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IT IS A great honour and pleasure for me to speak to you about Concorde—almost to speak to anyone, inasmuch as Concorde advocates nowadays appear so often to be treated as community lepers!

I spent part of my Christmas vacation reading Alistair Cooke's book on "America" and marvelled at the fortitude of the early travellers to this great Continent. Now, I am not saying they would have done better with Concorde or had such an exciting journey, but this chapter of early American history for me illustrated very sharply human inventiveness and the astonishing progress which man has made in a relatively few years, and I mused that if Concorde were flying scheduled services to the United States it would have taken the Pilgrim Fathers not sixty-five days of travail to reach America, nor even the seven and one-half hours that marked my progress across the Atlantic two days ago, but in Concorde, three hours and twenty minutes, for which I for one would be prepared to offer a short prayer of thanksgiving *and* pay a small surcharge on the fare.

I have styled this talk "Concorde—What's New?" but let me say at once that in most respects Concorde is far from being a novelty, and the common reaction of those who have been fortunate enough to fly Concorde is how conventional their flight has been. Far from detracting from the technical achievement of Concorde this fact only serves to underline its success.

It is important and a little surprising to remember that twenty-five years ago man had never succeeded in flying beyond the speed of sound. The problems of controlled supersonic flight were formid-

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able, and the features which favoured supersonic speed were the exact opposite of the features required for long-range and acceptable landing and take-off characteristics. The so-called sonic barrier was at that time regarded as a massive obstacle which had already claimed many test pilots' lives and was to claim many more. Some experts even predicted that controlled supersonic flight would never be possible. (Columbus encountered much the same problem of skepticism in the Fifteenth Century).

They were proved wrong by the flight of the Bell XI rocket plane which achieved Mach. 1.06 in October 1947. However, penetration of the supersonic regime remained extremely difficult, requiring at first rocket propulsion, and even when, in the 1950's, supersonic flight became possible with relatively conventional aircraft using jet turbine engines, it was confined to small military aircraft with very low endurance (counted only in minutes) at supersonic speeds.

When, therefore, suggestions began to be made in the mid-1950's that long-range supersonic flight might eventually be possible, and that this might lead to a supersonic transport aircraft becoming feasible, they were met with general skepticism. It soon became obvious, however, that the rewards in terms of progress and prestige were ample to justify the efforts required and Government interest chrystalised in complementary work being undertaken in France and England.

Numerous feasibility studies were considered employing a variety of shapes and range of cruise speeds. The studies included variable wing sweep and lift engine configurations, but all the work favoured the delta wing planform and a cruise speed of around Mach. 2, and it was the wing design—involving a totally new concept of lift—which finally resolved the apparent incompatibility to which I have referred between the problems of supersonic flight and the requirements of a commercial jet operation.

The speed of Mach. 2—twice the speed of sound—was chosen because it would be a sufficiently big jump—about two and one-half times then current jet speeds. To go much faster did not show significant gains, but was considered to be a very much greater technical risk; we knew something about flying twice the speed of sound and, since we would be able to build the aircraft from aluminum alloy and materials which we had been using for years, we could avoid having to venture into new and exotic materials.

Interestingly, the design problems of a supersonic transport arose mainly from the influence of the environment on the aircraft. Put simply, the earth's atmosphere is contained in a very thin layer around the surface. If you imagine that the earth were the size of an apple, then the whole atmosphere would be contained in the thickness of the skin. As one climbs away from the ground, conditions rapidly become cruel, eventually to the point where man cannot survive unaided. The air gets very thin and paradoxically the high speed of the aircraft will always search for thin air. The higher you go the colder it gets until it steadies out somewhere about 56°C. which, in gardeners' terms, is 100 degrees of frost. This is the world of Concorde flying in the temperature of still air; but the aircraft is also going forward, as a result of which the air scrubs the surface of the aeroplane, warming it up from friction. The effect is small for the subsonic aeroplane where it simply remains cold outside, but Concorde's speed is such that its skin gets heated to well above the boiling point of water.

