Concorde

edited by
Kenneth Owen

ICBH Witness Seminar Programme

Concorde

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Concorde

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> **Ken Binning, in 'Concorde', seminar held 19 November 1998 (Institute of Contemporary British History, 2002, http://www.icbh.ac.uk/witness/concorde/), p.45.**

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Concorde revisited: a seminar aide-memoire

Kenneth Owen
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Origins, 1959-62

> The Committee strongly recommends that a long-range supersonic transport carrying about 150 passengers should be built… The stage length required should be 3450 statute miles which will permit non-stop transatlantic operation. The cruising speed should be chosen to avoid any severe kinetic heating difficulties but should be not less than 1200 mph (M=1.8)…

This was the view of the Supersonic Transport Aircraft Committee (STAC) in March 1959, which considered that the United Kingdom could and should build a supersonic transport (SST) aircraft; a second, shorter-range design, to cruise at Mach 1.2, also was recommended but was not pursued. The Committee represented all the UK aircraft and aero-engine firms together with other interested bodies, and its work was led by the Royal Aircraft Establishment (RAE), Farnborough. The Committee's chairman was Morien Morgan, a deputy director of the RAE. The STAC report was the starting point for Britain's civil supersonic endeavours, leading inexorably to the 1962 Anglo-French Agreement to develop, for better or worse, for richer or poorer, the Concorde.[1]

Following the STAC report, the Cabinet agreed in September 1959 to place initial SST design study contracts with Bristol and Hawker Siddeley. In a departmental reshuffle following the re-election of the Conservatives in October 1959, the Ministry of Supply and the aviation part of the Ministry of Transport were merged to form a new Ministry of Aviation, with Duncan Sandys as Minister.[2] Officials began to explore the possibilities of international collaboration with their French opposite numbers, while the two firms had been instructed to make similar soundings both in France and in the United States.[3]

In July 1960 the Cabinet agreed to authorise continued SST design work. Significantly, the stated objective was 'to create a negotiating position from which the United Kingdom should attempt to secure United States collaboration in a joint project'.[4] The Ministry of Aviation pinned great hopes on an Anglo-American policy review meeting on civil aviation co-operation, held in September 1960 in London. But on SST collaboration this meeting proved inconclusive, in large part due to the conflicting preferences for a Mach 2, light-alloy aircraft (Britain) and an all-steel machine of Mach 3 or thereabouts (USA).[5] Peter Thorneycroft, who had succeeded Sandys as Minister of Aviation[6], continued to press the US Federal Aviation Agency for a joint Anglo-American programme, but all his approaches were stonewalled, and by June 1961 his officials were

1 Public Record Office, Kew (henceforward PRO) SUPP 29/1, RAE, Farnborough, Report of the Supersonic Transport Aircraft Committee, 9 Mar.1959, Summary.

2 The Ministry of Aviation was formed on 14 Oct. 1959.

3 PRO CAB 128/33, CC(59)52nd , Cabinet conclusions, 18 Sept. 1959.

4 PRO CAB 129/102, C(60)126, Cabinet memorandum by Chancellor of the Exchequer, Derek Heathcoat Amory, 19 July 1960.

5 PRO AVIA 63/21/AA/292/105, Discussion on Anglo-American Co-operation in Civil Aviation, note of meeting 7 Sept, 1960 between teams led by Sir William Strang for UK and E.R. Quesada for US.

6 Peter Thorneycroft was Minister of Aviation from July 1960 until July 1962.

advising him that such a deal was unlikely to materialise.

In parallel, official Anglo-French discussions had been held in London and Paris in October 1959 and February 1960, and (documents in the Public Record Office confirm) the French Government was given, 'in confidence', a copy of the STAC report. Peter Thorneycroft and Robert Buron, French Minister of Transport, held a succession of meetings throughout 1960 and 1961.[7]

In June 1961, the Chancellor of the Exchequer, Selwyn Lloyd, made a pre-emptive attempt to abort the Concorde project 17 months before it was started. In a Cabinet paper on the economic situation Lloyd suggested that, in a forthcoming statement to parliament, he should announce 'abandonment of the supersonic airliner project'. In the event, Lloyd's July 1961 statement to the Commons contained no mention of the project.[8]

Early in 1962 Robert Buron resigned as French Minister of Transport, but not before he and Thorneycroft had gone a long way towards agreeing a possible plan for a joint project to develop a light-alloy, 100-passenger, Mach 2.2 SST. Reporting this to the Cabinet, Thorneycroft suggested that the subject should be considered further by the Cabinet Committee on Civil Scientific Research and Development.[9] On 29 May 1962 the Cabinet agreed to this plan, and the Committee, chaired by Lord Mills, Minister without Portfolio, embarked on the study that would lead to the crucial (or fatal, depending on one's point of view) agreement.[10]

But a key problem that would dog the project for some years to come had surfaced in another forum earlier that year. The Ministry of Aviation had set up a Supersonic Transport Aircraft Board of Management (STABM), chaired by Morien Morgan, now the Ministry's Deputy Controller of Aircraft (R&D), on which the British Overseas Airways Corporation (BOAC), the British Aircraft Corporation (BAC, of which Bristol was now a part) and the ministry were represented. The STABM's discussions had led to private exchanges between the chairman of BOAC, Sir Matthew Slattery, and Sir Henry Hardman, Controller of Aircraft at the Ministry of Aviation, on the question of BOAC's commitment to the aircraft. Hardman warned the Minister: 'There is a potential conflict between the Department's two current policies of' developing an effective transport aircraft industry and of obliging the Air Corporations, like other nationalised bodies, to act commercially'.[11]

In the Cabinet Committee on Civil Scientific Research & Development, the Minister of Aviation submitted a long paper outlining the case for British participation in the development of a joint SST.[12] A second paper by Henry Brooke, Chief Secretary to the Treasury and Paymaster-General, warned of the risks and financial uncertainties involved. Thorneycroft told the committee that the project was too big and risky for the UK to undertake alone; a joint project would share the costs and work and would extend the market. Brooke did not think that the supersonic airliner was a commercially viable project.[13]

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7 PRO AVIA 63/20/AA/292/014, Brief for Minister's visit to Paris, 27 Oct. 1960; PRO SUPP 29/67/AE/281/02/A Supersonic transport aircraft: Brief for Minister's meeting with M. Buron, 7 Dec. 1961.

8 PRO AVIA 63/20/AA/292/014, Minute from Geoffrey Rippon, Ministry of Aviation to Chancellor of the Exchequer, 30 June 1961 on Economic situation – C(61)89: Supersonic Transport Aircraft.

9 PRO CAB 129/109 C(62)82, Memorandum by Minister of Aviation, 23 May 1962 on Co-operation with France in Building a Supersonic Airliner.

10 PRO CAB 128/36, CC(62)38th, Cabinet conclusions, 29 May 1962 on Aircraft Industry: Supersonic Airliner.

11 PRO AVIA 63/53/AA/8/071 note from Sir Henry Hardman, Permanent Secretary, Ministry of Aviation to Minister of Aviation on BOAC and the Supersonic Transport, 28 May 1962.

12 PRO CAB 134/1585/CSR(62)3, Cabinet Committee on Civil Scientific Research and Development: note by Minister of Aviation on the Case for British participation in the development of a supersonic airliner, 22 June 1962.

13 PRO CAB 134/1585/CSR(62)4, Cabinet Committee on Civil Scientific Research and Development, memorandum by the Chief Secretary to the Treasury and Paymaster-General on The Supersonic Airliner, 22 June 1961.

On Friday 13 July 1962 Sir George Edwards of BAC and Sir Arnold Hall of Bristol-Siddeley Engines outlined the joint industrial proposals to the Cabinet Committee on Civil Scientific Research and Development.[14] Later that day, the orderly progress of the Committee (and much else) was disturbed by Macmillan's so-called 'night of the long knives', a wholesale ministerial reshuffle in which Thorneycroft moved from Aviation to Defence, Julian Amery came into Aviation (though not into the Cabinet), and Lord Mills was replaced as Cabinet Committee on Civil Scientific Research & Development chairman by R. A. Butler, First Secretary of State and Deputy Prime Minister.[15] By the date of Butler's first meeting of the committee, 27 September 1962, Aviation ministry and Treasury officials had prepared six reports, covering co-operative arrangements; operating economics; launching and production costs; operating problems; loading in the aircraft industry; and the potential market. The Government's decision-time was approaching.[16]

The decision itself was left in considerable doubt in Butler's equivocal report on behalf of the Cabinet Committee on Civil Scientific Research & Development to the Cabinet, dated 3 November 1962.[17] 'We have not reached any final conclusion', he admitted. He summarised:

> This proposal may well constitute a natural and inevitable step in technological advance, offering the benefits of such advance and a moment of opportunity to enhance British and French prestige, but we may find in later years that United States industry ousts it with something better, and we are left with too small a market for our pains. And some of us believe that the right lines of technological advance for this country to exploit cannot be selected without regard to commercial prospects. On the other hand to decide not to venture in this field while America and perhaps Russia and France go ahead could well mean contracting out of the large passenger aircraft business.

The estimated cost of development was £150-170 million. Julian Amery felt strongly that the proposed Anglo-French programme should go ahead, and sent a 'personal and confidential' note to his father-in-law, Prime Minister Harold Macmillan, to say so.[18] It took the Cabinet two meetings to decide the issue. On 6 November 1962 Butler reaffirmed the Cabinet Committee on Civil and Scientific Research & Development's view that supersonic passenger travel was sure to come; on the other hand, they had felt that the proposal could not stand on normal economic grounds. Julian Amery reaffirmed his support for the proposal. Henry Brooke was concerned that neither the manufacturers nor BOAC was prepared to put money of their own into the project.[19]

The Cabinet authorised Amery to inform the French Government that the proposal for the joint development was in principle acceptable to the British Government, subject to assurances on the participation of French airlines and to final examination of market prospects. Two weeks later, Amery reported back to the Cabinet that Roger Dusseaulx, Robert Buron's successor as French

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14 PRO CAB 134/1585/CSR(62)3rd, Minutes of Meeting of Cabinet Committee on Civil Scientific Research and Development, held on 13 July 1962.

15 'Night of the Long Knives'. On 8 July 1962 Prime Minister Harold Macmillan undertook extensive changes in the composition of his Cabinet, shuffling 39 of 101 ministerial posts. Macmillan maintained that he had done so to mask the sacking of Chancellor of the Exchequer, Selwyn Lloyd, and thus to avoid giving offence to such a close and long-serving Cabinet colleague. Harold Macmillan, *At the End of the Day*, p.92, (London, Macmillan, 1973).

16 PRO CAB 134/1585/CSR(62)6, Proposed arrangements for management and financial control, PRO CAB 134/1585/CSR(62)7, Operating economics, PRO CAB 134/1585/CSR(61)8 Launching and production costs, PRO CAB 134/1585/CSR(62)9 Technical problems, PRO CAB 134/1585/CSR(62)10 Loading in the aircraft industry, PRO CAB 134/1585/CSR(62)11 Potential market, Cabinet Committee on Civil Scientific Research and Development, notes by officials, Aug./Sept. 1962.

17 PRO CAB 129/111, C(62)174, memorandum by the First Secretary of State on The Supersonic Airliner, 1 Nov. 1962.

18 PRO PREM 11/4612, 'Private and confidential' note from Julian Amery to Prime Minister Harold Macmillan, 2 Nov. 1962.

19 PRO CAB 128/36,(CC(62)6thCabinet conclusions, 6 Nov. 1962 Aircraft Industry: The Supersonic Airliner.

Minister of Transport, had assured him that Air France intended to operate the aircraft. The estimated number of aircraft that could be sold was at least 150-170. He had persuaded the French authorities that the aircraft should not be called the 'Super Caravelle'. After a somewhat muted discussion, the Cabinet gave the go-ahead for the project, under the name 'Concord'.[20]

This decision was translated into commitments in three agreements signed towards the end of November 1962: between BAC and Sud Aviation; between Bristol Siddeley and Société Nationale d'Études de Construction de Moteurs d'Aviation (SNECMA), the French engine company; and, on 29 November 1962, the historic agreement 'regarding the development and production of a civil supersonic transport aircraft' between the French and UK Governments, on the basis of an equal sharing of work, expenditure, and proceeds of sales.[21] The problem of BOAC involvement was resolved in a carefully worded memorandum of understanding under which the Government agreed to underwrite the airline's commitment to the aircraft until the early flight trials had enabled its suitability for BOAC service to be assessed.

An intriguing change in the drafting of the agreement, which had the status of a formal international treaty, has been noted privately by one of those involved. In July 1962 the written agreement in draft was for further feasibility studies, for which the Treasury limit was £50,000. In early November 1962, it was an agreement to design an aircraft. By 29 November 1962 it had become an agreement to design *and produce* an aircraft.

Reviews, 1964-65

Though it is the actions of the incoming Labour Government in October 1964[22] that are remembered as provoking the most overtly controversial chapter in the Concorde story, the programme was already under review by Sir Alec Douglas-Home's Conservative administration in the summer of 1964. Julian Amery presented a Cabinet paper noting design modifications, cost and price increases and noise problems, and posing what he called the essential problem: should we go on? He believed we should although John Boyd-Carpenter, Chief Secretary to the Treasury and Paymaster General, was concerned over the mounting costs.[23] On 25 June 1964 the Cabinet agreed that it would not be politically practicable to withdraw at that time, but that the project should be reviewed again later that year.[24] But the planned further review was overtaken by the general election.

In October 1964, Anglo-French relations suffered a traumatic setback when the new Labour Government led by Harold Wilson published a statement on the economic situation only ten days after taking office.[25] The statement warned that 'prestige projects' were to be cut, and added (at the insistence of George Brown, Secretary of State at the new Department of Economic Affairs): 'The Government have already communicated to the French Government their wish to re-examine urgently the Concord project'. There was no doubt that the Government in fact wished to cancel; the French Government did not; and the repercussions took many months to resolve. A frantic flow of telegrams passed between the Foreign Office and HM Embassy, Paris, as urgent ministerial meetings in London discussed how to repair the damage while sticking to the point that

20 PRO CAB 128/36, CC(62)70th Cabinet conclusions, 20 Nov. 1962, Aircraft Industry: Supersonic Airliner.

21 PRO FO 93/33/475, Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the French Republic regarding the development and production of a civil supersonic transport aircraft, 29 Nov. 1962.

22 The Labour Party came to power on 16 Oct. 1964 after winning the general election.

23 PRO CAB 129/118, CP(64)124, Cabinet memorandum by the Chief Secretary to the Treasury and Paymaster General on The Concord, 22 June 1964.

24 PRO CAB 128/38, CM(64)33rd , Cabinet conclusions 25 June 1964.

25 *The Economic Situation*, a statement by Her Majesty's Government, 26 Oct. 1964, HMSO.

Concorde prospects needed urgent examination.

During the tortuous attempts to reach some accord with the French, Roy Jenkins, Minister of Aviation, met his opposite number, Marc Jacquet, in Paris at the end of October 1964. At a meeting of the Cabinet's Economic Development Committee in mid-November 1964[26] Jenkins offered five options: break the treaty unilaterally and incur the resulting 'political odium'; urge the French to support an alternative £3 million research programme; consider renegotiating the agreement to cover the development of two prototypes only; consider bringing Germany and Italy into the project; and 'suggest a joint Anglo-French approach to the United States Government for the tripartite development and production of a supersonic transport'.

As the Cabinet wrestled with these self-inflicted problems, Sir Richard Way, Permanent Secretary at the Ministry of Aviation, felt obliged to put his own view on the record in a confidential note to his minister:[27]

> Whatever the merits or demerits of the Government's 'decision' to abandon the Concord project, the methods by which we have set out to achieve this end are a text book example of how not to do it…. If the object of the exercise was not only to abandon the Concord but also to do it in a way calculated to cause the maximum breach with the French Government, then we have succeeded admirably.

It took until January 1965 for the eruptions to subside. Jenkins flew to Bretigny in great secrecy to meet Jacquet again on 11 January 1965;[28] and was able to tell the Commons on 20 January 1965 that the Government had completed its review, had 'exchanged views with the French Government', still retained some doubts about the financial and economic aspects of the project, but stood by the treaty obligations.[29] (In the detailed discussions which followed, the idea of an agreement with the United States to co-ordinate the timescales of the Concorde and the planned American SST was floated, but sank without trace).

Commitment, 1968-74

The Labour Government's desire to extricate the United Kingdom from her commitment to the Concorde programme, handled so ineptly in 1964, was re-shaped in the light of continued legal advice over the next five years. Unilateral withdrawal remained a non-starter, such were the perceived dangers of legal action by the French. The only possible route was to establish jointly with the French that a 'fundamental change of circumstance' had occurred since the agreement was signed. But this proved difficult, not only in defining a 'fundamental change' but also in ensuring that the UK was not seen to be doing anything to jeopardise the future of the project.

In the summer of 1966 the re-elected Labour Government took another look at Concorde prospects, with the Ministry of Aviation now in the hands of Fred Mulley, and an official Anglo-French committee was formed to examine the commercial prospects of the aircraft.[30] By January 1967 Mulley had been succeeded by John Stonehouse;[31] and by April the Ministry of Aviation had been succeeded in its responsibilities for the Concorde by the Ministry of Technology under Anthony Wedgwood Benn.[32]

In 1968 Benn obtained the agreement of his French opposite number, Jean Chamant, to terms

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26 PRO CAB 134/1736/ED(64)14, Cabinet Ministerial Committee on Economic Development, memorandum by the Minister of Aviation on The Future of the Concord project, 13 Nov. 1964.

27 PRO AVIA 65/2167/ZS/25/10/E, Note by RGK Way to Minister of Aviation, 6 Nov. 1964.

28 PRO FO 371/182977/RF1382/11, Record of meeting held at Bretigny on 11 Jan. 1965 to discuss the Concord Agreement, record dated 12 Jan. 1965; and Ministry of Aviation amended version of record.

29 *Hansard*, House of Commons Debates, Statement by the Minister of Aviation, 20 Jan. 1965, col.197.

30 PRO CAB 128/41 CC(66)39th , Cabinet conclusions, 21 July 1966, Aircraft Industry: The Concord Project..

31 Fred Mulley, who became Minister of Aviation in Dec. 1965 was succeeded by John Stonehouse in July 1967.

32 The Ministry of Aviation was absorbed into the Ministry of Technology on 15 Feb. 1967.

that effectively defined the 'fundamental change' concept. By early 1974, during Edward Heath's Conservative administration, a joint Anglo-French official committee had concluded that such a change had indeed occurred – notably that the market for the Concorde had virtually disappeared – and that the aircraft was commercially unviable. This report was waiting for Benn when the Labour Government scraped back into power in March 1974 and he returned to office as Secretary of State for Industry, again with responsibility for the Concorde. (That responsibility had passed from Mintech to the Ministry of Aviation Supply in 1970; to the Department of Trade and Industry in 1971; and to the Department of Industry in 1974).

Benn decided to publish a statement based on the officials' figures, which showed the cost of five options, ranging from immediate cancellation to a revised programme proposed by the manufacturers (based on further development; and on production rising to 16 aircraft a year, completing 60 aircraft by the end of 1981). Britain's commitment to the Concorde was endorsed in July 1974 when Prime Minister Harold Wilson and President Giscard d'Estaing agreed to complete the 16 aircraft already in hand – but no more.[33] This controversial commitment was to survive many more reviews, by governments and by parliamentary committees, over the next ten years.

In an earlier review, in 1973, the Public Accounts Committee had highlighted the two key constraints under which officials tried to contain Concorde costs throughout the programme. The first was the decision by the two governments to launch an advanced technology project 'of an exceptionally speculative kind'. The second was the decision to proceed with the project to completion in a single stage, instead of having break points at which the option to withdraw could have been exercised.[34]

Development: problems and achievements of technology

> Passenger on Concorde inaugural airline service: 'But flying at Mach 2 feels no different from flying in an ordinary airliner'.
> Sir George Edwards: 'Yes – that was the difficult bit'.[35]

In 1962 it was by no means certain that a supersonic airliner could be built, let alone that it could be built jointly by British and French engineers working together. Quite apart from the political pressures and the economic and environmental problems, the technological challenge was immense. Though the economic and environmental problems remained unsolved, the Concorde somehow survived the political storms and is recognised as an outstanding achievement in technology.

The starting point was the STAC research in Britain, and parallel work in France, which pointed to the slender delta wing as the key to the design. The two countries had contrasting market objectives: the UK required a long-range, transatlantic aircraft while the French were aiming at a medium-range machine. In the initial compromise made to secure the 1962 Anglo-French Agreement, work began on two versions of a common prototype. By 1966, for reasons of both technology and marketing, it was decided to abandon the medium-range variant and to focus production design on the long-range machine. With hindsight, this change was inevitable, but it added years to the programme and a great deal to the cost.

The second key design point was the choice of Mach 2 as the cruising speed, in preference to a speed approaching Mach 3 as favoured in the United States. At the time, however, the 100-passen-

33 *Hansard*, House of Commons Debates, Written answer by the Prime Minister, Harold Wilson, 23 July 1974, col.429.

