back about three years when Commissioner Busquin set up a group known as the Group of Personalities, the people who actually signed off the sheet that Christine showed a few minutes ago. They recognised that aeronautics was facing some quite difficult challenges in the future due to forecast growth, which we all hope will occur, leading to congestion both on the ground and in the air and increasingly significant environmental impact . This Group of Personalities met for about 6 or 9 months and produced a report, which goes under the title of The Future of Aeronautics – Vision 2020. In other words, where does aeronautics want to be by the year 2020?

One of the recommendations of that report was to set up the Advisory Council. which comprises 35 members made up from industry, academia and research institutes, national governments and the Commission. Until recently its chairman was Profession Kroll of DLR but he has recently resigned and the chairmanship is currently vacant. The Vice-Chairman was Jean-Marc Thomas of the EADS who has recently handed over to Francois Quentin of Thales.

ACARE formed itself into a series of working groups, which I'll show you in a few seconds, and its first task was to produce a Strategic Research Agenda (SRA) for Europe. The first issue of the SRA was published at the back end of last year and is in two volumes. If you haven't read it, I recommend that you do so The report sets

out a strategic view of where Europe should go in aeronautical research and, indeed, it's already beginning to have some influence on the content of Framework 6 and will have far more influence on the content of Framework 7.

The technical working groups covered the themes of Quality and Affordability, the Environment, Safety and Security and Air Transport System Efficiency. I was one of the co-chairs of the Environmental Group but I'll speak about the others first.

Quality and Affordability – The growth we've seen in air transport over the last 30-50 years has been driven by three factors: GDP growth, the desire of people to travel and the productivity of the equipment itself. Because the aircraft is becoming fairly mature, there is a concern that we will not be able to sustain the continued improvement in ticket price and, therefore, growth will be less on that account alone. In other words it will follow GDP more closely..

The environment has always been a consideration but is taking on increasing importance. Noise has always been an issue since the jet came into operation in the late 1950's, then we saw local airport pollution and now, of course, climate change is an additional issue. So the environmental challenges are getting tougher.

Safety – the industry has an extremely good track record but with larger aircraft and with traffic doubling or tripling over the next 30-50 years or so, it is generally felt that the public will not accept the absolute number of accidents going up. Therefore, there has to be a fundamental improvement in the safety of aircraft in order to maintain the number of accidents at today's levels or less.

Just after ACARE had been formed, 9/11 occurred and so we included Security within the scope although it was not covered by the Group of Personalities' in their report. Safety and Security were put together

Then there's the issue of accommodating the capacity through the airports – you all know how difficult it is now to get to and through the airport and onto the aeroplane- and in the sky. Air traffic management, particularly in Europe, has become more and more of a bottleneck. In addressing this issue, we defined the scope of the ACARE study as being from check-in desk to custom's exit. We did not venture into the transport infrastructure around the airport, which is also a bottleneck.

The four working groups looked at the technical challenges, their potential technical solutions and the research agenda necessary to address those technical solutions.

Two further working groups addressed the other barriers to progress in Europe. One dealt with the research infrastructure, funding mechanisms and the integration of national and European programs and their funding. Issues such as how do we deal with duplication of facilities and of research efforts in various parts of Europe were considered.

The second working group looked at issues related to the less aeronautically intense countries in the Europe compared to the major ones of UK, France, Germany, Spain and Italy and how the smaller nations could play their part more effectively in this research agenda. The group also looked at the problems faced by SME's

The recommendations from these six working groups are contained in the two volumes of the SRA. report.

I would now like to focus on the environment notably the goals set by the Group of Personalities related to global warming, noise and pollution around airports. The deliverable by 2020 was left vague in some cases related to technology readiness and others start of production depending upon the difficulty in meeting the challenge. In either case it is necessary to invest in the technology now

The goal for global warming was to reduce CO_2 emissions by 50% with technology on the shelf by year 2020. The group of personalities' report was not subtle enough to realise that maybe CO_2 reduction is not the only factor that we should be taking into account in global warming – but I'll come back to that later.

The goal for noise was to halve noise relative to current levels. We interpreted all this as being aircraft in service by 2020, relative to the best current production aircraft.