The Concorde takes off warm, climbs slowly becoming very cold, and then accelerates with the skin getting hotter. All this time the passengers, crew, and the equipment sitting inside expect no change in comfort, the material we use to build the aircraft must keep its strength and the design must allow for the structure shrinking and expanding during flight. Apart from these technical idiosyncrasies, Concorde had to be developed to fit comfortably in the existing highly constrained medium of air traffic controlled airspace; it had to behave just like any other air transport, having the same or better levels of safety and reliability. At no time have we sought or been given any dispensations.

The first metal was cut on Concorde in 1965; the first flight took place in 1969 (and within six months Concorde had exceeded the speed of sound); it received its Certificate of Airworthiness on 5th December, 1975 and commenced scheduled services in January 1976. The flight tests have explored the whole of the flight envelope expected of Concorde. It has taken off many times at its maximum design take-off weight. It has flown many times air sectors longer than the design distance Paris to New York. It has reached 2.23 times the speed of sound (1,470 m.p.h.). It has climbed to 68,000 feet—nearly thirteen miles. It has demonstrated all emergency procedures and automatic landings.

The fundamental objective of the Concorde design has been to produce a useful commercial airliner, and not just a good flying machine. This meant that as far as possible the techniques, materials, and procedures associated with the aeroplane should be as familiar to the airlines as possible. As a result, although many of the design problems were novel, as far as possible, novelty of solution was avoided and solutions have been achieved by taking existing techniques as far as the state of the art would sensibly allow and by combining existing concepts in new ways. Where innovation was required, the approach has been both bold and imaginative.

You may find it interesting if I mention just a handful of new developments to be found in Concorde:

1. The fuel system has been designed with a multipurpose function. Apart from propelling the aircraft in the customary fashion, it also serves as a means of heat dissipation and, by virtue of pumping from forward to rear tanks and vice versa, alters the aircraft's centre of gravity during the transition from subsonic to supersonic speeds.

2. The powerplant utilises variable geometry systems for the intake and the nozzle which are linked aerodynamically as well as via the engine (which itself occupies only one-third of the total length of the powerplant).

3. The variable geometry nose and visor have been designed to compensate for the steep angle of approach without forfeiting aerodynamic integrity during supersonic cruise. The lift characteristics of the wing shape (to which I have briefly referred before) obviate the need for wing flaps, (and yet would you believe that an English aviation journalist solemnly reported a couple of months ago that Concorde's noise was largely attributable to maladjusted wing flaps?).

When Concorde entered airline service last month, it had been more thoroughly researched and tested than any previous commercial aircraft; more than ten years of ground testing and more than 5,300 hours of flight testing were completed to ensure Concorde's safety and reliability—more than three times the figure applicable to the Boeing 747. This leads me to say a few words concerning environmental issues, although before I do, may I say how genuinely impressed we all were with Mr. William Coleman's handling of the EIS Public Hearing held in Washington on 5th January and na-

turally how delighted we are with his verdict in favour of Concorde.

The environmental challenge to Concorde has been severe—I assume (on the part of some, at least) that it has been well-intentioned. Well, unless we are quite mad, we all believe in the environment, in the same way that we subscribe wholeheartedly to democracy and world peace. Please do not misunderstand me: I am not scoffing when I say this and I mean what I say. What annoys me are the absurd lengths to which a number of the critics are going and the attitude—almost as a matter of divine entitlement—that they must be right and the rest of the world wrong. Does anyone seriously believe that I or my colleagues are bent on destroying the world, a world which we *all* share, in which we *all* live? Your environment is no different from ours. Would we dare to release an aeroplane into service which we even suspected might be a hazard? Am I less concerned with noise and cancer than my neighbour? Who (I ask myself) is fooling whom? Some of the technicians and others who have successfully worked out how to carry one hundred or so passengers in safety over 3,000 miles in three and one-half hours applying a set of proven physical laws may be forgiven for believing that the only fault in Concorde's forward planning was to seek U.S. landing rights in a Presidential Election Year, and without doubt, there are Congressmen and Clerics who are making far more noise than Concorde. Whenever new technology arises the environmental impact of that technology must be considered, but carefully and without emotional exaggeration. BAC and Aerospatiale and their Governments have conducted worldwide tests and gathered data according to the most scrupulous and objective methods known and the results have been made freely available to everyone concerned. I can assure you that we are certainly no less responsible than the major American companies, no less mindful of our reputation, and of our professional and social responsibilities.