34 Committee of Public Accounts, Sixth and Seventh Reports, Session 1972/73, *Development and Production of the Concorde Aircraft*, (London: HMSO, July, 1973).

35 Sir George Edwards made this comment on the BOAC inaugural Concorde scheduled flight to Bahrain in January 1976, as reported in Kenneth Owen, *Concorde: New Shape in the Sky*, (London, Jane's, 1982).

ger, Mach 2 Concorde was generally regarded in the business as a first-generation SST which would inevitably be succeeded by a faster, larger machine later. But how many years later? The perceived 'race' between the Concorde and the planned American SST was a pacing factor which affected work on both sides of the Atlantic until the US project was abandoned in 1971.

Incidentally, there is no doubt that high-level American pressure to cancel the Concorde was exerted on British ministers – but the assumption that this was aimed at improving the prospects of the US SST is questionable. The aim may well have been to worsen those prospects and encourage cancellation.

In the development of the Concorde, the design was continuously evolving in the light of new information. At the start, a transatlantic-range Concorde was beyond the available technology, but the engineers believed that intensive research would provide the required answers. As the design was refined, the aircraft grew larger and heavier. Airline requirements also led to design changes. Trade-offs between conflicting requirements were continually required, and the customary (subsonic) development problems were compounded by the very small margins available on the supersonic design. The gross weight of the aircraft came out at 400,000lb, of which half represented fuel and only 25,000lb or six per cent was payload.

The division of work was outlined in an annex to the 1962 agreement. In targeting an overall 50/50 per cent split on the project as a whole, the French held the major share of airframe work while the British led on the powerplant. But all technical decisions were taken by joint Anglo-French committees. Production of aircraft parts was not duplicated, but parts were supplied to two production lines, one in each country, for final assembly.

To develop a brand-new engine for the Concorde would have been prohibitively expensive, and so the programme was launched on the back of the Olympus engine being developed for the TSR.2 strike aircraft. When the TSR.2 was cancelled in April 1965, the Concorde project then had to bear the whole cost of engine development. Progressive increases in the power of the Concorde's four Olympus 593 engines were needed to match the continuing weight growth of the airframe. Thus both airframe and powerplants were redesigned several times during the development of the Concorde.

Development of the powerplant was a complex task, involving not only the engine itself, providing the basic power, but also the equally critical air intake and exhaust nozzle. Intake, engine and nozzle all contribute to the thrust which propels the aircraft, but in startlingly different proportions as the flight progresses. At take-off, the engine itself provides just over 80 per cent of the thrust. In supersonic cruising flight, 92 per cent of the thrust is generated by the intake and exhaust systems. Hence the importance and difficulty of integrating and controlling these three elements of the powerplant so that the total combination is matched to the appropriate air speeds, temperatures and pressures throughout the flight. This was new technology, and both the intake control system and the exhaust nozzles were redesigned several times. Getting this right was probably the most difficult single aspect of Concorde development.

Another novel aspect of the design arises from the sharp changes of pressure that occur over the wing as the aircraft accelerates to supersonic speed. Careful shaping of the wing can help, but this needs to be augmented by a further method of balancing the aircraft in flight. Using special trim tanks in front of and behind the main tanks, fuel is transferred between tanks to adjust the centre of gravity as necessary.

Engine noise and the sonic boom were the two problems on which the Concorde was vulnerable to criticisms from the environmental lobby. The sonic boom was an insurmountable fact of nature, which in the end was overcome by not flying supersonically over land. Engine noise was intended to be no worse than that of contemporary subsonic aircraft – meaning at that time the Boeing 707 and the Douglas DC8. This target was met, but while the Concorde was being developed a new generation of quieter subsonic engines emerged and noise regulations became much more onerous.

The choice of aluminium alloy as the main material for the Concorde structure was linked to the chosen cruising speed of Mach 2. At that speed the heat generated by friction on the skin of the aircraft added to the many design problems, but was manageable. To withstand the higher temperatures associated with speeds approaching Mach 3 would have demanded airframes of stainless steel and titanium. (Such materials are in fact used in a few key areas on the Concorde to improve heat resistance and save weight).

The loads on any airliner during flight include stresses experienced as the cabin is pressurised to maintain a comfortable environment at high cruising altitudes. This regular imposition of stress by pressurisation – increasing, remaining at a maximum, and decreasing as the aircraft climbs, cruises and descends – is one cause of metal fatigue. Additionally, as mentioned, a supersonic airliner experiences thermal effects caused by the heating of the skin by skin friction. During climb the Concorde skin cools, during acceleration and supersonic cruise it heats up to about 100°C (extending the length of the aircraft by some eight inches), and during deceleration and descent it drops to about minus 20°C. On top of this, thermal stresses are experienced as the heating (and cooling) of the internal structure lags behind that of the outer skin.

These factors led to the construction of what was probably the most comprehensive ground test facility ever used in a civil aircraft development programme. This was the Concorde full-scale fatigue-testing complex at the Royal Aircraft Establishment, Farnborough. In this facility a complete airframe was subjected to accelerated simulations of Concorde flights, including both mechanical and thermal stresses. In parallel, a comparable facility in Toulouse verified the Concorde's static strength under a variety of conditions.

In flight testing, also, the Concorde programme was more comprehensive than anything that had gone before. Some 5,500 hours were flown on flight testing for development and certification and on 'endurance' flying over expected routes. Over 400 of those hours were needed to develop the sensitive control system for the engine air-intakes. For comparison, flight-testing of the Boeing 747 amounted to less than 1,500 hours. A research flight simulator at Toulouse was used to predict the flying qualities of the Concorde prototypes and demonstrate the effect of design changes, and a joint airworthiness programme with the Americans involved the use of an advanced simulator at NASA's Ames Research Center in California.

Though the end-product is a technological triumph, project management of the Concorde programme was less than effective, even by the standards of the time. In part this was caused by the problems inherent in a two-nation collaborative structure involving management by committee (both official and industrial), which certainly contributed to the delays. But some of those involved at the time have criticised also the absence of central strategic direction based on realistic estimates. Many of the early cost and weight estimates that were made were simplistic, they argue; the perceived need to stay ahead of the American SST led to hasty decisions; and the complexity of the aircraft was underestimated.

Certainly BAC put much effort into detailed quarterly cost reports, and a Performance Evaluation Review Technique (PERT) system was introduced with the aim of obtaining an overall picture and of controlling development progress. But not all participants reported punctually as the many changes were made, and so the PERT charts could not be updated in time to be effective. The reviews served to monitor, but not to control, the progress and costs of the programme.

The same could be said of the succession of scrutinies of the programme conducted by parliamentary committees, which had little apparent effect. (Originally it was expected that the firms would finance Concorde production, but in 1966 it was admitted that this would not happen). Compared with other European aerospace projects, however, the growth in costs and the extended timescales on the Concorde were by no means exceptional. (One participant has noted that the Concorde was the first airliner to fly at over 1,000 miles per hour (mph); the first to be the subject of 1,000 parliamentary questions; and the first to exceed its original estimate of cost to public funds by about 1,000 per cent – from £170 million in 1962 to over £1,700 million). The

programme cost the British taxpayer about £880 million, with much of the increase arising from design changes, devaluation and inflation.

Markets and finance

The total potential market for supersonic transport aircraft by 1975, the Cabinet was told in November 1962, would be more than 400, of which 'substantially less than 170' of the proposed Anglo-French SST might eventually be sold.[36] In the event, 16 production Concordes were built, of which 14 were in effect presented free, seven each, to British Airways and Air France.

The world's airlines were reluctant customers for supersonic transports. By 1967, however, competitive pressures had led 16 of them to take a total of 74 Concorde 'options'. These were not in fact options; they were reservations of delivery positions. Sir George Edwards called them 'phoney orders'. At that time, the same pressures had led many airlines to take options on the expected American SST also. The Concorde's market prospects always had been dubious, but, when the US project was cancelled in 1971, they became even more problematic. In January 1973 Pan American announced it would not be taking up its Concorde options. This decision led to the collapse of the world airline market for the Anglo-French SST, leaving only the French and British national airlines as the eventual customers.

The basic dilemma raised by BOAC's chairman in 1962 – the conflict between the airline's commercial interest and the government's promotion of the aircraft industry – was still an issue in 1974, when the Concorde figures published by Anthony Wedgwood Benn[37] reflected British Airways concern that to operate the aircraft could substantially worsen the airline's financial results. After the joint decision by British Prime Minister Harold Wilson and French President Giscard d'Estaing in 1974 to complete the programme, BA reaffirmed its commitment to the aircraft, and in 1979 the British government announced that the airline would be allowed to write-off the capital cost of its Concordes in return for 80 per cent of future Concorde surpluses (and the two governments allocated the remaining unsold Concordes to BA and Air France). No such surplus appeared, and in 1984 a deal was struck under which BA paid £16.5 million for the existing stock of spares, took over from the government the continuing in-service Concorde costs, and was released from the 80 per cent agreement. The in-service costs are substantial, and include the manufacturers' support costs.

Airline operations

In January 1976 the two airlines inaugurated the supersonic era of scheduled passenger services. British Airways flew from London to Bahrain, the first leg of a planned route to Australia. Air France flew from Paris to Rio de Janeiro via Dakar. Services to the United States began in May 1976, and operations on a number of other routes were inaugurated but fell by the wayside as the realities of economics and international politics became apparent. For a variety of reasons the hoped-for world route networks failed to materialise, leaving only the regular transatlantic services from London and Paris to New York.

Scheduled Concorde services to the United States began in May 1976. The record is impressive: nearly a quarter of a century of daily transatlantic flights at twice the speed of sound; more supersonic hours than all the world's air forces put together; over two million passengers carried. Seasonally, scheduled services are flown also from London to Barbados, Canada and the Middle East. As well as these scheduled flights, a wide variety of world-wide charter flights are flown, including round-the-world package tours, many short breaks to exotic places, and supersonic luncheon flights on Christmas Day.

As noted, each of the two airlines was allowed to write off the capital costs of its seven Con-

36 PRO CAB 129/111, C(62)174, memorandum by the First Secretary of State on The Supersonic Airliner, 1 Nov. 1962.

37 Minister of Technology July 1966 until June 1970.

cordes. On that basis, and at premium fares, the aircraft are now making an operational profit. Indeed, it is operating economics that is likely to determine how long they continue to fly, at least as far as British Airways is concerned.

In nearly a quarter of a century in service the Concorde's technical record has been good, though hydraulics systems have produced some headaches for the maintenance staff. Parts of the rudder skin on BA Concordes have peeled off three times, and part of the elevon skin once. A burst tyre on take-off by an Air France machine led to wing damage from the gear on landing back. But overall reliability has been excellent.

The Concorde could continue flying for many years yet: its annual utilisation is relatively low, and the heat generated by the friction of supersonic flight dries out moisture, and so minimises corrosion in the structure. British Airways reckons the airframe should be viable up to 2006 and potentially to 2012.

US approval

Against an informal background of unprecedented public opposition, the formal process of obtaining approval for Concorde services to the United States began with Environmental Impact Statements and hearings by the Federal Aviation Administration. But the key federal decision-maker was William Coleman, Secretary of Transportation, who after an exhaustive assessment including his own public hearing decided that services should be approved for a trial period of up to 16 months. Concorde services to the United States began on 24 May 1976 with flights by both airlines into the federally owned Dulles Airport, Washington. But the Port Authority of New York and New Jersey, operators of Kennedy Airport, promptly banned the aircraft from landing there.

This ban triggered the long and costly battle for the Concorde to gain access to New York. The airlines claimed that the Concorde could meet the Kennedy noise limit of 112 perceived noise decibels. The Port Authority knew this, but affirmed its concern about the low-frequency noise, the expected public reaction, and the need for further assessment. The airlines' response was to start to challenge the ban in the courts.

A lot of people were involved in the pro-Concorde campaign. For a start, the eight main interested parties – two governments, two aircraft firms, two engine firms, two airlines – together with their respective law firms, plus sundry consultants. For the UK Government, several parts of government were involved – the Foreign Office, the Department of Industry, HM Embassy in Washington and the British Consulate in New York.

The legal fight was a four-round affair. The two main cases were known colloquially as Concorde 1 and Concorde 2, and each was followed by an appeal. The main issue in the Concorde 1 case (in May 1977) was the question of 'pre-emption'. Did the federal Coleman decision pre-empt or overrule the local Port Authority's ban? Judge Milton Pollack ruled that it did. In the Concorde 1 appeal, Chief Judge Irving Kaufman overturned this ruling. The Coleman decision did *not* pre-empt the Port Authority's right to refuse landing rights on the basis of a reasonable, non-discriminatory noise regulation. But a new issue had been raised in an *amicus curiae* brief submitted for the US government at the request of the judge: whether or not the Port Authority's delay in reaching a final decision on the Concorde was reasonable.

In the Concorde 2 case, Judge Pollack ruled that the delay was not only unreasonable, it was discriminatory, unfair, and 'an impingement on commerce and on the national and international interests of the United States'. The appeal court agreed, and an appeal by the Port Authority to the US Supreme Court was denied. Concorde services to New York began on 22 November 1977. They continue, though the Washington services ceased in November 1994. Coleman's trial-period approval was confirmed by his successor, Brock Adams, in June 1978, in a decision that exempted the Concorde from the stringent subsonic noise rules. (Earlier, the first generation of subsonic jet airliners had benefited from similar special treatment).

In parallel with the struggle to obtain approval for Concorde flights to the United States, a sep-

arate process was needed to obtain a US airworthiness certificate for the Concorde. This was required before any American airline could operate the machine. The certificate was applied for in 1965 and eventually issued in January 1979, when Braniff inaugurated a subsonic extension service from Washington to Dallas/Fort Worth. This continued until 1 June 1980, when it was abandoned as uneconomic.[38]

38 A full account of the process of obtaining US approval for Concorde services appears in Kenneth Owen, *Concorde and the Americans* (Washington, DC, Smithsonian, 1997).

Chronology

1959	Mar.	STAC report recommends UK develop long-range supersonic transport
1962	Nov.	Anglo-French Agreement signed
1963	June	Pan American, BOAC and Air France sign Concorde 'options'
1964		Medium-range version dropped; long-range version enlarged
	Oct.	Labour government announces it will review programme
1965	Jan.	Government announces review complete, programme to continue despite financial and economic doubts
	May	Pre-production design announced
1967		Pre-production design revised
	May	Options reach total of 74 from 16 airlines
	Dec.	Prototype 001 rolled out at Toulouse
1968	Feb.	Government announces £125m production loan
	Sept.	Prototype 002 rolled out at Bristol; production design revised
1969	Mar.	First flight of 001
	April	First flight of 002
1970	Dec.	Design changes made
1972	April	Production of 16 aircraft confirmed
	July	BOAC orders 5 Concordes, Air France orders 4
	Dec.	Government increases production loan to £350m
1973		Design changes made
	Jan.	Pan American and TWA drop Concorde options
1974	July	Wilson and Giscard d'Estaing agree to complete only 16 Concordes
1975	Mar.	Draft US environmental impact statement published
	Nov.	Final US environmental impact statement published
1976	Jan.	Concorde airline services begin, to Bahrain and Rio de Janeiro
		Coleman hearing on Concorde US services
	Feb.	Coleman decision approves Washington and New York services
	Mar.	Port Authority of NY and NJ bans Concorde from Kennedy Airport
	May	Washington services begin

1977	May	New York litigation begins with Concorde 1 case
	Sept.	Concorde 2 case appeal confirms Port Authority ban unlawful
	Oct.	US Supreme Court denies Port Authority appeal
	Nov.	New York services begin
1978	June	Adams confirms Coleman approval, exempts Concorde from noise rules
1979	Feb.	BA to write off Concorde purchase cost
	Sept.	Unsold Concordes to go to Air France and British Airways
1981	April	Commons Industry and Trade Committee report says project 'had acquired a life of its own and was out of control'.
	Oct.	Future of Concorde discussed by UK and French ministers
1982	Feb.	Industry and Trade Committee report reaffirms criticism
	Oct.	AF drops Washington service
1984	Mar.	BA takes over support costs from UK Government
1987		AF takes over support costs from French Government
1994	Nov.	BA drops Washington service
2000	Aug.	BA and AF discontinued services, after suspension of Certificates of Airworthiness, pending their renewal[39]

39 See *After Gonesse*, p.83 below.

Bibliography

In this paper I have drawn on information in a compilation of Concorde documents from the Public Record Office, Kew, which I am preparing for possible publication; and on information from four of my earlier publications: *Concorde: New Shape in the Sky* (London: Jane's, 1982), *Concorde and the Americans* (Washington DC: Smithsonian, and Shrewsbury: Airlife, 1997), *Concorde and the Americans* (Royal Aeronautical Society Historical Group lecture, London, April 1997), and *Civil Supersonics: the Concorde Saga* (National Aerospace Conference, Dayton, Ohio, October 1998).

Other useful sources include *Concorde: the Inside Story* by Geoffrey Knight (London: Weidenfeld & Nicolson, 1976); *The Power Game* by Jock Bruce-Gardyne and Nigel Lawson (London: Macmillan, 1976); *Flying Concorde* by Brian Calvert (London: Fontana, 1981); *Brian Trubshaw,Test Pilot* by Brian Trubshaw with Sally Edmonson (Stroud: Sutton Publishing, 1998); and *The Technical Development of Modern Aviation* by Ronald Miller and David Sawers (London: Routledge & Keegan Paul, 1968).

Concorde
Session I: Policy

This witness seminar, organised by the Institute of Contemporary British History, was held at the Science Museum, London on 19 November 1998. This session was concerned broadly with policy relating to the development of Concorde. Peter Jay chaired this session of the witness seminar and the participants were as follows:

Sir Peter Baldwin	Cabinet Secretariat, 1962-64.
Christopher Benjamin	Ministry of Aviation (MOA, incl. Private Secretary to Ministers Julian Amery and Roy Jenkins) and Concorde project team, Department of Trade and Industry (DTI).
Ken Binning	DTI Director-General, Concorde 1973-76.
Peter Champion	BAC.
Handel Davie	Royal Aircraft Establishment (RAE), MOA and Ministry of Technology (MinTech); technical director, British Aircraft Corporation (BAC).
Mrs Eileen Denza	Legal counsellor, Foreign and Commonwealth Office.
Etienne Fage	French Air Ministry.
Nick Gardner	Concorde project team, MOA.
Captain John Hutchinson	Concorde captain, British Airways
Lord Jenkins of Hillhead	Minister of Aviation, 1964-65.
Sir Philip Jones	DTI Director General, Concorde 1971-73.
Eric Lewis	National Gas Turbine Establishment (NGTE) and MOA.
Captain W. D. Lowe	Chairman; Concorde captain and manager, British Airways.
John McEnery	Department of Industry (DOI) Under Secretary, Concorde 1977-81.
M. C. Neale	NGTE and Ministry of Defence (MOD).
Henri Perrier	Aérospatiale.
Brian Trubshaw	Director of flight test, BAC/British Aerospace; UK director, Concorde flight-test programme.

PETER JAY The essential purpose of this session is policy and finance, in other words, the basic questions of why did it get built, what went wrong, whose fault was it, and those sorts of questions that journalists like to ask about big projects of this kind. Originally I had planned to divide the session chronologically, first the period before 1964, then the period when Labour came into office and considered can-

cellation, and then on to subsequent phases. I am going to violate the chronology because of Lord Jenkins's timetable and come almost immediately to the 1964-65 period, when Labour contemplated cancellation of the programme and then decided not to cancel it. But before doing that I would like the members of the panel at the table to introduce themselves. I am Peter Jay and at one time between 1961 and 1967 I was in the Treasury, but I had almost nothing to do with the Concorde.

NICK GARDNER I was a member of the Concorde Project Office in the Ministry from 1964 to 1974, and I was responsible for the series of development cost estimates for Concorde and for some of the techniques used for managing the whole project.

HANDEL DAVIES I had the privilege of being involved (in various jobs) in the work which led to the Concorde from the beginning, when it was no more than a glimmer of light at the end of a long tunnel, to its final entry into service. The involvement began when I became responsible for transonic research in flight at the Royal Aircraft Establishment (RAE) in 1946. Eventually I became deputy director of the RAE at the time when all the research was going on for it, and later I was Deputy Controller for Aircraft Research and Development at the Ministry of Aviation under Sir Morien Morgan at the time when the agreement with the French was signed. I saw the project through from the government point of view up to its first flight, after which I went to the British Aircraft Corporation (BAC) as technical director and so saw the aircraft through the development phase with British Airways.

SIR PETER BALDWIN I was in the Cabinet Secretariat from 1962 to 1964, in the Cabinet Committee and the Cabinet itself when the decisions on this were taken.

ETIENNE FAGE In 1958 I was working on behalf of the French Air Ministry and one of the main tasks assigned to me was to establish the feasibility or otherwise of the supersonic Concorde aircraft. I remember in 1958 and 1959 we had several meetings here in England, especially with the RAE, under the direction of Handel Davies at the time. The state of the art at this time, at least on the French side, was materialised by a military aircraft, a medium-range bomber. The range for a Mach 2 bomber was probably a thousand miles, and considering a supersonic transport we were looking for more like 3,000 miles, so it was a huge step, which we thought would be very difficult to make. But after some time both the British and the French sides came progressively to a very similar technical approach and, as you know, in 1962 we reached a formal agreement between the two countries.