The goal for NOx around airports was to reduce by 80% which is a pretty well recognised target.

Finally, the processes used in manufacturing and operational support were addressed. The contribution from manufacture and support is small relative to aircraft operation. For example the energy usage in the manufacture and support of aircraft is less than 5% or that used during its operation. So the big challenge is to design the aircraft to reduce environmental impact.

First considering CO2 emissions, fuel burn and CO_2 production are synonymous. Earlier today other people have shown this chart illustrating pretty substantial progress in the last 35-40 years. Extrapolating the curve shows just how difficult it will be to realise a 50% reduction by 2020.You can see the arrow is nowhere going through the bull's-eye so some fairly radical change is necessary if we're going to meet that target.

The second emission of NOx, shown in red, is represented by the area of circles. Historic progress in NOx has been minimal illustrating the difficulty of the ACARE target. With NOx what has actually been happening is that combustion technologists have been working hard to improve NOx but the pressure to reduce fuel burn has led to pushing up the pressure ratio and temperature thus eroding the fundamental improvements that have been made in NOx emissions.

For noise, a similar chart was shown earlier. A 20db reduction has been achieved over the last 30-40 years and we're looking for another 10 by 2020. In fact, as has already been mentioned, the A380 has already made quite a big in-road into and is about halfway there. However, it is at the expense of a 2% penalty in fuel burn. So we are already trading one environmental factor against another.

This work has shown that the environmental targets are extremely demanding. Progress in CO_2 reduction needs to be at least twice the historic rate whereas the current trend is flattening out. We need to see some pretty dramatic reductions in NOx in absolute terms. You can make progress in NOx by dropping pressure ratio on the engine, but then the CO_2 will go up. We need to meet them concurrently. Indeed, there is a danger in trading at this point in time because the environmental models are not good enough. The only certain of making progress is to make progress on all fronts. Substantial noise is also reduction required

We came to the very strong view that some break throughs are required and that the goals are not going to be achieved by incremental improvement. We can probably get nearly half way by continued incremental improvement but to then we need some radical departures from what we're doing today. What's more, the task is larger than the capability of any single country in Europe; it will require the effort of the whole community. This is one of the areas where ACARE is beginning to be successful. It's probably the first time in Europe that we've had senior industrialists, researchers, national government officials and European Commission officials in the same room thrashing out these problems. Rather like Foresight in the UK some 8 or 10 years ago, one of the biggest achievements is that of creating a community of people who are beginning to understand and address common problems.

Some reference was made earlier today about United States. I strongly believe that certain aspects of the ACARE agenda are bigger than either Europe or the United States can address alone and need collaboration between the two. Certainly in areas of the Environment and Safety & Security, although there are competitive issues, there's much common ground. We are considering making some approaches to the United States in the next few months to try to get something moving across the globe. Without the two parties working together we could do harm to the whole industry.

The chart on CO2 emissions shows the cumulative fuel burn or CO_2 emissions as a function of range, the blue is how much is emitted below a given distance and the pink is the inverse. They cross at 1,200 nautical miles illustrating that 50% of the CO_2 is produced on stage lengths of less than 1,200 nautical miles.

That was quite a surprise to me; I'd imagined it would be 2 or 3 thousand miles. We make enormous effort to get the last 1% of fuel consumption for long haul in order to get the range and to get the economics right. In short-haul operations the emphasis on fuel burn is quite different because the acquisition costs and the other operating cost of the aircraft are proportionately larger so the trades you do in the design are quite different. This chart shows that over half the problem is with short-haul operation and gives us some clues to the way forward.

As John Green said this morning, CO_2 is not the whole story. We have to take into account NOx at cruise and contrails as they do have a significant effect, but of much shorter duration.To go for a zero carbon fuel such as hydrogen may not be significantly better than kerosene as water vapour will increase and NOx will still be produced. Therefore, a much better understanding of the chemistry of the upper atmosphere is required.