Is mankind to put back the clock, to lose its initiative for progress? I heard with interest a few weeks ago a report of an American town which had passed a law requiring horses to wear diapers; is this then the future of transportation—horses wearing carpet slippers and carbon-fibre underpants? Are we, like some totalitarian states, to rewrite history and, rather than praise him, now indict as some criminal lunatic the man who invented the wheel?

We welcome and expect comment, but please let it be fair, reasoned, and (if at all possible) informed. Regrettably, in the case of Concorde, factual and imaginary distortions have been multiplied to the point where almost all sense of reality has been lost.

Take noise. Concorde's airfield noise on entry into service has been demonstrated to be of the same order as that of current subsonic jets—such as the Boeing 707 and the McDonnell Douglas DC-8—large numbers of which will continue in front-line service, and represent more than two-thirds of all departures, for many years after Concorde's introduction. When Concorde's powerplant was chosen, it was aimed to be no noisier than then contemporary jets and this has proved to be the case. At that time there were no regulatory standards on noise. More recently, noise regulations for new subsonic aircraft have been introduced, the level being somewhat lower. The Tristar, DC-10 and Airbus-type of aircraft are in this bracket. Unfortunately, the powerplant they use is not suitable for a long-range supersonic aircraft. New quieter supersonic aircraft can be built but only with a new type of engine; and in time these developments will come. As Richard Fitzsimmons of Douglas Aircraft noted during the Coleman proceedings: "[T]he DC-10 is a dramatic improvement over its ancestor, the first DC-8." There is a variety of ways of measuring noise, but in our view it is the incremental effect on the true noise exposure to the human ear which is the only sound basis for judgment. The Environment Impact Statement, endorsed by Mr. Coleman, shows that the impact on this basis of Concorde's proposed operations at Dulles and New York will be negligible.

The 'sonic boom' phenomenon is the principal new problem associated with supersonic transport operation. Whether "supersonic corridors" are socially acceptable over particular countries will be a decision by their Governments, taken in the light of public opinion and mutual negotiation. Widespread practical evidence has shown the boom, however, to be far less intrusive than many of the more emotive commentators would have us believe, and I would remind you that Concorde's manufacturers have always assumed in their market research that supersonic flight would only be permitted over the seas and over land areas which are relatively uninhabited—which together form a very considerable part of the earth's surface.

In fact, around eighty per cent of today's intercontinental seat-miles are flown over oceans or land areas of this kind.

It has been alleged that supersonic operations in the stratosphere will cause serious disturbance to the natural balance and structure of the atmosphere and so produce considerable changes in the earth's climate. Many pessimistic forecasts have been made about the possible effects of SST operations on the ozone layer that protects the earth against ultra-violet light.

To this we say firstly that the problem of possible ozone depletion is by no means unique to Concorde and, secondly, that it will be impossible to detect any variation of the ozone amount which may be caused by Concorde within the variations otherwise occurring, including the effect, for example, of aerosols, natural volcanic eruptions, and military supersonic flights. The most recent American scientific evidence on the effect of high altitude flying in the earth's ozone layer shows that previous estimates may well have been significantly overstated and that any destruction of ozone by the nitrous oxides from aircraft engine exhaust emissions and the normal production of new ozone are actually very nearly in balance. The published American Government Climatic Impact Assessment Programme has concluded, after three years of the most thorough investigation, that Concorde poses no immediate threat to the environment. It would, the report says, take 125 Concordes to produce the smallest change in the ozone discernible by man over ten years of comprehensive monitoring and Concorde is merely "a pimple on the environmental problem." More recently still, this has been confirmed by the World Meteorological Organization.

It is an historical fact that the development of a new transport mode and indeed all innovative thinking has had its share of criticism from the "political and scientific pundits" of the day. For example:

About aviation:

> I have not the smallest molecule of faith in aeriel navigation other than ballooning. Lord Kelvin—1896.

and about the advent of railways:

> It is dangerous for trains to exceed thirty miles an hour, because air will enter the compartments and passengers will be suffocated. The farming community fear that cows grazing peacefully near

> the railway lines will be so frightened that they will give less milk, or even none at all. Panel of Experts from the Royal Society—1825.