SIR PHILIP JONES I was in the Ministry of Aviation, engaged on the Concorde project between 1967 and 1973, for the first four years working to Jim Hamilton and in the last two I succeeded Jim as Director-General for Concorde.

M. C. NEALE I joined the National Gas Turbine Establishment (NGTE) in 1958 and immediately began work on what ultimately became the Concorde powerplant. I retired from the Ministry of Defence as Director-General, Engines in 1987.

ERIC LEWIS My history is virtually a repeat of Mike Neale's. I worked on the Concorde powerplant at the NGTE throughout its early years, and was involved in all the discussions with my counterparts in France. In the later stages of Concorde I was involved on the management side in Ministry of Aviation headquarters in London.
If I may add a technology point in a policy session, I would simply emphasise the important role played by the British and French government establishments in solving the crucial technical problems on Concorde, including in particular work by ONERA in France on the powerplant intake configuration; and by NGTE in Britain on the powerplant exhaust nozzle.

JAY We are very privileged to have Lord Jenkins here. He was Minister of Aviation in Harold Wilson's government formed in 1964 and was deeply involved in that part of the story. Will you tell us what you can?

LORD JENKINS OF HILLHEAD I thought I would endeavour to give you an account, as seen from the political angle, of the Concorde, and particularly its attempted cancellation in 1964-65. I am not sure how much impact I made on the tangled story of Concorde, but what I am absolutely sure of is that, partly for accidental reasons, Concorde made a tremendous impact on me at that stage, several aspects of which remain strongly in my mind.
It was the first government appointment which I had ever held: I became Minister of Aviation. It was a ministry which kept on changing its name, but at that stage it was the Ministry of Aviation, responsible not only for civil aviation but also for military aircraft procurement. The Ministry of Aviation was, to be honest, a rather better job than I had expected to get in that government: I was not close to the Prime Minister at that time, I had been much closer to his predecessor.* So although it was a sort of curiously hybrid job, it was a minister in charge of a department, but not in the Cabinet. A non-Cabinet minister, which becomes quite important as I describe the next step to you.
Concorde impacted upon me, or if you like blew up in my face, on literally my third day as a minister, when in the hall of Brooks's Club the late Sir Richard Way, then my Permanent Secretary, came up to me and whispered that he had just heard that the govern-

Hugh Gaitskell (1906-63), Labour politician. Leader of the Labour Party, 1955-63.

ment's emergency White Paper, which was to be taken in Cabinet the next morning and published on the following Monday (this was a Wednesday), was in effect to announce a unilateral British decision to cancel the Concorde project. There was in my a priori view a good deal to be said against Concorde. It involved the committal of a significant proportion of scarce research and development resources to the hazardous creation of a project which was certainly going to be very expensive. Ten million pounds, which was the current estimate of the cost of a single aircraft, was then regarded as almost ludicrously expensive, and it showed little prospect of gaining a market sufficient to begin to produce a return on capital. The Anglo-French arrangements had been made in 1962 by my predecessor Julian Amery, with a good deal of, I thought, anti-American rodomontade, and the very tight treaty which had been signed with the French was more suited, again in my view, to a matter concerning a nation's honour than its commercial investment decisions. Furthermore, taken in conjunction with the military aircraft developments, which we also inherited from the previous government, it amounted to a heavy overloading of an aircraft industry in which at least one of the two remaining big firms had been encouraged to pay too much attention to developing, as opposed to making and selling, aircraft.

On the other hand, while it was probably the case that no proper cost/benefit study had been done by Amery's Ministry of Aviation in 1962, it was certainly the case that no rational reappraisal in the circumstances of 1964 had been carried out since the previous Friday by the triumvirate of ministers who in effect made this decision. These were George Brown,* James Callaghan* and Douglas Jay,* President of the Board of Trade (who dissented from the view of the other two, which was entirely in favour of cancellation). Also, the treaty, while it might have been unwisely drawn, was indisputably a binding treaty. It therefore seemed to me crassly foolish, from the point of view of either good general relations or of getting the French to agree that the project had lost its attraction, to present them without consultation with a unilateral decision of intention to cancel. And in any event, the issue was plumb within the responsibility of the Minister of Aviation and I had not been consulted.

George Brown (Lord George-Brown, 1914-85), Labour politician. First Secretary of State, 1964-8, and Secretary of State for Economic Affairs, 1964-6.

James Callaghan (Lord Callaghan of Cardiff), Labour politician. Chancellor of the Exchequer, 1964-7.

Douglas Jay (Lord Jay, 1907-97). President of the Board of Trade, 1964-7.

I therefore decided that, independently of merits, it was a typical example of government by rushes of blood to the head, and that I must do the best I could in the Cabinet next morning to get the decision reversed. It was an absolutely hopeless attempt. The disadvantages suffered by a non-Cabinet minister in such circumstances are considerable. He is just brought in for the single item and has to start talking, presenting his case, from the moment he sits down in that august Cabinet room. Anyway, the task proved hopeless, so there was nothing to do apart from accept defeat. Obviously everybody was resolved on this being the right way to approach the matter, teeth were bared, swords were girded, resolution not rationality was the order of the day. So, as I say, there was nothing to do

except accept defeat. I could hardly resign from a government of which I had only been a member for four days, and in fact neither the thought nor the desire ever surfaced across my mind. I had been a backbench MP for 16 years and it seemed to me to be rather perverse to resign on one's fourth day in office. I could not, however, just put my head down, for while decisions can be and were taken over the heads of non-Cabinet ministers, such inferior creatures had to be used for carrying them out. I was deputed to tell the Concorde airframe and aero-engine firms early on Monday, before the White Paper was published, and to confront the French later in the week.

Sir George Edwards, aviator and industrialist. Chairman, British Aircraft Corporation (BAC).

Sir Reginald Verdon Smith (1912-92), aviator and industrialist. Chairman, Bristol Aeroplane Company, 1955-9 and then subsequently Chairman, Bristol Siddeley and BAC.

The meetings with the British Aircraft Corporation, Sir George Edwards,* and with Bristol Siddeley, Sir Reginald Verdon Smith,* were not exactly joyous occasions but, dealing with a new minister who was their paymaster for most of their other projects, they had little alternative but to accept the news with dismayed resignation. The dismay was certainly genuine, but the resignation was faked, for they had every intention, which was quite reasonable from their point of view, of organising as much opposition as they could muster. They shrewdly saw that given the style and nature of the Wilson government the unions, with whom they normally disputed, and the press offered the best foci for that. Furthermore, the fact that I had insisted on putting the government position in semi-tentative tones, a disposition to cancel, no more (for otherwise our position with the French would have been indefensible) meant that they had an unbolted door at which to push.

Charles de Gaulle (1890-1970), French general and statesman. President, 1958-69.

The French seemed likely to be a more intimidating proposition. The government of General de Gaulle* did not have a reputation for forgiving tolerance when British clumsiness exposed a flank. Also, I obviously had to see them on their own ground. We could not just issue a unilateral declaration and summon them to London to hear the explanation. Accordingly, with a large party of officials, Richard Way, Morien Morgan, Handel Davies and Chris Benjamin were certainly in that party, I set off for Paris on the morning of Tuesday 29 October. Sitting in the plane on the tarmac at London airport – this is one of the things which remains engraved on my mind – I was handed a Foreign Office telegram which contained the encouraging phrase 'The Minister of Aviation should be prepared for the atmosphere of cold enmity with which he will be met in Paris'. This inspired me to spend the short journey working so hard at my opening statement for the afternoon that I did not notice when the plane landed. I looked out only as we taxied to a halt. I then saw a great crowd of people, mostly photographers and journalists, assembled on the tarmac. At that moment I came for the first time to realise more vividly than on any other occasion what was involved in being a minister. I had with me not only my Permanent Secretary and one or two experienced general administrators, but also aviation technicians of high quality. They all knew far more about Concorde than I did and were also more experienced in dealing with the French about it, but not one of them was

going to get out of that plane before I did. Ministerial privilege and ministerial responsibility united to ensure that I had to walk down the steps alone and deal with the waiting crowd. After a few on-the-hoof television and press conferences we drove to the British Embassy, where we had an hour's apprehensive respite over lunch. Thereafter things began to pick up a bit. The French weren't particularly friendly, but their enmity was not too cold.

The next stage in the Concorde battle was a House of Commons debate, arranged at very short notice on the following Thursday. There was no vote at the end of it, but in those days people attended debates much more than they do now. It was a new government, it was an issue which had a good deal of excitement about it, and the House was absolutely packed when I wound up at 9.30 at night. In the previous 16 years in the House of Commons I had never had a really full House, 200 or 250 perhaps on occasion, but a packed House was something I had never experienced. Then I began to realise that winding up a debate in a packed House is, I imagine, something like bullfighting, because if you slip you never get up again. If you once lose command of a packed, tense House in that final half-hour, the whole thing's finished. By the grace of God, and I cannot exactly understand how, my speech was thought to be a success and indeed led in the papers the next morning, although it did not finish until 10 o'clock. (All London newspapers were then perfectly capable of reporting what happened in the House of Commons at 10 or a little later at night in their editions the following morning. The advance of technology now means that that is completely impossible to achieve, and that would never occur).

That somewhat improved my morale. It didn't say anything at all, having won a debate, about my judgement or administrative ability as a minister, but according to the victor ludorum rules which applied to British parliamentary government in those days – perhaps to some extent still do, although diminished by poor attendance in the chamber – it greatly increased my elbow room for trying to exercise these qualities. After that debate I would not for a time have been treated in the Cabinet quite as I was before. My authority in the department also increased perceptibly and it had an impact on my general position. For a time, until I left to become President of the European Commission, from then until 1976, I became a sort of high-stake parliamentary player. The fact that I was alleged to have a command over the House of Commons was probably a major factor in my becoming, first, Home Secretary and, even more, Chancellor three years after the 1964 debate.

Meanwhile the Concorde affair rumbled on for several months. The French, if they genuinely wished the project to continue, played their hand brilliantly. They did not get over-excited, they reacted more in sorrow than in anger. They implied that it was inconceivable that we would actually cancel the contracts, except in agreement with them, and always kept in hand, neither brandished nor discarded, the threat of suing us for damages in The Hague

Court of International Justice. It was their trump card, particularly as the firm advice of our law officers was that if they did we would lose and might well have damages of the order of £200 million (probably the equivalent of nearer £3 billion than £2 billion today) awarded against us. I have often wondered whether the French, who are after all very good at intelligence, knew that this was the firm advice of our law officers. It did have a powerful influence on my mind, and I think it did on the Prime Minister's mind, too. It was not only the size of the sum which influenced me, but also the indignity of losing an action for breach of a treaty, the bad effect on our relations with Europe, and my conviction that the £200 million would become a major political factor, with at least as many lives as a cat. Whenever an awkward public expenditure issue subsequently arose, we would always be taunted that if we had not thrown away £200 million on illegality, we could have easily afforded X or Y. The damages would assume much more reality than the money we were saving by not building the plane. Nevertheless, I remember that when I went to Bristol on 11 December to look at what was happening on the ground, I still thought the plane was probably on its deathbed.

By mid-January, however, a reprieve, or at least a temporary stay of execution, had become available. When the Cabinet Committee met to consider the recently received third formal French note on the issue, which sounded as firm as could be, taken in conjunction with the law officers' persistent croak of doom (and also the fact that we were on the point of cancelling two embryonic military aircraft projects, the P1154* and the HS681,* and had a much bigger and much more advanced cancellation project, the TSR2,* lurking in the background), all this was sufficient to tip the balance and secure a reversal of the rushed and ill-judged October pronouncement. I think Concorde was also lucky in the later disputes, in the late 1960s and 1970s, to be manufactured mainly in Bristol. It had got an incomparable ally for a luxury transatlantic aircraft for a limited number of people, a Mr Tony Benn,* most firmly on its side on constituency grounds. As unexpected allies and unexpected auxiliaries are always powerful, and as of course he was Minister of Technology for part of the time, he did a lot to keep it going.

All this was ironical and it was ironical too that we had decided rather reluctantly on the reprieve (and I thought it was right to have the reprieve then, despite my general doubts about some aspects of the project) at that particular moment. For I subsequently received strong and very high-level, but not absolutely verifiable, hints that this third note was the last French throw, and that had we then persisted the French would have accepted that the project was dead – with a bad grace, but without going to The Hague Court. What is certain is that, when we made our brusque White Paper announcement, there were already deep French worries about Concorde which our unilateralism temporarily suppressed. Hamfistedness, therefore, had the paradoxical effect of saving the project. For had we approached the French confidentially, a quiet funeral could

A proposed vertical takeoff and landing fighter plane (Hawker Siddeley, main contractor). The project was cancelled in 1965.

A proposed vertical takeoff and landing aircraft (Hawker Siddeley, main contractor). In Feb. 1965 the incoming Labour Government cancelled the HS681 project on grounds of cost.

A proposed advance low-level bomber (British Aircraft Corporation, main contractor). Production cancelled in April 1965 on account of costs.

Tony Benn (Anthony Wedgewood Benn), Labour politician. Postmaster-General, 1964-6; Minister of Technology, 1966-70.

almost certainly have been arranged.
Whether this would have been desirable is open to argument. Concorde has been a technical success and it has brought some, but not vast, prestige to the British and French aircraft industries, as well as considerable convenience to a limited number of passengers. But it has cost a disproportionate amount of money, produced no return on capital and been in the circumstances remarkably unsaleable. It is also noticeable that the French in recent years have been less keen than have the British to keep Concorde services going. As in general the French disposition both towards continuity of policy and to state subsidies is greater than ours, this can be taken as some further confirmation of the view that their 1964 attachment to Concorde was only skin-deep.

JAY Would anyone like to take up any points with Lord Jenkins?

JOHN HUTCHINSON I am John Hutchinson, a retired British Airways Concorde captain, and I found Lord Jenkins's dissertation fascinating. However, he didn't mention the United States. Were they applying pressures of any sort on the British government during those years?

JENKINS They did not in my view apply any pressure which was remotely decisive. They never applied any particular direct pressure on me. One had the general impression that they thought of Concorde as a bit of nonsense on our part and we would be wiser not to go on with it, but that is different from direct pressure. The Federal Aviation Administrator was then Najeeb Halaby,* now the father-in-law of the King of Jordan. He was also subsequently head of Pan American Airways during its declining years for a time, and I got to know him quite well during that period. As I say, I think I have summarised his attitude fairly accurately: scepticism, slightly preferring we did not go ahead with it because it might be embarrassing for them, but no, nothing approaching direct, arm-twisting pressure.

Najeeb Halaby, American pilot. Administrator, Federal Aviation Agency, 1961-5; Pan American World Airways,, Director 1966-72; President, 1968-71; Chief Executive, 1969-72; Chairman, 1970-2.

BALDWIN Lord Jenkins, your insight into what was going on before you arrived in ministerial office is quite uncanny. When you referred to national honour, that is exactly how the decision was taken in the Cabinet. Rab Butler's* report from his committee* was a report without conclusion, as Kenneth Owen's paper rightly points out. There is a lot on one side and a lot on the other, and Rab Butler summed up by saying 'I think you will do it' – I don't know quite who he was addressing – 'and I think you will rue it'. And that was all he contributed. There was then a desultory discussion in which Julian Amery,* of course, pressed his case, but then he was the son-in-law of the Prime Minister and as Owen says he had done his best behind the scenes to get a tide running. The tide did not run, but what actually happened was that Macmillan came into the discussion with 'I am not going to allow De Gaulle to do it alone'. That was the conclusion.

R. A. B. Butler (Lord Butler of Saffron Walden, 1902-82), Conservative politician. First Secretary of State, Deputy Prime Minister, 1962-4: Foreign Secretary, 1963-4.

Cabinet Committee on Civil Scientific Research and Development, chaired by Lord Mills, Minister without Portfolio, until Prime Minister Harold Macmillan's so-called 'Night of the Long Knives' Cabinet reshuffle of 13 July 1962.

Julian Amery (Lord Amery of Lustleigh, 1919-97), Conservative politician. Air Minister 1960-2, Aviation Minister 1962-4. Succeeded Peter Thorneycroft as latter after Macmillan's Cabinet reshuffle of 13 July 1962

There is exactly what you say: this was done on national honour, and so were a lot of other things which were subsequently decided.

DAVIES

Marc Jacquet, French politician. Minister of Transport at the 29 Oct. 1964 meeting with Jenkins in Paris.

I was at the meeting in Paris with M Jacquet.* There is no doubt that Lord Jenkins recorded exactly what happened. But there is one comment I would like to make. I was very close at that time to the French officials, and there was no doubt about their attitude. After the meeting, at Lord Jenkins's request, I went to see my opposite number, General Gerardin. I would not have said that there was any doubt then in the official mind that they would have taken us to the court at The Hague. But that was just the official side, not including of course French government members.

JENKINS

Not including the Minister of Finance, in particular.

JOHN McENERY

I wonder if Mr Macmillan and other ministers realised at the time that the French had no engine which would power a supersonic Concorde.

JAY

Thank you for that important point.

W. D. LOWE

I have two points, which have been talked about a number of times and it would be nice if they could be cleared up one way or another, conspiracy theory rarely being the one that applies.
First, how much was backing for involvement with Concorde to do with our entry into the Common Market?
Secondly, at a slightly lower level, the major aerospace industry in Europe at the time was undoubtedly in the UK. By the end of the Concorde project that, it could be argued, had been transferred to Toulouse. Do you think that one element of the French objective was to reduce the impact of the British aviation industry and at least balance it or transfer some of it to Toulouse?

JENKINS

Two points on that. First, the Wilson government in its early days was not all pro-Europe. Part of the irony of my having to deal with Concorde and to tell the French we were disposed to cancel it was that I was the most pro-European member in that government. Of course they came round to it, and applied to join in 1967, but it took quite some time for that position to develop. So I don't think in the Cabinet decision there was any significant influence of the European dimension. In relation to aircraft industries I think yes, but not in the European direction, in the sense of membership of the Common Market.
Transferring the industry, or part of the industry, or the balance of the airframe industry, to Toulouse? I don't think the French could exactly have been plotting that by what happened in 1964, because after all they did not take the initiative. It was we who took the slightly hamfisted initiative, and I think it might be argued that our

slightly hot-and-cold, reluctant attitude to Concorde gave us, as such attitudes quite often do, the worst of both worlds. In other words, we didn't cancel Concorde, but we saw a lot of the work going to a more enthusiastic partner.

EILEEN DENZA I was the fledgling Foreign Office lawyer who did the research on what the figure would be on the assumption that we lost at The Hague, and the precedents all showed that the measure of damages was *restitutio in integrum* – that the French would have to be made good for the losses from our unlawful withdrawal. So the fact would have been that the French would have had all the credit and the British would have paid half the bill, and I understand that did not seem very attractive when it was considered by the law officers.

JENKINS Was the £200 million figure accurate in your recollection?

DENZA That figure floated as the plane cost went up, so it could not be firm.

GARDNER Did the possibility of offering the French some fraction of this in order to desist ever come forward?

JENKINS No, that was never seriously proposed, nor do I think the French would have been attracted by it. I think the French blew very cold – well, they were not all that enthusiastic at other levels, and they certainly were cold. It is very noticeable how much less they keep Concorde in service than we do; that I think is a factor.

JAY May I ask you, is it a fair paraphrase of your view that it might well have been wise to have got out of it in 1964-65 if one of two things had been true: either that Julian Amery had not tied up the legal position so irrevocably and so tightly as to leave no attractive way out; or if we had succeeded in negotiating some kind of a divorce with aplomb, rather than with the hamfisted, unilateral conduct which mucked things up in terms of the relationship and appearances, while having no bearing on the fundamental economics of the project?

JENKINS I think from an economic point of view it would have been wise to have got out of it, tactfully and gently, if we could have, which in my estimation we probably could have if we had played it differently with the French. But just as I don't think one should make economic decisions solely on the basis of honour, so I do not think that the economics are the end of the thing about any project. There are other considerations, there were technical considerations and considerations beyond that. I also think that it would have been a pity. The aircraft industry I came to be the responsible minister for was overcharged at that time, with all those projects going

on, but to have cancelled Concorde, the TSR2, HS681 and the P1154 all within the same six months would have been going much too far in the other direction. So a balance had to be struck, and once we got in this mess with the French the best balance that could be struck involved Concorde going on.

JAY On behalf of this seminar may I thank you very much indeed for finding time in your very busy schedule to come and discuss this fascinating but not entirely contemporary question. You are involved in so many more pressing and more current matters – we are very grateful to you for being with us.
What I would now like to do is to move on to discuss the period from the beginning up until 1964. In order to launch us onto this leg of our discussion, I would like to ask Etienne Fage to pick up the story about the early stages of the project as he saw it, from the point of view of someone in the Air Ministry in Paris. How did the story start?