John Green showed the study done by Cranfield, where they optimised the aircraft and engine design to reduce the impact on global warming using a particular atmospheric model The conclusion was to drop the engine pressure ratio to reduce NOx, in other words to go back to 1960's engines, to solve the environmental problem. I don't happen to believe this is the right way forwards, nevertheless, it illustrates the importance of understanding the atmosphere. We have to be quite careful in using these studies because they can very easily lead us to the wrong conclusion.

However, for short-haul operation, we need to think about the design speed, altitude and range . We've all got used to aircraft as being part of a family where you design it for very long range but quite often use it well off its design point. But if we're going to have 2 or 3 times as many aircraft in 20 years' time perhaps we should be looking

much more towards single point design aircraft. After all, we now have to do single point design engines for every aeroplane produced,

Looking at the CO_2 we can probably get just under halfway to the ACARE targets by incremental improvement but then we need some basic changes. We may have to change the speed and altitude and maybe go back to open rotors of some form for short-haul operation. For long-haul operation, as has already been said, aircraft like blended body wings would give a worthwhile improvement. It may be that we will use a different style of aeroplane for short-haul and for long haul.

Noise – same chart coming up yet again so you can see how tightly the industry works. We are going to see significant progress in noise in the next 10 years and for one very good reason. We now have the computational power to understand far more fundamentally what's happening to noise at source. We can study the structure of the flow in different parts of the engine and relate it to the observed noise data and, therefore, start to use CFD of the design process.

For example, control of the tones emitted by fans are now part of the aerodynamic design of the fan, whereas even 5 years ago they were not. We're going to see the same with jets - as we get a better understanding of the flow structures in the jet we can begin to predict the results that an engine or aircraft flight test gave. I'm less pessimistic about noise than I am about CO_2.

For NOx reduction, there are two steps that the industry sees beyond the current conventional combustor. The first is the staged combustor where you start the engine on a pilot burner and then part way up the power curve you switch on the main burner and go up to take-off. This is enables you to lean off the combustion at take-off and therefore run to much lower absolute temperatures in the combustion chamber thereby reducing NOx. The technology is largely on the shelf, but the combustion chambers need more cooling air and that tends to erode much of the benefit and they are also expensive. This concept will take about halfway to the 80% target – about 40% reduction relative to current legislation.

In order to get to the full 80% target, what you have to do is to mix the fuel and the air in a premixer ahead of the combustion chamber and then, when it enters the combustion chamber it will catch fire and burn. The problem is to prevent it from catching fire (auto ignition) in the pre-mixer as it will then burn the whole engine out instead. Overcoming auto-ignition is a big challenge as the auto-ignition delay time of kerosene is pretty short. We don't yet have proven solutions to that problem. But, if we could solve it then you certainly can get down to these quite low levels of NOx.

Finally, the manufacturing and support processes don't make a big contribution, but they are areas where improvements can be made – it's almost low-hanging fruit – and quite often reduces the cost of manufacture. In Rolls Royce, very seldomly did we find driving for green manufacture drove up our costs, it normally reduced them. Foe example, simple things like reducing the amount of water you use causes your water bill to go down.

To conclude, the goals that have been set by ACARE are very demanding and have to be tackled on a European scale. We should endeavour to build collaborative relationships with the United States because then we will have the very best chance of getting the right answers, particularly in the areas related to regulation.

We are going to need some radically new technologies to achieve the goals. What's very important is that we look at the total air transport system to assess these new

technologies. For example, In Europe, the distance that an aircraft flies is typically 15% longer than the point to point journey distance. This is because of air traffic management restraints around military airspace, hold patterns and so on. In addition you might have to fly via an intermediate stop to reach your destination. Air traffic management can also contribute to noise reduction by allowing steeper descents and climb rates to reduce the noise footprint.

Better airport planning can also contribute. Should we still be building houses so close to airports and creating a problem for the future?

By taking a systems approach we can look for solutions in a way that is not possible if we look at the challenges in an isolated way. That has been one of the strengths of ACARE.