In the early days of SST agitation, water vapour in the jet exhaust system was seen as the principal hazard. The prediction was that injection of water vapour into the stratosphere would in time create a permanent cloud layer; one school thought that this layer, by reducing radiation from the sun, would bring about a new ice age; another that it would produce a "greenhouse" effect and send ground temperature soaring.

Concorde, you see, is no exception and, if I may be permitted one more equally erudite quotation from *The Economist* in July 1965 "Someone must call the bluff: the Concorde supersonic airline will not be built."

Thankfully, legal evolution has not been a hallmark of Concorde's development to date, but that picture may change with the expected advent of lawsuits by community interest groups and, already, adventurous words have been spoken about the interpretation of International Treaties, the superiority of Federal over State authority, the relevance or extent of airport owners' rights, and so on.

One small development which I can report—on a more terrestrial level but certainly no less important—concerns Concorde's insurances. For some years I have been advocating a single Product Liability Policy for Concorde embracing the interests of both airframe manufacturers, the engine manufacturers and the hundreds of sub-contractors and suppliers engaged on the programme. This pattern of insurance removes the need, as between the co-insured for a number of wasteful subrogation actions; it reduces defence expenditure and makes a more effective use of premium, ensuring adequate indemnities for each of the insured irrespective of his size. I am happy to tell you that this Insurance Policy is now a reality, although one important step remains, which is to include the operating airlines. Who knows—exculpatory clauses may become a thing of the past!

So, where does all this leave us today?

We are convinced that the benefits of supersonic transport can be achieved without excess pollution of the environment or dis-

advantage to society in general. In our view the supersonic transport represents the highest point yet reached in the development of transportation. Civilised life on this planet is dependent on close links in all forms of human communication. Concorde will make a dramatic contribution toward this need. During the last war, Britons at home were urged to consider whether their journeys were really necessary. Levity and politics aside, today no-one seriously asks if Dr. Kissinger's journeys are really necessary and perhaps it is not surprising that he feels that Concorde has an important role. I can not say whether the supersonic transport aircraft is the ultimate step, but our planet is of a finite size and it does seem that Concorde or Concorde type aircraft will fill this slot for the rest of this century.

Whilst there are many factors besides speed influencing the growth of air traffic, equally clearly there is a causal relationship between journey time and the number of passengers availing themselves of the service. More than six million passengers would simply not have travelled across the Atlantic last year if the journey still took five days, and the demise of the trans-Atlantic liners, notwithstanding all their luxuries, is no mere coincidence.

Studies have shown that when a destination comes within a day's travel, the traffic increases sharply. Concorde literally halves the world's airline timetables. Therefore we can confidently expect Concorde to have a very stimulating effect on world-wide travel. Speed promotes traffic and speed is the commodity which the air transport industry is basically selling.

On 17th June 1975 Concorde showed its paces to spectacular effect. It took off from Boston at 8:22 a.m. and, at almost the same time, an Air France Boeing 747 left Paris en route for Boston. The two aircraft crossed when the 747 was 620 miles out of Paris and Concorde was nearly 2,400 miles out of Boston. Despite the Concorde turn-round time at Paris being extended to sixty-eight minutes because one passenger could not be found, at the end of its return flight it landed at Boston eleven minutes ahead of the 747.

We have demonstrated in many parts of the world that Concorde is perfectly capable of operating within the existing air traffic control system, in the existing airports environment, and in all weather conditions. The overall programme has confirmed the validity of the objectives and the design estimates to what must be regarded as an unusually high degree. So much so that the most plausible ex-

planation may well be that the British and French were so critical of everything the other did that every problem was sure to be argued out exhaustively and each decision had to be justified in two separate languages!

As with all successful commercial aircraft, developments of the basic model of Concorde will undoubtedly come, initially most probably towards increases in range; longer term, they will be larger and have powerplants using new technology, but today's Concorde is the first and essential step. I do not see the Russians stopping at the TU144. My personal and sincere hope is that the new Concorde models will arise through full collaboration with the United States.

By its very nature, aviation is international. Whatever the arguments concerning Concorde, she is now demonstrably far too significant to our whole future to be denied the chance to prove herself in service. If not, believe me, we shall all be the losers.