FAGE I think it started very simply by considering that here we had an aircraft already developed, which represented the state of the art in those days, able to fly at Mach 2 with a significant range, but far short of what would be necessary for a supersonic transport aircraft. I was asked to see whether using the technology, the state of the art in those days, and scaling-up this military design, there was any way we could make a reasonable civil aircraft. So I was given the basic assumption concerning the main characteristic of any aircraft, which is lift-over-drag ratio, and the engine characteristics and the intake and other characteristics, so that we could work up some paper aircraft. The conclusion was of course very easy to reach: using these basic assumptions there was no way we could ever have a reasonable transport aircraft. Military specifications are one thing and civil aircraft are a completely different ball-game.
Having reached this conclusion, this was I believe more-or-less what would have been the conclusion of the British team, and the British who were playing with this in those days were thinking of the very long-range aircraft, an aircraft able to fly easily between London and New York, with some significant margin. So after a couple of years of mutual discussion we came to the same conclusion: with today's technology it is not possible but, with a lot of work, assuming we are given the time and the money, why not? Everything is possible, given the resources. So eventually we managed to have a very successful aircraft, technically at least, which is currently flying to the satisfaction of both British Airways and Air France, I believe.
That is how it all started. Of course you could say it has taken us more time and more money than was originally assumed, but the same can be said for most advanced technology programmes. These risks are inherent in these programmes and it is very difficult to accurately assess what the result will eventually be.

JAY

Aubrey Jones, Conservative politician. Minister of Supply, 1957-9.

Thank you very much indeed. I see sitting in the front row the Rt Hon Aubrey Jones,* who as Minister of Supply in the Macmillan government played an important part in the early part of this story. We are very pleased to have you here, and we look forward to hearing your contribution this afternoon. Who on the panel would now like to pick up the story from where Etienne Fage took it to, perhaps about the British end of those very early days?

DAVIES

Can I first pay tribute to Aubrey Jones, because there is one crucial thing he did during the time the Concorde was under discussion by the Supersonic Transport Aircraft Committee, and that was to knock the aircraft industry into better shape. It was he who ordered us to run a meeting with the industry and tell them that unless they got their act together there would be no further orders from Her Majesty's Government. That is what led to the formation of the British Aircraft Corporation and Hawker Siddeley in a properly co-ordinated way – the biggest move forward made in the industry in the post-war years. The Concorde was then of course taken over by the British Aircraft Corporation as an amalgamated group.

Coming back to what Mr Fage said, we must not underestimate the importance of the very great aerodynamic breakthrough which was made by both the French and the British simultaneously, and that is the use of a slender, delta-shaped wing with 'sharp' leading edges. That was an absolutely crucial thing, without which the Concorde would not have been possible, and which by an extraordinary coincidence was simultaneously developed by the French and ourselves, as far as I can see. I led the first party from the RAE to go to France in 1961 and we found to our astonishment that they had made exactly the same breakthrough that we had made – slender delta, sharp leading edges, and airflow separation from the leading edge. These features make for a fundamentally different aerodynamic regime compared with conventional subsonic aircraft.

JONES

What I don't think anybody has yet explained is why we went for supersonic transport at that particular juncture. The rest of the world started to go for jumbo jets and airbuses. This particular period was before I was engaged on the Concorde but I have seen the papers, and it did seem that technicians on both sides of the continent were saying, 'America dominates the civil aircraft market, we in Britain want to be in it, we the French want to have a stronger stake in it, let's take the next leap ahead. Let's go to the supersonic transport, we can do it because of the delta wing, we can do it actually just by going on existing technology. We take this great leap ahead, we will be in the vanguard again and everybody (and this again was a big assumption) will always pay for speed.' I think that in that statement a whole lot of doubtful assumptions were made, but I think it was critical to the launch of the SST in both countries.

JAY

I think that is extremely important. Does anyone want to agree or disagree with Philip?

McENERY

With respect, I would disagree with this. I looked after aircraft projects in the British Embassy in Bonn from 1966 to 1970. This was an extraordinarily active time in exploring the possibilities of a large subsonic European Airbus. The French, the Germans and ourselves were all extremely active in this. As it happens we dragged our feet, our money was split between engines and aircraft, so the French went ahead in 1968 with the Germans and that was when the foundation of the success of the Airbus was laid, only six years after the start of Concorde. It so happened that the Embassy in Bonn succeeded in getting Hawker Siddeley into the Airbus project, without any British money being spent, and that is why we are in the Airbus today.

JONES

One can dispute the arguments, but I would rest on what I have said. What is quite interesting during the Concorde saga, when ministers looked at this and from time to time said 'Should we cancel it or not?', one of the options they did look at was, 'Should we cancel Concorde and go into the Airbus?', because they saw that as the increasing market. I am quite clear in my own mind that it was the decision to go supersonic, and that meant for a whole number of economic reasons, resource reasons, our involvement in Airbus in particular and in the development of other jets had to go way behind. And you can argue that was one of the significant, perhaps fateful, mistakes.

CHRISTOPHER BENJAMIN

Peter Thorneycroft (Lord Thorneycroft of Dunston, 1909-94), Conservative politician. Minister of Aviation, 1960-2.

I was in Peter Thorneycroft's* office, I was Julian Amery's Private Secretary and I was also Roy Jenkins's first Private Secretary. I also subsequently turned up on the Concorde project team. The only correction I would make to Roy Jenkins's account is that when we got to Paris on that fateful day, normally the Private Secretary is at the back carrying the bags, but on this occasion everyone said, 'After you, Chris', and I was pushed out to the front, so *I* was actually the first down the steps. But I do think that the account we have had so far does miss the very high political drive for this particular project. In the Thorneycroft era, and he was very much a motivator for this, the Conservative government was extremely pro-Europe. We were looking at a number of joint programmes as part of this drive for Europe.

The second point is that there was a sort of industrial machoism about the aerospace industry. We launched all these projects which Roy just described, many of which were subsequently cancelled, but we saw ourselves, as a residual effect of the war, having a strong aircraft industry. It was one of the areas where we could be competitive versus America and therefore we needed to expand into Europe. And I think Philip is absolutely right. I was present at those meetings where George Edwards and others made presenta-

tions to ministers, and the logic was: this is a natural evolution of the technologies that have gone before. We are using aluminium as distinct from steel and titanium, and we actually have an engine. It was presented as being a fairly orthodox transition from existing technology, particularly now that we had got the new configuration, and as the logical succession.
But I would go back and say one should not forget the very strong political pressure. I can recall challenging Peter Thorneycroft on one occasion about the missing break clause, and he said quite simply, 'If you are going to do something as major as this with the French, you cannot start out on the assumption that you are going to stop'. It was as simple as that. Now you find no record in any Cabinet minutes about the mysterious 'no break clause', but that is the nearest I came to getting at the reason why.

JAY

Can I ask you an immediate supplementary? I remember, though this is only hearsay, somebody who was present told me that Julian Amery went around after 1965 saying, in private, that of course he had deliberately in conjunction with his French opposite number set out to write an agreement that no future government could ever conceivably get out of, except at a price that no future government would ever be willing to pay. That he had quite deliberately – because he believed in the project, for the political prestige and industry macho reasons that you have described (there is no suggestion of insincerity) – set out to make it impossible for any future government, Labour or Conservative, to get out of this agreement. And that was what created the conditions which persuaded Roy Jenkins, in the circumstances which he described, that it would be better to go on with this project, whatever its commercial and technical merits.

BENJAMIN

A quality of all politicians to some degree is vanity, and I think Julian [Amery] had it perhaps in a larger dose than most. Actually, all the legwork on the treaty was done by Peter Thorneycroft. The Jacquet treaty was signed not long after Julian took office, and basically all the legwork had been done. He revelled in the glory of it, and so far as he was concerned this was his one great moment of history, but I think his memory was a little bit distorted by then.

JAY

But do you think Peter Thorneycroft then had this motive that my legend attributed to Julian Amery?

BENJAMIN

Thorneycroft was a genuine European, in many ways a more genuine European than most other ministers at the time. He was one of the ambassadors whom the government sent out to old Commonwealth countries to sell them on the idea of Britain joining the European Community, and he was very much an out-and-out European. As he saw it, this was but part of the general capability of Europe. ELDO,* for example, was another project which was

The European Launcher Development Organisation.

happening about this time, and one of a whole range of activities where we were deliberately moving into fairly high technology with Europe.

JAY But on the question of why write an agreement which is quite deliberately intended, over and above just omitting a break clause, to be impossible to get out of contrary to normal practice, who did that and what was the motive for it?

BENJAMIN It is the 'lock yourself into a project which will be a symbol of Britain in Europe'. I think that is the rational way of putting it. I don't think there is anything malicious in it. When I was on Concorde we looked over the records and it is very hard to find the origin of this no-break clause, it is not reported anywhere. As I say, the only record I had was that remark by Peter Thorneycroft.

JONES It is part of the mood of the time, as well, because the ELDO project again did not have a break clause, and that was to make sure our partners could not leave it. I think it was that atmosphere which went across also to Concorde at the same time, but the important difference with Concorde of course was that it was a treaty, which made it much more difficult.

BENJAMIN I would like to make one point to back up a question which was placed earlier. There was as I say this industrial macho around. I happened to go to Toulouse, long before this project started, and Toulouse at that time looked like an American Air Force base in Norfolk. It was a set of Nissen huts in a large flat area. And the French did see Concorde as being a way of building up their national technology. The number of disputes we had, and Philip will bear this out, over the brakes, over titanium honeycomb, and a whole series of very long-drawn-out, difficult debates on bits and pieces of technology, was very much a result of the French trying to get hold of technology for their aspirations.

JAY Did Thorneycroft try to prevent the French backing out of the project?

DENZA I was not directly involved, but my legal colleagues said that it was pointed out that this was quite extraordinary, not to have a termination clause in a bilateral treaty, and the response was that that was quite deliberate, that the word was that the French would usually back out.

GARDNER My intention is to introduce some numbers into this. At the time when the Concorde was started as an idea, the Supersonic Transport Aircraft Committee advised ministers that the development cost would be between £75 and £95 million, and the market would be between 150 and 500 aircraft. There were as I recall no econo-

mists on that committee, it was composed essentially of engineers. When economic appraisal started to be done, I can assure people that there was never an economic appraisal which gave any chance of that development cost being recovered. And of course development cost in fact was not £75 million but £1,100 million and the market was not 150 to 500, it was 16.

JAY It was nil, because the 16 were not paid for.

GARDNER Sixteen were given away, yes, but there were also airlines that would not accept it as a gift.

JAY The market was negative. Thank you, that is a very lucid and succinct summary of that aspect of the matter. I think we should move on in time and look at events subsequent to 1965. Ken Owen, perhaps you would like just to remind us what are the key moments we should focus on in the post-1965 story?

KEN OWEN A key date was ten years later, in 1974, when I believe officials, both French and British, had agreed that the Concorde project was not viable, and were going to recommend – or did recommend – in a paper to governments that it should be cancelled. Then there was a general election in the UK. Labour returned to power, and Tony Benn* published the officials' Concorde figures. After some controversy, the two governments decided that the programme would continue, but only 16 would be built. I think 1974, after 1964, is a key date to focus on.

Then Secretary of State for Industry, 1974-9. In 1968, as Minister of Technology, he had had Concorde discussions with Jean Chamant, the French Minister of Transport.

KEN BINNING I was the Director-General, Concorde in 1974. The position was as Ken Owen described. It was even more dramatic, I think, in that Chris Benjamin and his opposite number worked extremely hard in producing estimates of probable cost on a number of different assumptions. These were presented to the Conservative government, who concluded that if the French could be got to agree then the project should be cancelled. Almost immediately after the election, in March 1974, a White Paper was produced in the UK which set out these arguments and also, very importantly, was accompanied by a major study, principally organised by British Airways but to which others had made major contributions, which demonstrated that the demand for such aircraft was likely to be extremely small. This was the first time that such an estimate had been made public. The debate became totally public in the UK, it was also public in France, and perhaps to the surprise of people in the UK the French attitude was much more complacent than was expected, because prior to that we had all been round the houses yet again on what compensation might be payable if we were sued for breach of the treaty, which was even then regarded as having a high probability.

The discussions were not finalised for about two months, but the significant happening was that in July there was a meeting between the then Prime Minister and President, and in 15 minutes they had agreed that the honour (to use the French word, I am not quite sure what English word was used in that context) of the parties and the involvement of the parties was so obvious that it could not be cancelled, and that 16 aircraft in total should be produced. This has enormous consequences thereafter, but in three months these decisions had been hardened up and were never altered.

DAVIES

I think there is some danger of the debate becoming unbalanced unless we take more detailed cognizance of the technical aspects. It must be remembered that in the early 1950s the prospect of designing long-range supersonic transport aircraft had not been seriously contemplated, since the problems involved seemed to be insuperable. However, following the formation in 1956 of the joint RAE/industry committee to study the problems in greater depth, solutions began to emerge. After three years of hard work, phenomenal progress had been made to the extent that most of those involved had become convinced that long-range air travel at Mach 2 was likely to become technically feasible and possibly financially viable. Unfortunately, the effort mounted on the financial and marketing aspects and on the management organisation needed to make such an advanced international project commercially viable was not comparable to that which had been deployed on the technical aspects. In the event the technical decisions made by the Anglo-French design team all proved to be immaculately right, making the Concorde the technical triumph which it undoubtedly is. Some, at least, of the responsibility for the commercial failure must however be accepted by the engineers involved (including myself), who may have allowed their enthusiasm for their technical achievement to cloud their judgement.

JAY

You make a very good point, which is that the technological imperative was extremely important in this project: because it is possible it must be done.

GARDNER

I think we should say a little about the period between 1964 and 1974, because that is when all the major technical developments took place. And it was a very unusual project. It was a project which had to be exactly right in order to succeed at all, technically. Perhaps a little anecdote. They discovered that the weight had gone up to the point where the wheel had to be larger to meet the runway requirements, but the wheel was a tight fit in the wing. So a bulge had to be produced in the wing. The result of that was that the air resistance was greater than it had been, more fuel was required, and to carry that fuel a heavier structure was required. Because a heavier structure was required, an even bigger wheel was needed. That is just one little anecdote, but that was part of the sort

of thing that happened in the technical development of the project all the way through.

I think it is a lesson for future projects: if you can identify that it is that sort of project, that only if you get it exactly right will it work out, then you know that the costs are going to go up. What happened was that it had to be redesigned twice, perhaps 2½ times, completely because of weight growth, and in the course of redesigning it, more expensive methods of construction had to be adopted and more expensive materials, and the result was that the production costs turned out to be about four times as high as had been anticipated. The economics of it went completely. They had never been very good, but it became obvious from the mid-1960s to anybody that this was economically disastrous, even while there were doubts about whether it was technically possible which still had to be resolved.

JONES

I agree with what Nick has said, but I think it is important that between 1964 and say 1974, to which Ken [Binning] has given a detailed exposition, ministers regularly, about every three or six months, looked at the project to see whether it should be cancelled, and there was a very clear technical and, if you like, financial divide. The technicians were excited with it, it was an exciting project. That did not count, actually, with ministers. Ministers would have got out of it if they could, and they spent basically the whole of that period seeing whether they could. It was kept alive initially by the lawyers – I always thought the first aircraft should have been called the Sir Elwyn Jones.* We then did have a separate study with the French to see whether we could agree on the sales forecasts, and our sales forecasts were very much lower than theirs. I think, speaking from memory, we said it would be at most 50 and could be considerably less, and the French colleagues in those days were still talking in the 150s or 200s. But there was a specific Cabinet examination of Concorde every three to six months in that period.

Sir Elwyn Jones (Lord Elwyn-Jones, 1909-89), Labour politician. Attorney-General, 1964-70.

LOWE

Perhaps I could quickly make a couple of points. The first, probably an obvious one, is that the price that an airline will pay for an aircraft has nothing to do with its cost of development. And, as an aside, the Concorde aircraft were not given away, the price was I think £35 million and British Airways paid £160 million for the five aeroplanes they received. That was then changed in 1979 when the capital was written off, but there was an 80/20 profit share, and then in 1984 that was subsequently changed again, where British Airways paid £16.5 million in order to take on the aircraft and the support costs. The support costs in the first year were well above £10 million, which about equates to the cost of capital to buy them. So the proposed purchase or sale price of the aeroplanes of about £35 million was probably not far wrong. I think if we take out the high inflation years of the late 1970s, the sorts of returns that we are getting, whilst commercially sensitive, probably justify that as a

sensible selling price.
That begins to beg the question at which point did we decide to separate out the three elements that could have driven this project. One was national pride, another was technological leadership and technological spin-off, the third was Europe and how do we get out of it? I think perhaps there could be some comment on how we balance those three elements. We knew pretty well what the selling price of the aircraft could be, the cost of ownership, therefore we knew quite early on that there could not be a financial return. But still we carried on. How important was it at that time to be seen to be a technological leader, as well as the other elements of getting out of it and pride? Something had to be the driver that kept it going, it could not have been money at that stage. As I say, the guess at what the selling price should be probably was not too far in error.

BALDWIN

I think there is a distinct difference in the view of ministers on the technical merit of this proposal in the later 1960s, compared with what it was in the first part of the 1960s. I believe there was quite a feeling, particularly in the minds of Thorneycroft and Amery, that British industry, particularly BAC and Bristol Siddeley, should be helped to be given their head; and when their two great figures, George Edwards and Arnold Hall,* addressed the Cabinet Committee, they were very convincing in talking about the industrial proposals involved in this. There was of course on the other side, to follow the last speaker, a great deal of difficulty in inducing the airlines to give an estimate of what they would need and therefore what the market would be. So ministers found themselves with these two points in their mind and they did do the balancing act, and the way they did it was to go along with this treaty relationship, share the risks with France and not worry too much at all about the fact that the market figures were very unconvincing and were always seen to be such by the Treasury, successive Chief Secretaries and Chancellors. So we had this division of opinion, and it isn't a rational economic decision, but I don't think we should underrate the desire of ministers of the day to see British industry at the front in some area or other, and where else than in aircraft? That I believe was a reality, but they learnt it is a hard road.

Sir Arnold Hall, aviator and industrialist (1915-2000). Director, 1955, Vice-Chairman, 1959-63; Executive Chairman, 1967-84; Hawker Siddeley Group.

JAY

Technological jingoism is what I would call it.

BALDWIN

I would say national honour.

PETER CHAMPION

One of my responsibilities in the Concorde project administration directorate in the British Aircraft Corporation was to make realistic predictions of the ultimate performance, timescale and cost outcomes of the Concorde programme. The results of those predictions arrived as a bombshell to the organisation, because I predicted the weight growth to which Mr Gardner has referred.

That was readily predictable from analysis of other projects, and it was perfectly clear that weight growth was intimately associated with the degree of novelty, difficulty, complexity inherent in the programme. Concorde was very difficult and very novel and a very complex programme. I predicted also the ultimate development cost share of the British Aircraft Corporation, and the dates of the first flight and of the certificate of airworthiness (C. of A.).

I made these predictions in 1967, and I have to tell you I got them all wrong. I underestimated the weight of Concorde ultimately, I made it 400,000 lbs and it came out at 405,000. I underestimated the degree of delay that there would be in the programme and I had the certificate of airworthiness in 1974 instead of 1976. So in that sense I failed. What I did not fail in was in producing estimates, including cost estimates, which were much closer, by a very large margin, to the ultimate outcomes than any other estimates of which I am aware. When my figures were first circulated in limited copies to directors of the company in Bristol, they were like a bombshell. My paper was at first described as dangerous nonsense and the managing director phoned me up one Friday evening and told me to tear it up. However, over ensuing months he became convinced that the analysis was realistic, and I do recall subsequent internal meetings in which members of the whole Concorde design and development organisation were subjected to stringent exhortations based upon these very damaging figures.

Out of all this, I would like to say two things. First of all, the escalation in cost, itself largely due to the escalation in weight and to the other technical difficulties with Concorde that happened, was to a large extent entirely predictable. What we should be examining here today on this front is how it is that a self-trained econometrician (I was trained as an aerodynamicist) seems to have done so much better than anybody else could do. It is that subject that we should be looking at, because it contains the lessons for all future projects which involve high risk. If the right techniques are applied at the right time with the right open-mindedness, then a much better idea of the ultimate outcomes of programmes *can* be obtained.

JAY

There is one comment I would like to inject, arising directly out of that very interesting contribution. I think on occasions like this there is a temptation to talk as though decisions are made in a very rational and calm atmosphere, even if we think the substance of the decisions are prone to gross error, and then we ask ourselves how come that such gross errors could have been made by supposedly rational men. I think perhaps a missing element in that picture is the climate of public opinion. Politicians may or may not be wise and intelligent men, they may or may not be well informed, they may or may not be well briefed. But their decision-making is not confined to listening to official and technical advice, it also consists of listening to all the other things which seem to politicians to be important, which in general includes public opinion including the

media.

I submit the thought that, going right back to the war time, when the boffins were heroically struggling against appalling bureaucratic obstacles in Whitehall to communicate to the high command the technically brilliant solutions to the urgent and important problems of defeating the enemy, a kind of culture grew up in Britain from the early 1940s onwards in which there was a kind of alliance between the boffins, the media – particularly the tabloid end of the media – and the very senior politicians. Certainly in my time in the Treasury we regarded it as virtually axiomatic that when some important spending decision was about to come before the Cabinet, and there was some chance in our view of the Cabinet deciding to abstain from whatever the military folly happened to be, in that morning's *Daily Express* there would be a huge story as to how the wicked bureaucrats were about to slaughter yet another fine British technological achievement.