We need some study projects to identify the best options for future research. One I'm quite keen to get launched is to take 2 or 3 different atmospheric models, maybe a median model and two extremes, and look at how we might re-optimise the aircraft and the engine design with today's technology to see what the implications are. One atmospheric model might have a very strong driver on NOx which would lead to the sort of conclusions we saw earlier today, but in another model NOx might be relatively unimportant. Understanding the sensitivity between possible atmospheric models and aircraft and engine design parameters might be quite revealing.

We are going to need large-scale integration platforms or technology demonstrators. For example, if we do a blended body wing aeroplane, there's going to be a need for some sort of demonstrator aircraft before the full-scale production programme. Likewise, some advance cycle engines being contemplated would require fairly significant demonstration to reduce risk before put them into production.

I probably should have mentioned the helicopter earlier. ACARE has looked at how we might improve the utility of the helicopter and reduce its noise in order that it can contribute to the air transport system, although I'm not sure that we found it could make a major contribution to air transport.

I hope I have given you a flavour of some of the things that ACARE is doing. We're now in the implementation phase and doing two things. The first is looking across these themes because there are conflicts between the four themes. For example, if we concluded that we needed to fly more slowly it does reduce passenger choice and therefore is in conflict with some of the themes of the Quality and Affordability working team.

We are also looking in more detail at what the research programmes should look like in terms of content and timescale. We are also addressing some of the issues of implementation; I can see us getting into quite strong debate about funding and the contribution from national government versus European government. There's still plenty to do.

Thank you very much.

Floor

If I can sum up this afternoon in just a couple of sentences. When I became involved in this subject it was very much a repeat of something must be done but nothing must happen. Whereas I think now we've got to the stage where everyone is agreeing that

something must be done and it's a combination of short term, common sense and achievable things, direct route approaches, technological developments being implemented that we know are there, and then the step change. We've clearly had adequate examples of both the immediate and possible and the longer term and needed items this afternoon, so thank you to all our speakers.

We're a little bit behind schedule but not much, I suggest we have tea now and get back in at 4.10 and that still leaves us 35 minutes for discussions, questions to be put to the lecturers, to the presenters and still gets us away in good time.

Floor

One of the part-authors of the IPCC report. The question I was going to ask this morning was related to the short-haul or the 1,200km/2,000km distance that was stated for substitution for rail. Looking at the fuel efficiency curve that the Royal Commission produced I wondered to what extent that could be flattened by using fit for purpose aircraft. However, on the other hand you have the added problem of the radiation forcing multiplier, which makes the comparison on energy efficiency between rail and aircraft even more difficult because of the added effect of NOx and water vapour. That's on one hand, but on the other hand you have the problems of substitution by rail because rail itself is not an easy solution because of the constraints and capacity and, indeed, the faster rail goes the less energy efficient it gets. I see this as quite a big problem for the future and I wonder if this afternoon's speakers have any views to give on it.

Speaker

I certainly agree with you. I think that what we haven't investigated the benefits of fit for purpose aircraft, especially if it's at lower altitudes and whether that reducing the forcing coefficient significantly. It clearly is, as Phil began to point out, one of the big decisions we've got to make in the future, as to how many segments you have in terms of different types of aircraft and what fit for purpose you're going for. But having said that perhaps, Phil, you'd like to start off with the answer.

Philip Ruffles

I don't know about starting off with the answer but I can certainly comment on the question.

I think you're right. Particularly below 1,200 nautical miles it's a good news/bad news story isn't it. The good news is that there's probably some things we can do but working out exactly what it's going to be is going to take some time. That's why I said in my summing up that it is quite important to do some studies along the
Lines that I indicated. Today, the aircraft is designed to minimise the overall fare costs and is driven largely by first cost. I know we've seen the move recently to regional jets to give better passenger comfort, so it's first cost and passenger choice that is determining what happens and not fuel efficiency or environmental impact. We just has to do the work to find the best solution. I think there's a grave danger in any of these things of just saying that you know the answer and missing a lot of the problem.

The trade off with rail is certainly an issue.

Economics and passenger choice. A lot of infrastructure would have to be put into the rail if you wanted to increase it enormously. I don't know how that would map. I

mean you just have to look at what's happening at St Pancras at the moment just to get the Channel Tunnel properly serviced - an enormous amount of infrastructure as much as building a new airport at least.