If this interrelationship between the boffins, the sponsoring departments, the newspapers and the senior politicians as a mechanism for getting the taxpayer to pay for technological imperatives of the times – to say nothing of the salaries and occupations of the boffins themselves – was, as I believe, an important and pervasive part of British public sector life throughout 25 years or so after the war, then it possibly was an important part of the Concorde story. Because, as Handel Davies has very clearly and rightly said, it was very easy to represent in tabloid newspaper terms the excitement, the dramas, the national prestige, the national honour, the national primacy that was involved in a project like Concorde. It was very easy to represent the argument that every technological step that is possible is also mandatory, that whatever can be done must be done, that everything will always go faster next year than it did last year, and on *ad infinitum*, and in that atmosphere the pressure on politicians to go with such projects, because public opinion has been persuaded to go with such projects, is an extremely strong part of the story. The fact that there are other parts of the story that may point in the other direction may frequently not be sufficient in the minds of the politicians to counterbalance the protests that come via public opinion and the media from those kind of pressures. I think that is part of the story.

BENJAMIN

I am just going to comment roughly on the point which Philip [Jones]made about this jump of a decade which seems to be inherent here. It is obviously impossible in retrospect to replicate what that period was like. Taking up the point about development estimates, this was a joke when you were in Concorde division. The C. of A. slipped uniformly with time, and the development estimate was infinity and it remained infinity for a very long period of time, until someone had actually fixed the final shape of the aeroplane. So it was by no means an easy choice, presenting ministers with a balance of what the truth here was.

The second point I wanted to make is that that period was one of the Benn/Chamant agreement and, as Philip has said, the British government was permanently keeping the project under review. And the question inherent here is that if the British government had resolved 'we are going to be like the French and go hell-for-leather to do it', might we not have saved sufficient time to get this contentious aeroplane into the market at a point where there *was* a market? Because the particular point where it came in was just at the time when most airlines had decided on buying 747s. If we had been there at the time when there was a genuine choice, maybe they might have bought a few, who knows? But there is a question about whether the 'keeping options open' stance actually held the project up.

The other point I would like to make is your one about this mystical combination of technology and administration and public opinion. Public opinion was not uniformly in support of Concorde. In fact we spent an enormous amount of time dealing with environmentalists. We virtually originated the upper-atmosphere debate, since no-one had even thought about the question of the ozone layer until someone came up with the idea that Concorde might somehow deplete it. I can tell you from the administrative side, a very large part of our effort was spent in handling extremely hostile criticism. When we had a Concorde Bill going through the Commons, the committee stage, if you want to read it, was composed 90 per cent of hostile questions. So it is by no means a case where ministers were following public opinion.

HENRI PERRIER

Georges Pompidou (1911-1974), French politician. President, 1969-74.

Giscard d'Estaing, French politician. President, 1974-81.

I was working from the French side in the flight test department. Very briefly, a few points about the crisis from March 1974. One point, which is purely political, is the fact that President Pompidou* died on 2 April 1974, so there was a general election for a new president. And certainly in the compromise which was achieved by July and August for the 16 aircraft, Giscard d'Estaing's* position on the programme differed from that of Pompidou.

The second point, which follows what we were saying a few minutes ago, is the pressure from French public opinion against cancellation: very high pressure of opinion from the left to the right of the political spectrum. This included the Communist Party, which always supported the programme in France, just because the Russians were developing the same type of aircraft in parallel, so there was no argument to say it is only an aircraft for rich people. In the UK too there was pressure, from the unions as far as I remember, and on both sides of the Channel there was a good relationship between the unions. Certainly during the months of April, May and June, the discussions between the French and British governments were probably frozen, because on the French side we had a new government, and when the discussions were restarting at the beginning of July, public opinion was certainly of the first importance even in your country. It was no more popular, as far as I understood, in the UK to cancel the

programme. It was a position which was taken during the campaign in February 1974, but it was probably not in the end the popular feeling in your country, and certainly more than 90 per cent of the French opinion was against cancellation.

BRIAN TRUBSHAW I used to fly the aeroplane. I don't think anybody should underestimate the influence that the unions exerted on some people, particularly Wedgwood Benn (or 'Tone', as they used to call him), because I recall a mass meeting at Filton, all Rolls-Royce, all British Aerospace, which in those days came to something like 10,000 or 15,000 people, and during the course of that occasion, when they were all out on the airfield being addressed by Wedgwood Benn, he received a note which said 'Remember one thing: your job depends on us and we depend on you'.

JAY Thank you very much indeed. I can think of nothing more appropriate than that the last word of this session of the seminar should be spoken by the first man to fly the aircraft.

Concorde
Session 2: Technology

This witness seminar, organised by the Institute of Contemporary British History, was held at the Science Museum, London on 19 November 1998. This session was concerned broadly with technology and the Concorde programme. Captain W. D. Lowe chaired this session and the participants were as follows:

Frank Armstrong	NGTE, RAE and MOD.
Peter P. Baker	Concorde test pilot, BAC/British Aerospace; Civil Aviation Authority (CAA)
G. H. S. Barton	Group supervisor, Concorde maintenance, BAC.
Christopher Benjamin	Ministry of Aviation (MOA, incl. Private Secretary to Ministers Julian Amery and Roy Jenkins) and Concorde project team, Department of Trade and Industry (DTI).
Peter Champion	BAC.
Dudley Collard	Sud Aviation/Aérospatiale.
Gordon Davidson	Concorde director, British Airways.
Professor J.E. Ffowcs Williams	Chairman, Concorde Noise Panel, 1965-75.
Captain John Hutchinson	Concorde captain, British Airways.
Simon Aubrey Jones	Son of the Rt. Hon. Aubrey Jones, Minister of Supply, 1957-59.
Sir Philip Jones	DTI Director General, Concorde 1971-73.
Gordon Lewis	Bristol Siddeley Engines/Rolls-Royce (technical director).
John McEnery	Department of Industry (DOI) Under-Secretary, Concorde 1977-81.
M. C. Neale	NGTE and Ministry of Defence (MOD)
Henri Perrier	Aérospatiale.
Jean Rech	Sud Aviation/Aérospatiale.
Guy T. Smith	Bristol Siddeley Engines/Rolls-Royce (marketing director, Bristol engine division)
S. J. Swadling	BAC/British Aerospace (technical director).
Brian Trubshaw	Director of flight test, BAC/British Aerospace; UK director, Concorde flight-test programme.

W. D. LOWE

We would like to begin this afternoon with a statement read for the Rt. Hon. Aubrey Jones by his son Simon, which in effect completes this morning's session.

SIMON AUBREY JONES

On behalf of my father, who has difficulty with his speaking, this is what he would have said to you:

"I was Minister of Supply under Harold Macmillan as Prime Minister between the beginning of 1957 and October 1959. The Ministry of Supply procured weapons for the armed forces and sponsored the aircraft industry. In March 1959 there came into my hands a report from a technical committee,* headed by the Royal Aircraft Establishment at Farnborough, on a supersonic passenger aircraft and advocating that something should be done about it. I thereupon placed design contracts with Hawker Siddeley Aviation and the Bristol Aero Engine Company. In June 1959 I took advantage of a visit to the Paris Air Show at le Bourget to speak with the French Minister for Air Transport (we spoke in French, for before the Second World War I had been a correspondent in Paris of *The Times*). I suggested that we should jointly develop a supersonic civil aircraft.

The Supersonic Transport Aircraft Committee.

"My motives were twofold. First, I had become weary of the Treasury's cancellation of most aircraft projects, and the Treasury might find it difficult to cancel a project undertaken jointly with another country. Second, I believed that as a country we had made a mistake in holding ourselves aloof from the European Common Market. Co-operation with France in an aircraft project might be a partial remedy for that mistake. My suggestion was eventually taken up. Thus was Concorde born. Despite the paucity of sales, Concorde was an outstanding example of international collaboration. I am proud to have been present at the birth.

After my time, attempts were made to involve the Americans in the Concorde project. To this day I believe I would have been opposed, for I attached importance to the construction of a European aircraft industry, to compete more effectively with the Americans."

LOWE

My name is Jock Lowe. I work for British Airways and I am flying the Concorde still. I think my little claim to fame is that I am the longest-serving Concorde pilot, and I run the Concorde commercial world for BA. I have to blame the man on my left [Brian Trubshaw] for this, because he decided to take Concorde for its first flight in the UK on my twenty-fifth birthday, and I was watching the television and thought 'Well, that wouldn't be a bad job'.

I think in this session we can, at least in part, celebrate tremendous success. I think there is little doubt that technically Concorde has been a superb success. Indeed, I often say that it is possibly the first piece of twenty-first century technology. Try to think of another piece of machinery that was built in 1969 and that is still 20 years ahead of the nearest opposition come the turn of the century – there aren't too many of them. We carry on flying it, and in the last few

weeks we have had the best technical performance we have had for many years with the aeroplane. It can carry on flying for many years to come. So, in terms of technical achievement, the aeroplane really has set some milestones. But it was at a price, and perhaps that is one of the elements we can talk about this afternoon.

So we have celebration of success, celebration of the fact that we are carrying passengers, and have been now for 20-plus years, at twice the speed of sound, when the only other people up there are in spacesuits while our passengers are drinking champagne and eating caviar. But it was at a price because of the time the aeroplane took to design, build, construct and enter into service. It was there because of the complexity of the aeroplane, and one has to wonder whether or not it was the right technical challenge to take on. That we overcame the technical difficulties is I think without doubt, but should we have done it? And what led the French, in particular, to spot in the mid-1960s, before the Concorde was even flying, that actually the next step was not supersonic aeroplanes, but was lower seat-mile-cost subsonic aeroplanes – bigger, technically advanced. They switched in a way that we did not. So if there are some lessons, it is perhaps at least in part to see how you can control cost and complexity, how you can work international projects (we learnt a lot from that) and how at the same time you can still analyse that you are backing the wrong horse, if indeed the objective is to have a successful and profitable aviation industry.

We should not forget that the UK still has an extremely successful aviation sector, in which we still punch well above our weight: a £35 billion turnover, half of that in exports; a £3-5 billion contribution to the Treasury; world leaders in many aspects. Rolls-Royce engines, for instance, are now flying on 32 different commercial aeroplanes and 28 military aeroplanes. So we may have got some things wrong with the investment in Concorde, but nevertheless we have still ended up with a very successful industry, despite all that we can say about how we could have done it better, quicker, cheaper, or not done it at all. We should not rule out the fact that we have done a pretty good job.

Perhaps the people on the panel could say a few words about where they fitted into this technology development of Concorde as a whole?

DUDLEY COLLARD I worked at Aérospatiale at the time. I had worked at Boeing on their SST from its conception in 1958 until 1962. Then I moved to Sud Aviation and worked in the aerodynamics department. I was there when the prototype Concorde wing design was defined, and was responsible for the production aircraft wing design. I also worked on intakes and, since you are talking about the length of development time of various items, we had a lot of problems with the wing leading-edge and also we changed the rear fuselage shape. They might be two items we can speak about later, as indications of the kind of problems we ran into.

G. H. S. BARTON

I am a retired maintenance engineer. I used to be the group supervisor on Concorde maintenance. I had the release for the Concorde, and I was involved in a survey with a project manager in 1974, before the Concorde was taken up by British Airways, into the possibilities of maintenance being carried out on the aeroplane. We eventually concluded that it *was* possible to maintain it.

LOWE

And the rest is history, when you said it could be done.

PETER CHAMPION

A proposed vertical takeoff and landing aircraft (Hawker Siddeley, main contractor). In Feb. 1965 the incoming Labour Government cancelled the HS681 project on grounds of cost.

A proposed vertical takeoff and landing fighter plane (Hawker Siddeley, main contractor). The project was cancelled in 1965.

A proposed advance low-level bomber (British Aircraft Corporation, main contractor). Production cancelled in April 1965 on account of costs.

I started my career as a supersonic aerodynamicist at the British Aircraft Corporation. I moved briefly to Hawker Siddeley for 2½ years in the mid-1960s, and incidentally had the doubtful pleasure there of seeing the HS681* and then the P1154,* with both of which I was then involved, cancelled. Soon after I returned to Bristol in this relatively new activity of econometrics I had the pleasure of being involved in the TSR2* and again seeing that cancelled, so sometimes I felt like a bit of a Jonah – if I got involved in something it got cancelled. I spoke this morning about some of my thoughts on this programme, and I would just like to add one more if I may. Among the other salient errors of foresight on Concorde was that, irrespective of how wrong the estimates were and how optimistic the technical prognoses and so on, it was thought at the time that Concorde could compete with a fare surcharge of about 20 per cent. I think critically that part of the reasoning underlying this compared Concorde with then-current subsonic aeroplanes. A decade later, when Concorde was in service, you had a very different breed of subsonic aeroplane, with much lower operating costs, and in retrospect it now seems obvious that Concorde should have been compared with some forecast of the likely future competition at the time it was in service.

GORDON LEWIS

The Olympus 593.

I have had 44 years' involvement in the aero-engine business. I started as a technical assistant at Bristol in 1944 and departed 44 years later as technical director of Rolls-Royce. But one of my very first jobs was the concept and design of the first Olympus engine, so I really lived with what became the Concorde powerplant* for many years. I feel I am here representing a very old friend and colleague who sadly died some years ago, Pierre Young, who those who were involved in the Concorde remember as the person who led the effort on the engine programme enormously effectively. To him goes a huge amount of the credit for the success of the final product.

S. J. SWADLING

I started at Bristol in 1956 and became involved in their supersonic work two years later, involved in our all-steel Mach 3 Type 198 aeroplane, also the Type 221, which was a conversion of the FD2, an experimental aircraft in support of Concorde. I was primarily involved in the early days of Concorde with structure and with powerplants, and that I think is something we need to talk a bit more about in this session. I then moved off onto other things and finally

came back to Concorde in my last ten years at the company as technical director, when Concorde was one of the aeroplanes I was responsible for in its in-service support.

J. E. FFOWCS WILLIAMS

Stanley Hooker was technical director (aero) of Bristol Siddeley Engines, becoming technical director of the Bristol engine division of Rolls-Royce in 1966. The Concorde Noise Panel was formed in 1966.

Imperial College of Science and Technology, one of the constituent colleges of the University of London.

I got involved in 1964, when Stanley Hooker* called me and said, 'The risk that this aircraft will be too noisy to operate is too high. The physics of the problem is difficult to understand and I am sure that we do not have a solution within the industry. Will you come and please help?' I was at the Mathematics Department at Imperial College.* I ended up by directing the Concorde Noise Panel and had an enormous amount of fun doing it; some of the things I remember most clearly are to do with funny things.

When the panel was given charge of the research for the noise on the Concorde it was announced in Paris. We had a great ceremony and the French minister made a great speech in French. He indicated to me I had to reply but I don't speak French, so I replied in Welsh at about the same length. He then gave a short speech in French and said in English 'Will you please speak now?'. I said 'There are many here who regard French and Welsh as foreign languages, but they probably all understand English', and from then on all the noise research work was done in English.

I also remember announcing the noise level, it was a sensitive figure. The noise level that Concorde would take off at was to be quoted in effective perceived noise decibels. The decibel measures sound energy and 'perceived' accounts for the annoyance of that energy; on that unit the Concorde was difficult to contain. But Concorde noise does not last very long, so bonus points for being over quickly; Concorde doesn't whine, so bonus points for not whining; and by the time you have normalised it all the effective perceived noise decibel comes out and that was the unit on which the performance was quoted. It is now the unit that is internationally accepted for aircraft. That was a rather important development in the project. But when I announced the number I said Concorde would take off making a noise of 118 EPNdB, and Richard Wigg, chairman of the Anti Concorde League, jumped up in the audience with a bit of paper. Wigg then said 'I have in my hand a telegram from Toulouse. Concorde took off this morning from Toulouse, and its noise was measured. It did not make 118 decibels as the professor said it will, it made 140 decibels.' I thought very quickly and replied 'Richard Wigg will be interested to know that a bumblebee in his ear will make 140 decibels', which turned out to be true.

LOWE

And that became one of the standard phrases of the whole Concorde history.

GUY T. SMITH

Société Nationale d'Étude et de Construction de Moteurs d'Aviation.

I started a year after Gordon Lewis at Bristol and became involved in what I believe was the first post-war contact between the French and the British industries. SNECMA* came to Bristol in about 1947, interested in taking a licence on the Hercules engine. The team that

came over was not English-speaking and our chief engineer, Roger Ninnes, who had been with Gnome-Rhone before the war, came into the design office and said 'Anybody speak French?'. Being an ambitious young man I raised my hand, became immediately involved in French business, and so gave up engineering for many years. When Bristol became Bristol Siddeley I became sales manager, and eventually when Rolls-Royce bought Bristol Siddeley I was made director of marketing of the Bristol engine division.

My part in the Concorde was primarily on relations with the French, and in particular with SNECMA. I had spent an enormous amount of time with them, and I recognised that a partnership with SNECMA was a very positive contribution to ensuring that the Olympus was the chosen engine. We were of course in competition, amongst others, with Rolls-Royce at that time. I was very close to the technical director of SNECMA, Michel Garnier, at that time; I spent a lot of time with him, I knew what they were thinking and why they were thinking it. Eventually I was made the regional director for Europe by Rolls-Royce, after we joined the Common Market as it was then, and I spent nearly eight years in Paris, again working very closely with them. I chose Paris as it seemed to me the most sensible place, because if we did not get on with the French there was no hope for Europe at all. I spent those eight years there and I think, a bit of a boast if you like, that as far as it is possible for an Englishman to understand the French I did.

LOWE John Hutchinson, I know you have to go very shortly, so would you like to say a few words about yourself and maybe pick out a couple of points from airline operation?

JOHN HUTCHINSON I was on Concorde from 1977 until 1992, when British Airways with their age discriminatory policy of retiring people at 55 dragged me kicking and screaming away from my favourite hobby, which was flying this beautiful aeroplane. I have just under 4,000 hours supersonic (which irritates the life out of my military fighter pilot friends).

Speaking as an operational pilot, Concorde was the finest, and probably still remains the finest, civil aircraft operation in the world. It has a very closely integrated, three-man flight crew, and everybody on that crew has to know exactly what they are doing. It is a complex aeroplane, it is a complex operation, things can happen quite quickly, there is no room for carrying dead weight on the flight deck. Consequently, it is a supremely rewarding aeroplane to operate and to fly; I don't think there is anything like it. When I view people flogging across the skies in 747-400s for eight, 12 hours or whatever, I think I was exceptionally lucky and privileged to fly this beautiful aeroplane.

Concorde has enjoyed a most remarkable safety record in British Airways, and I am going to touch wood because I am incredibly superstitious and I don't wish to encourage thunderbolts from above. It enjoys that safety record not through any sort of accident, but because British Airways training is impeccable and done to an incred-

ibly high standard. This conversion course, incidentally, takes the best part of six months. So that is point number one: the training is second to none.

The second thing I would say is that the engineering support that the aeroplane enjoys also is second to none. For example, the Concorde flight crew were always met by the ground engineers on return to Heathrow, and they would then discuss any problems they had had directly with them. I think that sort of interaction between flight crew and ground engineers was incredibly valuable, very significant and very important. The final thing I would say is that the aeroplane was built in a pretty strong sort of way. It may look beautiful, delicate and pretty, but it is built like the proverbial brick lavatory. It has the most amazing structural strength, and also tremendous spare capacity built into it. And as I said, it has been my enormous privilege to have operated that aeroplane for 15 years. Thank you, British Airways.

LOWE

Brian, I wonder if you would give us a summary of what you saw as the technical difficulties of prime importance that had to be overcome, the way of doing it and the highlight of the achievements in getting this wonderful aeroplane into service?

BRIAN TRUBSHAW

I think the first thing I would say, reflecting this morning's remarks, is that when I was injected into the programme in 1965 it became very obvious quite quickly that the French government, irrespective of what faith they were, were intent on having an aircraft industry, whilst the intention of H[er] M[ajesty's] G[overnment]s of various sorts was not quite so obvious. If you need any proof of that, you have only got to go to Toulouse today and see this fabulous facility which Airbus have built there, which is second to none in the world, whereas I am afraid my main memory is the Nissen huts at Fairford.*

British Concorde flight testing was based at the RAF airfield at Fairford, Gloucestershire.

The biggest fact which I think affected the timing, the cost and everything else was that the prototypes were not a commercial proposition, and that became known quite early. Consequently a lot of changes were made to the prototype, in that the production aeroplane was slightly bigger and various major changes were made to it. That meant that we had to do a lot of the testing several times over, because some of the changes that were incorporated were not all done at the same time. For instance, when I first saw the prototype, I was totally horror-stricken by the metal visor which you used to put up after take-off, and you could not see forward properly or even look through a little peephole upwards. This was a supersonic transport, I was told. There I think is one big message: you cannot have an aeroplane which is fundamentally different to the other ones which are floating around. But the prototype met the vision requirements for supersonic transports, and it was only when the FAA* got into the act and one of them told me over a whisky and soda that they would never certify the aeroplane in that form, because the Airline Pilots Association would have their guts for garters, that it suddenly

US Federal Aviation Administration.

became possible almost overnight to have a transparent visor. That sounds a simple thing to say, but it made a very big change to the aeroplane from a structural and design point of view. And then there were all these other changes which were incorporated, to try and make sure that this aeroplane would meet the fundamental requirements of a transatlantic supersonic airliner.

The other factor which I always felt had an enormous effect on the Concorde was that, when it was in its early days of development, there was no real airline input. There wasn't a customer for the aeroplane who said 'I want it this way and I want it that way'. And come the day when people did actually get down to business we found that a lot of changes had to be made, because of airline requirements. That also affected some of the costs and delays which went into this programme.

As far as the programme itself was concerned, I personally think that the engine/intake combination was the most difficult bit to get right, and for those who don't know what was required it can be stated very simply. The air going into the engine, irrespective of the speed of the aeroplane, has to be digestible and if it is not digestible the engine does the same thing that we tend to do, it belches it out in front, and we call that an engine surge. We experienced these engine surges very early on the Concorde, in fact the first time it went to Mach 2 I thought World War Three had started, when I throttled back at the end of the first run and both the right-hand engines surged. These surges are quite loud and unpleasant and they certainly don't go with the roast beef and champagne which was going on in the back.

LOWE

SR-71 is a US advanced strategic reconnaissance aircraft which came in operation in the mid-1960s.

Just one point before we start the discussion. The success of Concorde was first really illustrated to me the first time I flew to an airshow at Toronto, where we met some SR71 Blackbird spy-plane* pilots, and they said that they had been used to flying photographic missions at 60,000 feet over Cuba for many years in their spacesuits and bonedomes. One day air traffic control asked them to move 20 miles to the right and they asked why. Control said, 'Because you have an aircraft coming past you, coming out from Caracas', and they said 'and there we were looking, and there was an Air France Concorde which went past us with a hundred people sitting in shirtsleeves drinking champagne'. And they sat there in their spacesuits. That demonstrates the success, in a way. But I will counter that by adding that the SR71, which flies at Mach 3, was built and operated and put into service in 3½ years and not the 16 years that it took Concorde. So on the one hand we have a demonstration of Concorde excellence, but we also have an example where, with different organisation and different objectives, a similarly difficult technical project can be overcome very quickly.

With that as my hopefully sole contribution, perhaps I could ask someone to comment on what they thought as being the most complex of all the issues that were raised in the design and testing and

entry into service?.

SWADLING

I am sure that Dudley Collard will share my view that, without doubt, the powerplant is *the* challenge on supersonic transport. Brian [Trubshaw] has already said the air has to be digestible, that means it actually has got to go into the engine relatively slowly, down to about Mach 0.3, with good clean pressure distributions, and that is the function of the intake. This bears very much, as I see it, on the argument of Mach 2 versus Mach 3. On Concorde we have in fact a relatively simple, elegant intake, which is capable of operating at around Mach 2, with a relatively simple intake control system, and giving the engine air which is easily digested. At Mach 3 one would have to go to entirely different types of intake, which I think at that point in time we would be unable to control because of the speed and response that would be required to maintain that digestible air at Mach 3.

The whole question of intake, engine and nozzle matching is very complex. It was made in many ways more difficult on this aeroplane. We had what was then the British Aircraft Corporation doing the intake, we had Rolls-Royce and SNECMA involved in the engine, and we had SNECMA doing the thrust reversers and the exhaust nozzles. With respect to the sort of problems we had, I can remember sitting at one meeting in the SNECMA design offices, and Jumel, their chief engineer said 'This is what we are going to do with the electrical system' and my specialist said 'You can't do that, your polarity in the electrical system, the way you earthed it, is the reverse of the rest of the aeroplane'. Jumel said 'Oh, that's quite simple, you change the aeroplane'. Simple things, but we really did have exactly these sorts of problems at much more difficult levels.

The whole question of the intake control system was a long drawn-out process and the problem was how to avoid the engine surges which Brian [Trubshaw] has already referred to. To give you some idea of what they involved, the pressure wave coming from the engine is at something like three atmospheres of pressure, so this forms the design case for the intake structure. On one of the prototype aeroplanes we did actually lose part of the intake control mechanism, the ramps, when we had a surge: it actually broke the structure, which creates a severe problem. The solution to the intake control system problem was partly aerodynamic, we altered the shape of the intake side-walls to make it easier, but mainly it was a very long and difficult development programme. In this we were operating in the Middle East at high temperatures, flying one day, getting test results, having changes to the intake control system made overnight in Filton, and flown out to be fitted to the aircraft the following day. Fortunately we had decided to go to a digital system rather than an analogue system, which was our saving.

On the question of Mach 2 and Mach 3, a lot of play is made of the material differences – aluminium at Mach 2 and titanium and steel at Mach 3. I think in Europe we really did not have the technology to

deal with titanium or steel aeroplanes. Although at Bristol we had been talking of Mach 3 civil transports and we had the Type 188 research aircraft made in stainless steel, to actually get an efficient structure out of those materials would have been beyond us. But an important fact that is ignored is that the70 degrees or so extra temperature you get at Mach 3 really makes life extremely difficult for all the non-metallics on the aeroplane – such as seals in hydraulic and fuel systems, sealants for fuel tanks, insulation on electrical systems. Whilst we could probably have seen a solution to the metallic problems, with difficulty, I suspect many of the non-metallic problems would have been beyond our technology.

COLLARD

I would say that from an aerodynamics point of view the air intake was the most difficult part of the aircraft. On the airframe, aerodynamic design methods followed 'classic' engineering practice. For instance, in wing design, it involved constant comparison between steadily improving theoretical methods and wind-tunnel measurements. The process was difficult, with occasional unpleasant surprises, and it took a large amount of time and effort, but on the whole it was orderly and progressive.

However, there was no precedent for Concorde's unique air intake, and so 'classic' practice was not sufficient. Before the first flight it was recognised that the prototype intake would probably give unacceptable levels of flow distortion at the compressor face, at Mach 2 and above and at low incidence or in sideslip. It could probably not be certificated, and would not allow what BAC called 'carefree operation' by the crew.

Sid [Swadling] says that the intake control system was the major problem, but being an aerodynamicist I am not entirely in agreement. A control system drives the variable geometry to a position where the distortion is sufficiently low. On the prototype, in the peripheral conditions of Mach number greater than 2, low incidence and sideslip, such a position did not exist. In 1971 the project directors established a special powerplant development group under Etienne Fage and Sid Swadling. Its brief was to find an acceptable 'entry into service' solution and to study longer-term improvements. I was lucky enough to be a member of this group, which included two brilliant aerodynamicists, Jacky Leynaert of ONERA,* who had conceived the unique Concorde intake geometry, and the late Terry Brown of BAC, an incredibly able man whose contribution has not been fully appreciated.

In retrospect the modifications to the intake geometry, necessary for certification, were minor, but they were not easy to find and identify quantitatively. Ground test facilities were not sufficiently comprehensive, either being limited to a (non-representative) uniform flow field or being at too low a Reynolds number.* All available English and French test facilities were used (Pyestock,* ARA* and RAE, ONERA and LRBA,* Vernon in France). With time and work the specialists acquired an understanding of the flow which is impossible

Office National d'Etude et de Recherche Aérospatiale.

Reynolds number is an aerodynamic factor which is used to relate the conditions of scale-model testing to the performance of a full-scale aircraft, in this case the Concorde. In general, the higher the Reynolds number, the more realistic the test results.

Pyestock, adjacent to the Royal Aircraft Establishment at Farnborough, Hampshire, was the site of the National Gas Turbine Establishment (NGTE).

The Aircraft Research Association, a wind-tunnel facility based at Bedford.

Laboratoire des Recherches Balistiques et Aérodynamiques.

to put into words but which goes much beyond that required to solve normal engineering problems.

To illustrate this, a modified intake lip leading-edge was retroactively fitted to the Concorde after certification. The goal was to improve performance. Many tests were made on different shapes (mainly at Vernon, where we could achieve the highest Reynolds number), but the definitive geometry was adopted for production only by looking at the design on the drawing board. It was *felt* to be satisfactory, and in flight turned out to have bigger margins in the peripheral conditions while reducing transatlantic fuel consumption by over a ton.

Coming back to the air intake control system, the innovative use of a digital system allowed complex control laws to be adopted (to find optimum ramp and dump door positions). Just as important, it allowed the calculation of intake local Mach number from the fuselage-mounted anemometry, which was not influenced by engine surge. I think that intake surge precluded the use of a local flow sensing system, and using aircraft flow measurements to estimate local intake flow precluded the use of an analogue system. The digital control system that was adopted was the only way to go and its design, development and certification should be a source of pride to British Aerospace. Final intake flight-test development to define intake control laws was completed by a joint BAe design-office/Aérospatiale flight-test effort on aircraft 001 and certification was obtained at the end of 1974.

I mentioned earlier wing leading-edge problems. On the prototype a sharp inner wing leading-edge led to incipient vortex flow *under* the wing at low incidence. This interacted with the intakes causing all four engines to surge during a pushover. Unanticipated, this was found as soon as the aircraft attained Mach 2. To identify the problem, define a new leading edge geometry, test it in the wind tunnel and build it for flight-test evaluation extended the flight testing of the intakes by about one year.

LEWIS

I think one of the most eloquent ways of expressing the difficulties faced by the powerplant, the intake and nozzle systems, and the aircraft in terms of its drag, is to look at these simple numbers. Typically for a subsonic aeroplane the percentage of the gross weight that is payload is about 20 per cent; in modern aeroplanes it can be a lot higher. In the case of the Concorde it is six per cent. With the Concorde there is no option about varying the range, because there is no point in setting off from London and falling into the sea this side of Gander, so the range is fixed. And then you get these sorts of rates of exchange: if you have a one-per-cent increase in fuel consumption compared with the assumed figure, you have to take five passengers off the aeroplane. If you had 150kg increase in each engine weight, you would likewise take five passengers off the aeroplane. The sensitivity of a deviation from the design targets, either in drag or thrust or fuel consumption, is at least three or four times as great, in terms of the effect on payload. And the option of adjusting the range of the

aeroplane was not open, because the range was marginal – the aeroplane had to reach New York from London with adequate reserves. That was the problem, I think, with all the complexities that have been outlined about the intake system and the requirements that were based upon it – for example by noise abatement. The intake had to be opened-up during take-off to allow more air in to reduce the jet velocity and reduce the noise just after the take-off. It then had to be closed to track the shockwaves correctly at high Mach numbers during transonic acceleration up to Mach 2. So it was a very complex mechanism, which changed its shape in the various flight regimes. Similarly the nozzle at the back had to open-up to provide reheat, it had to encompass thrust reversal and so on. This was a hugely complicated box of tricks. It had to be aerodynamically smooth because, don't forget, a one-per-cent loss in thrust means you take five passengers off. And it was not easy to design something with these huge, heat-resistant barn doors, moving and shutting with great precision and being as far as possible leakproof, and retaining this absolutely essential level of performance. That was the challenge.

TRUBSHAW I was going to make the point that this is something which no-one else will ever have to face. The only experience on supersonic flight before Concorde was on military aeroplanes, which flew for relatively short times at supersonic speeds and were able to have a wide margin between the condition under which they were operating and the engine surge line, whereas on a long-range transport you have to operate as near the surge line as you dare. That was why we had to tune this aeroplane finely to the extent that we did. But of course this is one of the facts which we now know about; nobody else who ever comes along to design a new SST has to start at the same point as we did.

LOWE Would anyone like to comment? I don't want to spend too long on this. I think the point is well made already that this was the most complex of the issues, which therefore added to time and cost and so on. The lesson for the future is: can these things be foreseen?

PETER B. BAKER Three points are worth mentioning which I think were significant in development: reaction of the aircraft to rough runways; vulnerability to foreign-object damage; and the need to cater for possible high-pressure compressor surge in the engines. First, the aircraft response to rough runways resulted in some very high accelerations during take-off, especially during rotation, and at one time it looked as if the Concorde might be severely limited in the airfields it could use when operating at high take-off weight. This problem was eventually solved by modifying the telescopic oleo legs in the landing gear. Second, the aircraft was particularly vulnerable to foreign-object damage to tyres because of the position of the intake in relation to the chassis. Air France had a very unpleasant incident out of Washington, clearly calling for some action to be taken. The French came up with an

ingenious solution using strain gauges to warn the crew if a tyre has been deflated. Finally, the original decision that there was no need to provide against possible high-pressure compressor surge resulted in my view in some of the most exciting engine testing of all, when it became apparent that the possibility of such surge was far from remote. I recall someone saying that initial 'worst case' estimates indicated that the ultimate strength of the relevant structure was capable of sustaining only 83 per cent of the predicted load. Tests were then undertaken to prove the point by inducing surge by deliberately overfuelling an engine, which left little doubt in the crew's mind that heavy loads were involved. Happily, the worst predictions were not confirmed, but some structural strengthening did result from these tests.

JOHN McENERY

Mention was made of the intake-lip modification. I believe that modification was done in 1979, and the interesting thing about it was that it was a unilateral British modification, in which the French refused to play any part. But as a result of the modification being successful we eventually sold it to the French, and in fact Her Majesty's Government made a profit out of that particular deal.

JEAN RECH

I have been involved in the Concorde ever since the beginning, with my British colleagues who were members of the technical management group of the project. I then became chief engineer on the ATR 42 and 72 aircraft and later on engineering director. I should like to make a comment about the degrees of difficulty, and I entirely agree with the previous speakers about the difficulty in integrating correctly the intake/engine/aircraft system. But I think there is another aspect which has not been presented yet which illustrates the peculiarity of Concorde in terms of difficulties to surmount. I would call it the heat management throughout the flight. Of course we had the experience of military aircraft flying at Mach 2, but not for three hours. The problem involved all the systems: all the heat you have to reject to keep the passengers alive, to keep the engine oil from cooking, to keep the hydraulic fluid from boiling, to keep the kerosene cool enough at the entry to the engine. Everything had to be right. You could always reject heat to the atmosphere, but because of the sensitivity, as we have said, of the payload to any loss of anything – weight, drag, heat, everything – we decided to put as much heat as possible into the fuel. Because that way it was not lost, indeed it was increasing the energy power of the fuel. That is why we developed an entirely new system of heat exchangers, fuel, hydraulic fluid and engine oil. The point was so difficult that several times during the programme the question was asked: should we develop a new type of kerosene, better than JP4 in terms of heat resistance? But that was out of the question, for economic reasons. So we had to watch the heat margin we had at the end of the flight, and after three hours of bisonic flight there is no further margin. The fuel is entering the combustion chamber, having passed all these heat exchangers, at a

temperature which could not be higher, otherwise it would be cooked and would clog up the fuel injectors. This characterises the general difficulties we had to surmount all along.

LOWE

A very valid point. I think that that part of the flight system is something we take as read. The aeroplane carries on flying at Mach 2 and the passengers stay at 25 degrees C. Somehow that must happen and I do agree, we perhaps underplay that element.

CHRISTOPHER BENJAMIN

I have three points on the technical area. I want first of all to take Brian up on a point he made to me informally many years ago. He said if he was allowed to get on a bicycle with a shopping basket and go round the world buying systems off the shelf, he would have built this aeroplane at half the price in half the time. I think there is a danger in this part of the programme that people are so concerned about the high technical areas we have just been discussing that they tend to ignore some of the more routine elements. There was one scandalous example we discovered, which was that the price of lavatory handles was quite astronomical. I do think that perhaps, with a lean production approach to this aeroplane, both cost and time could have been saved.

My second point is that the sheer cost of this project cast a shadow over the entire government's ability to support aerospace, and there is a question lurking in the background. I know for example there was a BAC1000 aircraft for which, had there been the resources and had one put money into the bank, the commercial outcome might have been better. It was as I recall an aeroplane which was in the [Boeing] 747 area, and that was possibly a more lucrative area in which the British nation might have invested for aerospace purposes. But because of the budgetary calls of Concorde, these options were virtually ruled out; you would never get the Treasury to buy anything. So Concorde did cast a shadow over quite a large area.

The third point, from my experience under both Philip and Ken, was that the crucial moment was: when could you freeze the design of this aeroplane? As I mentioned earlier, for a long time the development cost was infinity, and there came a point when we were saying someone has got to fix a number, there has to be a final point where this aeroplane delivers. There was a lot of controversy at this time, but the manufacturers had before us proposals costing I think £400 million, that figure hangs in my mind, for further developments of Concorde. In theory you could have been developing this aeroplane almost to infinity. For example, the aeroplane we have now has a lot of wiring. If you were doing it today on an Airbus model you would have had a series of computers with fewer wires. I don't know how much weight that would save, but it would be quite substantial. So there was always this constant temptation to continue to refine.

TRUBSHAW

I would like to comment on that point. I would challenge Chris if he is making a point against it. The fact is that this country has always failed to develop its civil aircraft: the VC10* was never developed, the BAC One-Eleven* was never properly developed. And, in the case of the Concorde, the development money which you are referring, which was for the B model (which had moving devices on the leading edge and would have been a much better aeroplane than the present one) was in many ways what you would expect people to do to make a success of any civil project. Look at the way that Airbuses have been changed as the years have gone on, or follow the Boeing stable. It is fatal just to do a few and then you go on to something else. If you start you want to have in mind that you are going to go on and you are going to refine the aeroplane and it will go on for a long while. That will become more and more true, I am sure, as aeroplanes become more and more expensive.

A four-engine British Aerospace long-range commercial aircraft, operated principally by UK airlines and a few Commonwealth carriers during the 1960s and 1970s.

A two-engine short to medium range aircraft which began operations in 1961. It did manage to carve out for itself a niche market and, in comparative terms, was one of the more successful UK-built commercial aircraft, operated not only by British carriers but also by small US regional airlines like Mohawk and Allegheny.

LOWE

To my mind this is one of the crucial lessons that we can learn. It became obvious that this was a very complex aeroplane, where we were into unique solutions with very fine margins, and therefore it must have become apparent to many people that both the timescales and the initial and revised cost estimates were widely out. I would like somebody to comment on that in a moment. The second lesson is: at which point did it become obvious that whilst the technology could be found, it was at such a cost that it was no longer a viable overall economic project? Therefore, why did we not ask what *was* viable, as others did (Brian [Trubshaw] has mentioned Airbus and Boeing) and then, having confirmed that we had got the right project, how can we ensure that we spend enough development money and don't end up, as our history shows, with lots of good but underdeveloped products? The BAC One-Eleven is probably the classic case; we had the Viscount,* we then moved on to the One-Eleven which was in many ways a world-beater. But as a nation we somehow cut off the development funds. It was not seen as a government role, which it is in the US, and it was not seen as a manufacturer's role because they did not wish to commit that risk capital. Somehow, for me anyway, these are the lessons: assess complexity and therefore costs, which allows you to assess if you are on the right course. If you are not, jump, but when you know you are probably on the right one for goodness sake do it properly and not in a half-hearted way. Our contribution to the Airbus is a good example of that.

The Vickers Viscount was a four turbine-propeller aircraft, first operational in the early 1950s. It remains the UK's most successful commercial aircraft, with 444 built and sold around the world.

COLLARD

Concorde is a very underdeveloped aircraft. Directly it was developed enough to perform its mission, development stopped. Brian cited the aircraft B, and I think it is worth saying what this aircraft with minor improvements could do. In aircraft B, the half-span was increased from 12.78 metres to 14 metres, a small increase. We added integral leading-edge flaps inside the wing, they were only 60 mm diameter, and *they were built and tested*. Rolls-Royce, I believe, zero-staged the Olympus; they built a new compressor and *they ran it*.

SNECMA put acoustic treatment in the jet pipe, very difficult in a reheat environment; *they ran it*. With these modifications, aircraft B would fly non-stop with a full payload from Rome to New York, flying subsonically until it reached the Atlantic. It also meant that on a typical mission, say from London to New York or Paris to New York, there was a total 15 decibel reduction in noise at the three measurement points. This is dramatic, but nothing exceptional as an example of the performance improvements to be achieved after an airliner has entered service.

LOWE I think the point is that even with all those modifications, and knowing what I know about the operating costs – costs of maintenance, cost of ownership – the potential sales could only have gone up from a genuine ten aeroplanes to perhaps 20 or 30. So in many ways it was a continuation of the technological challenge rather than the financial challenge, and in a way we had to decide as two nations: which one was it? I don't think we have ever really decided. Any further comments on the complexity, cost and so on?

CHAMPION I would just say that, if you have an aircraft which is already demonstrating a certain level of commercial success, then there is every incentive to spend more money on developing it into an even better article. And clearly Concorde could be developed into a better article. At the same time, it would not raise the market from ten to something more, it would raise the market from nought to nought, because that was the actual real market for the Concorde. Nobody was interested in it under the economic conditions which prevailed when it was available.

LOWE I accept that.

GORDON DAVIDSON I would just like to pick you up on this technology aspect. Obviously, an aeroplane could be highly superior to Concorde, or certainly superior. The real question is: what is the market for it? We are into a marketing rather than a technological situation. In my view, supersonic flying died when we were stopped flying supersonically over land, which therefore reduced the market size for any supersonic aeroplane to a quarter of what it might have been. You cannot find, and I spent many years looking for them, any large number of city pairs which justify the frequency of a supersonic aeroplane. They have to be over water, not over land, but there aren't many of them. We couldn't find any, and therefore in my view there will never be a successor to Concorde. Concorde will be the one and only, because there just is not a market. And, in any case, who really needs this market? Is it an ego trip on the part of the people who say 'I must save three hours', particularly if those three hours are saved at the wrong time of day? And which are the three hours they want to save? Most people work on aeroplanes and another three hours flying to New York is not going to hold you up.

LOWE

I respect and appreciate this, but I think things have moved on now. With the 6,000 mile range, just over 70 per cent of the world's long-haul routes are now either over water or over unpopulated areas. So it is not a quarter any longer, because of the increase in range which was not there when you were analysing it. And I think there is now some pretty strong market research which shows that those three hours actually do save the day in terms of the perceptions of the senior businessmen who use it. Perhaps we can debate this a little later, but my own view is that whilst I don't think there will be another supersonic, it will be because of the reasons we heard here at this table. I think it will be environmental restrictions that will be the most difficult to overcome, as indeed they became in Concorde's case through the political angle. Take-off and landing noise and upper-atmospheric emissions are very likely to be the constraint in future, rather than the market opportunity. But that is a personal view. Professor Ffowcs Williams, I don't know whether you'd like to comment on that environmental aspect?

When an aircraft flies faster than the speed of sound it produces a shock wave or impulsive noise known as a sonic boom. This because an aircraft flying at super-sonic speeds it does not send out ordinary sound-waves but a V-shaped ripple which takes the form of a cone of pressure around the aircraft. As the aircraft flies, it drags this cone along the ground. Observers on the ground perceive changes in pressure caused by this cone as a either a cracking or a thundery noise.

FFOWCS WILLIAMS

The sonic boom* problem stopped it flying over land.

LOWE

I was thinking more about the engine noise for any future supersonic on take-off and landing, and emission levels.

FFOWCS WILLIAMS

I want to publicise a patent: I have a patent on avoiding sonic booms, I happen to believe that it is avoidable. It was classified, suppressed for ten years.

LOWE

Now you tell us.

FFOWCS WILLIAMS

I don't think that the technology exists for allowing supersonic air-craft to meet the stringent noise standards of today. I believe it is possible, in principle, to make a virtually silent jet, but it will have to avoid being turbulent and I believe that is conceivable. It would have to have a lot of very high-risk research. No project evolves on that basis, but I don't think there is any theorem that says all jets have to be turbulent or noisy.

LOWE

That is interesting. What about atmospheric emissions?

McENERY

I am inclined to agree with Gordon Davidson. We set up a potential routes committee in 1978 or 1979 with a view to finding routes for Concorde, and I can assure you there were very few. But to come back to the sonic boom, I don't think it is the direct boom that is the real problem, it was what they call the secondary sonic boom, which goes on and on and on for miles. They could pick up Concorde in New York when it was about 400 miles out, and they could have used that to ban Concorde if they had been really malevolent. I don't think that we are going to get very far with a new supersonic aircraft

unless we can do something about the sonic boom.

LOWE The secondary boom is there, but we alter our descent by about 50 miles in the winter, not 400, so it is there but it is containable. But I would stress again that over 70 per cent of the long-haul routes now are suitable for supersonic flying. This has changed because of the extended range – in other words, you can go round the bottom of India, you can go round the Caribbean Islands, you can go across the Pacific – which was not the case previously. So in that respect it has changed, albeit I certainly agree with the prognosis which is that it is unlikely for the future.

HENRI PERRIER Just for the record, the first flight at Mach 2 was not in 1969, it was 4 November 1970. On the various challenges which were mentioned for the success of the programme – the propulsion, the aerodynamics, the systems, the weight – I want to add another, which is to achieve the best possible handling qualities. One of the targets for the airline pilots was that this aircraft, within this new flight envelope, should be easy to fly. It was one of the basic targets in the design of the flight control systems, and certainly it was one of the cases in which we were going further than any subsonic transport aircraft in the same period.

LOWE Are there any other comments?

SIR PHILIP JONES We have heard about the technical challenges, which were major and were overcome, and enormous attention *was* paid to the technical problems during the development of Concorde. Equal attention was not given to the marketing and sales aspects. We have heard whether or not there might be a market in the future, but the best test of a market in fact is whether those building the plane are prepared to back their judgement by putting some of their own money in. The fact of the matter is that in Concorde the manufacturers had no money of their own in this, they were not prepared even to finance the production line. Against that background of course you can find technology answers, but perhaps you can find better and quicker ones if the manufacturers had some financial stake in the project.

LOWE Yes, an open chequebook is not always the way to get the cheapest result.

M. C. NEALE I agree absolutely with Sir Philip. My experience as a lowly foot soldier in the early years of Concorde development, and subsequently in more senior positions associated with further aerospace projects, has convinced me that a significant financial stake by the manufacturers, right from the outset, should be an imperative. Given the importance that is attached to overseas commercial sales, and the profits these can secure for manufacturers, I would even extend

this to defence projects – though I know that many will disagree with me.

Having said that, I would also argue that because aerospace is essentially a long-term business in which, world-wide, governments and industry are inextricably linked, the maintenance of a UK aerospace industry of anything like its present capability requires us to take a much longer-term view of the future of the industry than is customary – not merely in government, but sometimes I think in industry as well. In particular, the issues surrounding the funding of the ever-advancing underlying technology need to be resolved today, just as much as ever they did. We need long-term measures, and not the series of ad hoc accommodations that has been our lot. Above all, after having spent years working on the intake/engine interface which, it has been suggested, 'was the most difficult bit to get right', I would say that never again should we embark on such a massive excursion into unknown technology. Adoption of the points I have made should go a long way towards preventing this and, hopefully, with the passage of time, towards lifting the shadow which in my view Concorde has understandably cast over government thinking on aerospace.

FRANK ARMSTRONG I used to be at the National Gas Turbine Establishment and at the Royal Aircraft Establishment. On the possibility of a successor to Concorde, I thought it might be of interest to say a word about what some people would call the transonic transport. The original STAC report did offer the choice of two kinds of supersonic transports that might be seriously considered. One was to fly at about Mach 1.2 and the other was about Mach 1.8 to 2, and eventually it was the second one that was taken up and became the Concorde. The first one was not envisaged as a boom-less transport, because at that time people were not foreseeing that the sonic boom would be such a stopper as it proved to be. But the transonic transport, which one might define as an aeroplane flying at transonic speed but just below the onset of a boom, perhaps Mach 1.1 or thereabouts, has been looked at to some extent and I personally feel that that type of aeroplane might be worth looking at again in view of the advances that have taken place in the understanding of transonic aerodynamics and other technology since. I say this because with the extensions in range you, chairman, have spoken of, people do find these 5,000-mile-plus journeys pretty irksome. When crossing the Pacific and so on the journeys do seem very long to passengers, and if one could develop an aeroplane which could travel at its full speed of about Mach 1.1 over long journeys (which might include land masses) and thereby offer a journey-time reduction of 20 or 30 per cent, it seems to me that this might offer quite a degree of passenger attraction and could be a possibility for the future.

LOWE I absolutely agree with you.

ARMSTRONG

Achieving an adequate lift/drag ratio for long-range transonic cruise poses a major challenge, and would require substantial research. While there have been great advances in transonic aerodynamics, it is not evident at this stage that the required L/D would be achievable, but it seems to me that the prize is worth some serious investigation.

LOWE

We are coming to a close, so perhaps I can sum up by saying that, as I see it from things I have heard today, an extremely complex project was taken on, where it quickly became apparent that the difficulties far exceeded those that had been anticipated and therefore the costs were going to go up, but we persevered and we overcame them all and we have a beautiful aeroplane. But is the lesson that we should continually check that we are investing in the right thing, and are we really backing the aeroplane that is going to be a commercial success? Or if commercial success is not our goal, and technological success and leadership is, should we then not declare it a little bit more up front, so we can celebrate our successes a little more?

Interestingly, no-one has mentioned one of the difficulties being the fact that this was conducted in two different countries. It was the lead, major international project, often requiring the same thing to be done in a little more detail because of that – and yet it has not come up. So perhaps we could claim as one of the successes that we learnt how to run big international projects, the lesson being that, if you want the project not to be cancelled, make it an international one. It might not be cheaper, it might not be quicker, but it sure gets finished.

We also learnt the hard way that environmental concerns were of great importance, and that is often difficult for the pure engineer, scientist and aviation man to grasp as being important. Perhaps the technical challenge itself is enough, without adding these peripherals. I don't think we have got the space to be able to do that again. But let's not forget, we did it and no-one else did.

Finally, when people ask me what is my most testing moment on Concorde, I will tell you what it is. The engine is round, the intakes are square, so at the corner of each engine there is a little gap. So we have secondary air doors, as they are called. I think it is the only Heath Robinson system on the aeroplane. It is driven by one motor and one cable, and we have had more turnbacks because of this purely incidental system. The doors have to be closed for take-off because the engines are so powerful they would suck the exhaust gas back in; they have to be open for supersonic flight, because the air has to cool the engine. And they have given us trouble. I flew the Prime Minister* earlier this year to meet President Clinton,* with Mrs Blair on board, and on take-off, if these doors don't open, you have to keep the speed back to keep the air loads off so you can try to open them. We have a senior flight engineer sitting there, Mr Blair sitting behind me, we have just taken off with all the bands and fanfare and Mr and Mrs Clinton are waiting, and the engineer says 'Can you just keep the speed back to 250 knots, Jock?'. He whispered it,

Tony Blair, Labour politician. Prime Minister, 1997-.

Bill Clinton, American politician. President, 1992-2000.

and I knew he could only be saying that for one reason: the secondary air doors had not opened. So what was my most testing moment? It was the minute that it took him to re-set the circuit breaker. Anyway, they re-set and we went off on our way, we got there on time and everybody was very pleased. So this little Heath Robinson system is still there, testing us now.

Concorde
Session 3: Flight operations

This witness seminar, organised by the Institute of Contemporary British History, was held at the Science Museum, London on 19 November 1998. This third session was concerned broadly with Concorde flight operations. Sir Neil Cossons,[1] then Director of the Science Museum, London, chaired this session and the participants were as follows:

Peter P. Baker	Concorde test pilot, BAC/British Aerospace; Civil Aviation Authority (CAA).
Richard Beckett	Chief engineer, Olympus engine, Rolls-Royce.
Ken Binning	DTI Director-General, Concorde 1973-76.
Gordon Davidson	Concorde director, British Airways.
Rt. Hon. Edmund Dell	Labour politician. Chairman, Public Accounts Committee 1973-74 and Secretary of State for Trade, 1976-78.
Mrs Eileen Denza	Legal counsellor, Foreign and Commonwealth Office.
Derek John	Concorde technical sales, Bristol Siddeley Engines 1962-66; marketing director, BAC 1970-76.
John McEnery	Department of Industry (DOI) Under Secretary, Concorde 1977-81.
Gordon Lewis	Bristol Siddeley Engines/Rolls-Royce (technical director).
Henri Perrier	Aérospatiale.
Jean Rech	Sud Aviation/Aérospatiale.
Guy T. Smith	Bristol Siddeley Engines/Rolls-Royce (marketing director, Bristol engine division).
Captain Brian Walpole	Concorde captain and manager, British Airways.
From the floor:	
Harold Caplan	Lawyer.
David Edgerton	Professor of the History of Science, Imperial College of Science and Technology, University of London.
Patrick Keatley	Journalist.
Simon Young	

1 Since 2000, chairman of English Heritage.

SIR NEIL COSSONS We have reached the final session, and the focus is moving from the politics and the technology towards the operational issues associated with Concorde. I should like to invite each of my colleagues on this side of the table to introduce themselves and, in three or four sentences, set the scene for what they believe to be the crucial issues in the introduction of Concorde into commercial service.
We have dealt primarily with the evolutionary politics of this project and with the core technology of it, and we have reached the point where the scene is set by the Anglo-French 1974 decision which defined how many Concordes there were going to be and established, so to speak, the parameters within which operational considerations could be properly considered. Then turning the focus to things like where Concorde could fly, the fact that the North Atlantic was going to be the crucial arena, and this would, of course, bring into play the question of American approval.

DEREK JOHN I was involved on Concorde technical sales with Bristol Siddeley from 1962 to 1966, and came back to the project from 1970 to 1976 as marketing director of the British Aircraft Corporation. For us, the crucial issue undoubtedly was timescale. We had, whatever anybody else may say, several serious customers wanting to buy and operate that aeroplane amongst so-called option holders – Pan American, Qantas, Japan Airlines, to name but three, over and above our own national carriers. The difficulty was of course that one went in in 1970 and talked about a 1971 or 1972 Certificate of Airworthiness (C. of A.), and then six months later on again and on again, and by January 1973 when I went over to meet Bill Seawell* and the Pan Am* executive board I was to be told that they were pulling out and then of course the cards collapsed. Timescale was the big issue.

Bill Seawell, airline executive. Chairman, Pan American World Airways.

Pan American World Airways, New York.

PETER P. BAKER I joined the Concorde project in 1966 as a test pilot and remained with it until 1982 with British Aerospace. I then retired and went to the Civil Aviation Authority and still had some small responsibility for it, in the form of the annual airworthiness checks on the aeroplanes. What was the crucial point? I don't really know. As a member of the team I was under the sneaking impression that at any time during the many number of years that I was on it I was going to be out of a job, not least because it did not appear to me, even when we did deliver the aeroplane, that the airlines that received it (maybe I am unfair to Air France, but certainly British Airways) ever gave me the impression – other than the good aircrew who flew it – that they were in the least bit interested in having it: quite the reverse. So I suppose it was rather an unhappy period in that sense, except that the testing was a fascinating experience.

COSSONS Would the word instability characterise your view of the airline relationship to you?

BAKER

Yes, but another factor was that at the time we also suffered labour problems of a sort which are unbelievable and which no doubt added enormously to the cost. I do not seem to recall a time when we did not have a labour dispute of some sort between 1976 and 1982. And some of our adventures abroad and the methods by which they were done and paid for I can only describe as extraordinary.

GORDON DAVIDSON

I was made director of Concorde of British Airways when BA finally decided they were going to commit to an order. If you ask what my problems were, they were not entirely dissimilar from yours. I think it is true that there was no great enthusiasm for Concorde in British Airways, which is not surprising, since the results that were being forecast – with great precision and with a fairly high degree of optimism – were appalling. However, if you are given the job of putting Concorde into service you have to change your spots, and I certainly was enthusiastic to get it into service.

My problems were various. Perhaps the biggest one in a way was: where can we go? And it was not until 1976 that we finally set off for that exciting place Bahrain* – there was nowhere else to go. I will only mention one other big problem (there were more than two, I may say). This was that up till then, with due respect to everybody here, the French had always been first with everything: the first flight, the first this, the first that. I was determined that they were not going to have the first scheduled flight, nor were they going to have the first flight to the USA, nor were they going to have the first flight to New York. And if I achieved nothing else, I achieved that.

One of the states comprising the United Arab Emirates in the Persian Gulf.

BRIAN WALPOLE

I was a Concorde captain from 1976 to 1989, technical manager of the Concorde fleet 1976-82, and general manager of the Concorde fleet from 1982 to 1989.

Our biggest problem, in my view, in the early days was the total, utter lack of commitment of senior management in British Airways to making Concorde work. There were obvious exceptions, there is one sitting on my right [Davidson]. The turnaround came when John King* summoned me in his office in 1982 and said, 'You have got two years to turn Concorde round from these mega-losses to profit.' British Airways at that stage was just about at the nadir of its fortunes. He gave me two years to form my own team, and Jock Lowe was an integral part of that, to turn the aeroplane round. In fact it took us 2½ years to turn it round from its losses to significant profit. The critical decision was to allow me and my team to form an airline within the airline, with its own authority, its own capacity and its own ability to make decisions.

Sir John King (Lord King of Wartnaby) airline executive. Chairman of British Airways, 1981-93.

HENRI PERRIER

I was working on the Concorde programme on flight test from the beginning to the end as far as the manufacturers are concerned. But in parallel with this activity in the flight test department I was

involved for Aérospatiale in what we have called the battle for New York. I will not summarise it, because it is very well described in Kenneth Owen's paper. I will just mention the fact that at the time of the Coleman decision at the beginning of 1976 to authorise an experimental period of 16 months of operation to the United States, the main difficulty with the Port of New York was appearing very quickly. Both British Airways and Air France felt that it was their respective governments' responsibility to clear the problem, because the two airlines had ordered aircraft, under pressure from their own governments but with the target of the transatlantic London to New York or Paris to New York route. So in this whole procedure the responsibility passed to our governments, and from the governments to the manufacturers, to give the right arguments to the lawyers. There was a large discrepancy of approach between the British side and the French side. Our British friends were more in favour of going as soon as possible to the court, while the French side was more in favour of trying some kind of lobbying of the Port of New York Authority, of the Governor, and so on, before starting court proceedings. We could not say if one was better than the other. It was the second one which, as a compromise, was the choice at that time. The result was that at the end the battle was won in October 1977. If the battle had been lost I am sure there would be no Concordes in operation today, because that is the only route on which both companies are working.

Slightly correcting Mr Davidson, the first arrival in New York was a French aircraft. We were making three flights the day after the final decision of the Supreme Court; we decided to go immediately to Kennedy Airport* and make three take-offs and three approaches. We took off from Kennedy at the normal take-off weight for a transatlantic mission and in the middle of the ocean made a U-turn and returned, so in the same flight we could record one take-off and one approach procedure. This was to clear the sky with all the environmental people for the official opening of the New York service on 22 November. The aircraft was painted on one side with British Airways colours and on the other side with Air France colours. But it was a French-registered aircraft.

John F. Kennedy Airport, one of the three airports in New York.

JOHN McENERY

I was in charge of the project in the Department of Trade and Industry from 1978 to 1981. I suppose my claim to fame is that we took a decision that we would cease to pursue the chimera of sales to foreign airlines and we decided we would make British Airways the chosen instrument. This was very important, because we saw that what mattered was that Concorde should have no competition from another Concorde on the same route and therefore we had to limit London Concordes to British Airways, and that is precisely what we did. I believe that the commercial success of Concorde, such as it was, started from that point. And of course British Airways were only too happy to become the chosen instrument. I was very interested to hear it said that in retrospect £35 million was not

too outlandish a price for this aircraft, and if you do a few sums this will give you some idea of the operational surplus that British Airways is now making from it. So from some points of view this aircraft has been a big commercial success. It certainly put British Airways into the top line of airlines in the world. Without Concorde they would not have arrived there.

EDMUND DELL

My first contact with the problem of Concorde was when I was chairman of the Public Accounts Committee in 1973 and we did a very detailed inquiry into Concorde, which was subsequently published. My next responsibility for Concorde was as Secretary of State for Trade, when it fell to my department to try and get Concorde into Singapore, New York and Washington. I flew on the inaugural flights to Washington and New York, but I never flew on an inaugural flight to Singapore, because we never had an inaugural flight there.

The problems which emerged were, first, the problem of sonic boom: where could this plane fly other than over oceans? When we were trying to get to Singapore I was advised that it would be very convenient if the plane could be permitted to fly over southern India. I asked how many people would be disturbed by sonic boom if it flew over southern India and I was told only 25 million. The Indian government's response as I remember was that if the British government was prepared to allow Concorde to fly supersonically over the United Kingdom, they would give serious consideration to its flying over 25 million people in India. I didn't think that was a prospect which the British government would be likely to wish to contemplate.

The other question, with which we became very much better acquainted during the negotiations in the United States, was the nature of a federal system. One of the reasons why the British government decided that the better way was the court rather than political lobbying was that the US federal government told us that this is a federal system, the State of New York is a sovereign state within the constitutional parameters, and the courts of the State of New York will make their decision whilst the federal government have no say in the matter. We could exercise political pressure in Washington in relation to a federal airport, Dulles Airport, but we could not do that in respect of the State of New York. That was the reason why the British government came to the conclusion that the right way to proceed was via the courts in New York, and I remember having a long conversation with my French opposite number on the telephone, at the end of which he agreed that the lobbying process had been exhausted and we should go to the courts, which we successfully did.

KEN BINNING

I was the Director-General for Concorde in the UK from 1973 to 1976 and was at the operational end of some of the points which Edmund Dell has raised. A couple of observations. First, all the

negotiations with all governments was made immensely more difficult by the publicly stated decision by the British and French governments to build '16 Concordes and no more', to quote their words. This clearly meant that this was not, in the normal sense, a commercial aircraft. What was it? How far, therefore, were other governments expected to make available routes and access in those rather unusual and unique circumstances?

The second set of problems were environmental ones for those who, particularly though not exclusively in the United States, were looking for an opportunity to air them, not necessarily in relation to supersonic aircraft. It just happened to be remarkably convenient that there was an authorisation being sought for a supersonic aircraft, not owned by Americans, in relation to which they believed they had some status. This meant that all sorts of groups in the United States who had an interest in environmental pollution, noise, the adverse effects of airports on their environment, high-level ozone depletion etc, came forward and made life extremely difficult for the federal administration in the United States. This was quite apart from the problem of the dichotomy between the responsibility for interstate (including international) transport, which is a federal matter, and the responsibility for transport within a state, which is a state matter. It was absolutely clear that without being able to land the aircraft in New York the Concorde project would be dead. That was why efforts of all sorts were concentrated on that area.

EILEEN DENZA

I was a Foreign Office lawyer who was wheeled in at various critical times. The first time was in 1974 when, rather contrary to what was suggested earlier, the lawyers did advise that it was possible to escape from the treaty commitment, on what the international lawyers describe as the *rebus sic stantibus* doctrine, which is similar to 'fundamental change of circumstances' in English contract law – the hike in the oil price and the collapse in the options meant that it was possible to escape an adverse judgement had the French taken us to the International Court. So the decision to proceed to the 16 was in fact taken for the reasons of politics, prestige, commitment that were outlined earlier. Cancellation was not blocked by the lawyers in 1974.

I then came back to it in 1976-77. The British, somewhat contrary to what has been suggested, were internally rather divided. Certainly within the Foreign Office, and I think also in other departments, ministers and officials were at the outset by no means convinced that the treaty rights would prevail. A lot of the reasons why we were persuaded have been dealt with by other speakers. The essence of the case in New York was really the all-pervading nature of the right under the Bermuda 1 agreement (we were renegotiating that and soon after we had Bermuda 2, but we were still operating on Bermuda 1) and the entitlement of Air France and British Airways depended on the fact that Concorde had a British

Certificate of Airworthiness and that it complied with the laws and regulations of the United States, which it just did. We were also I think persuaded by State Department friends. The State Department were extremely helpful in their *amicus curiae* (friend of the court) brief, which strongly supported the treaty rights position being argued by the airlines and supported of course in the background by the two governments. At this stage, although of course there had been suspicions before between the British and the French, my own experience was that there was a great deal of close and helpful co-operation between the two legal teams in Washington and New York, which ultimately led to good results both in the Court of Appeal in Washington and then in the New York Court of Appeal and the Supreme Court.

GUY T. SMITH

This seminar has not yet tackled the important subject of lessons to be learnt from the Concorde programme. If one looks back to 1945 one sees that the French aerospace industry was in ruins having lost virtually six years of progress, whereas the British industry was immensely strong after emerging from a successful war. Today, although British Aerospace and Rolls-Royce are the dominant European companies in their respective fields, it is France which has the dominant political position in European aerospace. Most of the European aerospace programmes have their headquarters in France – Airbus Industrie, Eurocopter, Euromissile, the European Space Agency, Ariane etc. How has this political dominance by France come about?

Some answers to this question may be found in the French attitude towards her defence industry (of which aerospace is the major component) and in France's pursuit of an independent foreign policy from the moment General de Gaulle* became president. Aviation is almost a religion in France. Many French people genuinely believe that aviation was invented in France and that history has failed to give France due credit for the achievements of its pioneers. The French also believe that they have a natural flair for the subject and that they are better at it than other countries, notably better than the British. Whether the evidence to support these beliefs is as convincing to the rest of the world is not important. What is important is that these beliefs do foster a unity of purpose in France and lead to an admirable collaboration between government and industry which advances the national plan. The plan was, and still is, to make France the dominant aerospace power in Europe. It is noteworthy that, over the years, changes of government in France do not produce noticeable changes in the country's defence or aviation policies. Even when Mitterrand's* socialist government gained power [in 1981], there was no perceptible change in France's arms export policy. Contrast this with what frequently happened in Britain after a change of government: the aerospace industry was repeatedly subjected to cancellation of programmes as defence and industrial priorities were changed.

Charles de Gaulle (1890-1970), French general and statesman. President, 1958-69.

Francois Mitterrand (1916-96), French politician. President, 1981-95.

It was through the Concorde programme that France was able to equip her industry to produce large commercial aircraft. At the same time the British industry taught the French how to organise the standards of product support demanded by airlines for a major commercial airliner. The same experience and expertise subsequently enabled Airbus Industrie to present itself as a credible supplier of large commercial aircraft to major carriers world-wide. France thereby gained her rewards for persistently following her plan.

I think we need to learn from the French how to recognise and exploit the less obvious benefits which can flow from international collaboration. There is currently talk of setting up a European consortium analogous to Airbus Industrie but dealing with military aircraft. The French are understandably keen that the consortium should be based at Toulouse. I believe Britain should claim the right to be the host country if the consortium is created. British Aerospace and Rolls-Royce have more experience of military aircraft than the rest of Europe combined and have also more experience in leading collaborative programmes for military aircraft than any other European companies. The fringe benefits to be gained from being the host country to such a consortium in both economic and political terms are significant. It is time we had our rightful share. I believe this is one important lesson to be learnt from the Concorde programme.

COSSONS Could I invite reactions from the floor to that panoply of issues set out by the panel?

SIMON YOUNG I don't have any connection with the Concorde project but I want to ask a question. I was very struck by the reference to the decision to make only 16 aircraft. I think it was described by one speaker as a limitation, but by another as a kind of driving force. It seems to me that immediately that went into operation the government was already working towards a damage-limitation approach, and the original vision that this type of flight, which after all was unique and way ahead, might escalate into something that everyone would want, seemed to have expired. I wonder whether there was a process of transition from the original vision to what does seem to be rather like damage limitation as expressed in the '16 only' phrase.

BINNING I think you are right, it was primarily a response to two incompatible objectives. The first was to maintain the view that this was a magnificent joint technological project, the other was to recognise that it was a commercially disastrous project. And the response was to do precisely that. I mentioned the words, because the words were very important. It was the first public recognition I think of the intention to do '16 and no more'. Had the drafting been different, one could have had a situation which was less precise than that and would have helped the negotiating position (I was, after all,

referring to this in relation to the negotiating position). But whatever else it did, it made the negotiating position remarkably difficult, not only in the United States.

W. D. LOWE

I think one of the relevant points is that the cost of production exceeded any conceivable cost of sale. So if we say that the £30-£35 million was the maximum that could possibly be charged, the then cost of construction of each airframe was significantly above that: at least double and possibly treble that, regardless of trying to write-off any development costs. I am sure that just the general economics and the improbability of any significant sales helped to drive that decision.

COSSONS

It was containment, in effect. Was this also related to the issue of the numbers of aircraft?

BINNING

Yes.

JEAN RECH

I don't know whether it is the appropriate time to make these reflections, but here again is the term 'commercial disaster' or 'commercial failure' referring to Concorde. I would agree that in standard, narrow economic terms (that is, what is the investment in an enterprise and what is the return?) it was a failure. But should we not look at it in a more historical and wider sense? If we regard the money that British and French taxpayers have put into the development of Concorde as partly developing a project and partly financing research ahead of development – because of the difficulty of the project it was not a development like an Airbus model development is today, which is a four-year period involving launch customers, guaranteed performance, guaranteed price, guaranteed credit – then on the other hand it was a very big focus for the research on Concorde, in all its new ways: computing power, computing test equipment, the organisation of European collaboration in civil aircraft. In some 40 years, the civil aircraft industry in Europe has come from a very weak situation (though with occasional successes such as the Viscount* and Caravelle*) to a much stronger situation today. And if you ask the question 'Has Concorde contributed to that situation?', I think the answer is yes. We are sorry that we could not sell it, but we do not have the impression of having wasted the money of the British and French taxpayers.

The Vickers Viscount was a four turbine-propeller aircraft, first operational in the early 1950s. It remains the UK's most successful commercial aircraft, with 444 built and sold around the world.

A two-engine jet medium-range aircraft produced by Sud Aviation in the late-1950s.

GORDON LEWIS

A quick slant on the 16 aircraft. Supposing that we were thinking of future supersonic aircraft, there are many environmental and other problems, but the real obstacle is airfield noise. We do not know how to make a Mach 2 or Mach 3 supersonic aeroplane quiet enough at take-off. At the start the yardstick was the noise level of the 707* and the DC8,* and the Concorde just about scraped in –

A long-range four engine jet commercial aircraft built by Boeing in the late-1950s.

A long-range four engine jet commercial aircraft built by McDonald Douglas in the 1950s.

with the unexpected though not calculable benefit that it did not make the noise for quite as long a time. I suggest that 16 aeroplanes is just about all we could have got away with. If they had twice or three times as many Concorde operations at Heathrow and Kennedy it is quite possible that the whole thing would have been stopped years ago. So perhaps 16 was a pretty clever number.

COSSONS But a decision not consciously taken for that reason, perhaps.

DAVID EDGERTON I wonder if we could get some clarification on the costs of Concorde operation in the first years. What exactly did British Airways pay, what did the government allow to be written-off, what other kinds of hidden subsidies were there to operations, and why was it that Concorde operations became profitable, at least for British Airways, around 1982 if I remember correctly?

DAVIDSON The fairly obvious answer to most of that is that when I was running Concorde I remember charging its full costs of £164 million over ten years, so depreciation of £16.4 million a year had to be put into the Concorde account. Brian [Walpole], when he was running it, had a free aeroplane to all intents and purposes. That does make a lot of difference. My operations were limited, because we didn't have the permission and we did not have the pilots (because, as with British Aerospace, we also had industrial relations problems, with our pilots). But when you have New York, with a free aeroplane, it is not too difficult to make a profit. If you can extend those operations, as Brian has done in some very successful charter services (which were hardly the purpose of building a supersonic aeroplane) then you can probably make quite a reasonable profit.

McENERY
Stanford University, California.

I remember giving a lecture to the airline management course at Stanford University* on this, and I'd like to bring out two relevant points. The first is that if you take a subsonic aircraft you have got to amortise it very quickly, because a subsonic aircraft has a limited life and is going to be overtaken by an improved subsonic aircraft in X years. There is no conceivable rival to Concorde on the horizon, and this was obvious 20 years ago. Therefore there was no need to amortise Concorde at all, and you only begin to get to the idea of economically using this aircraft when you have got away from the idea of amortisation. This was why the government had the good sense to write-off the public dividend capital and transfer the aircraft more-or-less free to British Airways, on the basis that the government would get 80 per cent of the operating surplus. That arrangement did last for a few years.

The other point is that, if you don't have to amortise, you are not worried about high utilisation. This is very important, because it means that you can concentrate not on maximum utilisation but on maximum profitability. This was the thesis which Gordon [Davidson] and I developed together. That meant that you go for the

'thick routes' and concentrate on New York. You don't worry about going to Bahrain because you are not going to make any money that way. If you go to New York you can perhaps have an 80 per cent load factor twice a day, sometimes even a 100 per cent load factor. Then you really are making money.

LOWE

Just to clarify this issue, hopefully once and for all. The aeroplanes were bought for £164 million, five aeroplanes, and the other two were given for I think a consideration of £1each to British Airways. In 1978-79, £160 million was written-off in exchange for an 80/20 profit-share arrangement which lasted until March 1984, at which point British Airways bought the aeroplanes for £16.5 million. In addition to that, they took on the treaty responsibilities to continue in perpetuity to supply support costs and spares. In the first year I can tell you that the support costs exceeded the amortisation costs, had you put them in. So it is a quite unique arrangement, but it is not correct to say that the aeroplanes came free. In effect there is a charge, which is still ongoing to this day, to support Rolls Royce and British Aerospace, which equates to the sort of charges you would put in.

I think the last points made are very accurate. Once you know the expected life of an aeroplane, you gauge your amortisation rates accordingly. And that is why we began to make significant inroads into the profitability equation. How did we turn it round to making a profit? It was very simple. We did some market research and asked the passengers how much they thought the Concorde fare was. (It was about 25 per cent more than the first-class fare). When we asked them, they didn't know. Then we asked them to guess and most of them guessed that it was higher than it actually was. So we simply said: we will charge them what they think they are paying. And whilst we have contained costs and proper business footing, we have tried to promote the product with the non-scheduled flights and so on, and we have tried to keep a very regular and punctual service going, we have made a profit ever since on that basis.

WALPOLE

There are one or two points I would like to add. First, for British Airways in general, the halo effect (this is an expression which was coined by Gordon Davidson many years ago) of Concorde into British Airways was very significant. This was highlighted by some market research that we did in 1982-83 when Concorde had become an entity within British Airways. This market research asked people sitting down the back end of a 747* why they were flying British Airways, to which a significant response was basically, 'If you can operate clever things like Concorde, you sure as heck can get me safely down the back end of a 747 from London to wherever.' That was a classic example of the halo effect.

A long-range four engine jet wide-body aircraft built by Boeing in the late-1960s.

The other issue that we had to address in our market research was to ask people not so much were they happy with what we were

doing with Concorde, but what did they want us to do with Concorde? These are two separate and very different issues. It was in the light of their response to the latter question that we tailored and massaged and changed the Concorde operation. One of the prerequisites of that of course was to have our own dedicated engineering base, to support regularity and safety and efficiency with the Concorde operation.

HAROLD CAPLAN

I am a lawyer, I have had a slight contact with Concorde, apart from being a passenger occasionally, in that I was involved in contract negotiations for the purchase of Concordes outside the realms of British Airways and Air France. If there had not been a popular revolution in Iran, there might well have been another reluctant airline customer. I wish to ask Mrs Denza whether, now we are outside the 30-year period, the public records of the law officers' advice on the breakability of the contract are available, comparing 1962 when the treaty was signed with 1964 when the government obviously wished to get out of it. *Rebus sic stantibus* (fundamental change of circumstances) is always the excuse used by government when they find things get a little awkward, so it would be interesting to know: are those papers now publicly available?

DENZA

The papers on the advice in the early 1960s would be available in the Public Record Office. The advice given in 1974 has not yet run the 30 years, so I expect to have the handcuffs clapped on me when I leave the building.

DELL

Reference has been made to some of the benefits that have arisen, for example to British Airways, from the existence of Concorde. I don't know how substantial they are and whether they have been calculated, but I would very much doubt whether they justify the enormous expense of this aircraft. But if anyone can produce figures which show that they justify that expense, it would be very interesting to see them. The other thing is, something I don't place very great weight on, that a negative effect of Concorde was of course trying to negotiate it into destinations other than Washington and New York. It is true that Bahrain was not a very interesting destination, but the object of going to Bahrain was to get to Singapore and that might have been an interesting destination for Concorde. Unfortunately, getting into Singapore involved not merely getting round India, because India would certainly not have agreed to it flying supersonically over India, it also involved it going down the sea which lies between Malaysia and Indonesia. I remember this particularly well, because my opposite number at that time was a Dr Mahathir Mohammed,* who is now and has been for 17 years the Prime Minister of Malaysia. I had a conversation with him about the possibility of Concorde being allowed to use Malaysian waters on the way to Singapore, and his immediate response was, 'I'll consider that if Malaysian Airlines are given more landing slots

Dr Mahathir Mohammed, Malaysian politician. Prime Minister, 1981-

in Heathrow'. There were these other, negative aspects to these negotiations. We never got Concorde into Singapore, partly because we were not prepared to give Malaysian Airlines those additional landing slots which he wanted as a bargaining counter if permission were in fact granted.

DAVIDSON I was involved in this, too, and indeed we would have been charged or penalised by Singapore Airlines as well as Malaysian Airways. But I made a deal with Singapore Airlines whereby they shared the costs of a joint service between London and Singapore. And, contrary to what was said earlier, there was an inaugural flight. There were three flights before the fishes of the Malaysian Sea had to be protected by the withdrawal of Concorde, and it didn't return until several years later. When the service did operate, apparently it was grossly uneconomic and was cancelled. I have never understood why. That always looked to me one of the best long-haul routes for Concorde, because we would have fed all our traffic from Europe and the USA into it, Singapore Airlines would have fed all their traffic from Japan and Australia and so on into it. It should have been great, but it did not work.

DELL When was the inaugural flight to Singapore?

DAVIDSON 9 December 1977.

DELL Well, you should have invited me on it.

McENERY I don't know the exact history of the Singapore flight, but I think it is worth making the point that it wasn't just, as Mr Dell has said, the problem of getting round India and getting round Sumatra and going off airways down the Sumatra Strait, there was a problem of getting over the Middle East. We never solved that problem. I think we started off by going over Syria and then I think we were going over Sinai when Sinai was a no-man's-land, and when that was got by the Egyptians it became problematic. I think we gave up then, didn't we?

WALPOLE Yes, we did. There was another issue, and that was that the amount of spares that were available to Concorde were limited. To have to stretch our limited spares capability all the way down the Far East, through Bahrain, Singapore, and the alternate airfields as well and into Australia simply did not make sense. The money that Concorde was going to make for British Airways was to be found on the North Atlantic, for which it was originally designed. Combine that issue with the fact that, in spite of the best endeavours of the negotiators, we were being quietly screwed by Singapore Airlines – another issue for another day.
One further point. When British Airways was privatised I was

Mrs Margaret Thatcher (Baroness Thatcher of Kesteven), Conservative politician. Prime Minister, 1979-90.

A World's Fair held in Vancouver, British Columbia, to mark the city's one hundredth anniversary.

invited to fly Margaret Thatcher* to Vancouver for EXPO 86,* and it gave me an opportunity to encourage her to take a sympathetic view to Concorde. She was in transmit mode and it was very difficult to get her into receive mode, but anyhow we had a go, it took about two hours. We were able to explain to her that, in spite of her protestations that the government would never ever fund another project like Concorde, British Airways was privatised for something just short of £1 billion, and approximately 10 per cent of that asset value was Concorde and its then profitability. So there was a return to government of something like £100 million of profit through the privatisation issue. A point which, she said, had not entirely escaped her.

DELL

Can you give those figures in real terms? The value of money unfortunately has changed rather substantially over the period 1962 to 1982.

WALPOLE

Absolutely. No I can't; I'm sure an accountant could.

COSSONS

Derek John, you made the point that there were other airlines in the frame as potential purchasers early on for Concorde. How close did any of those airlines come to being real buyers, and what routes did they think they were going to use them on?

JOHN

Trans World Airways, an American carrier.

The major carriers included Pan Am (the most enthusiastic), TWA,* and Braniff (which was going to operate in South America). I have to say that in those days in the early 1970s there was a more relaxed attitude with regard to flying over populated areas; it was thought that this was a problem that could be solved, and that negotiations over the less-populated areas would allow airlines a degree of flexibility. Notably, for instance (unrealistically or otherwise, because the Russians had the Tupolev 144) it was thought that carriers would be allowed to fly London-Novosibirsk-Tokyo, and of course Japan Airlines liked the idea of that as well.

Lufthansa, the German flag carrier.

Who else? Lufthansa,* of course, and here I should mention that one of the problems we had in marketing was undoubtedly the tightness of the range of the aircraft. This is why the proposed B aircraft for us marketing guys was pretty important. If we had a few hundred more miles, Frankfurt-New York was a possibility. Lufthansa were among the option holders, but frankly we knew that that was going to be pretty tight. Up to about 1972 most of these airlines were genuinely, seriously interested. The customer airlines participated significantly in a group known as the Mentzer Committee (led by Bill Mentzer, then technical director of United Airlines) which co-ordinated airline requirements for Concorde. I am sure that those here today who were on the development programme will agree that they did contribute significantly to making that aircraft much more airline-compatible. These airlines, I propose to you, were up until about 1972 very serious about Concorde.

Returning to the overflight of populated areas, I was quite proud that after a lot of discussion down in Australia we got permission to fly, admittedly on a trial basis, the Melbourne-Singapore route. We did that successfully seven times. There was evidence that it was not unrealistic to think that you could fly these aeroplanes in areas that were populated. Subsequently it all fell apart, as I said, because of timescales. The range of the aircraft and the timescale is really what knocked the hell out of the enthusiasm of several important carriers.

Many figures were being bandied about at the time for the market potential, such as 150 to 200 Concordes. We did not believe that in the British Aircraft Corporation, we didn't kid ourselves at all, but I do believe that we could have made a sale of about 50 or 60. This raises Gordon Lewis's point as to whether the world would have lived with that. That is another issue, but I believe the airlines would have been seriously interested in trying.

PERRIER

Just to add that, during the development phase for the definition of the production aircraft there were three airlines which were in permanent contact with both British Aerospace and Aérospatiale: BOAC* at that time, Air France, and Pan Am, with exactly the same level of responsibility for the Pan Am representative up to 31 January 1973. During the night of 31 January/1 February 1973 we received the cancellation of Pan Am, and two hours later from TWA, and a few days later American and Japan Airlines, and it was the end of any discussion with a major airline. And I am sorry to correct you, Derek, but there was never a good level of discussion with Lufthansa.

British Overseas Airline Corporation. The merger of BOAC and British European Airways in 1974 formed the carrier British Airways.

JOHN

Not from a technical point of view.

PERRIER

From a technical point of view, exactly, with the idea that maybe they will operate the aircraft and maybe not.

COSSONS

Not a major airline, but did Iran Air not order two at the time?

JOHN

They did.

PERRIER

I think we on the French side were in a closer relationship with the Russians than our British friends, for political reasons, and I think Jean Rech is the best person to answer the questions on the reasons for which the Tupolev 144* was not achieving the same technical result.

The Soviet supersonic passenger aircraft. One crashed at the Paris Airshow on 5 June 1973.

RECH

I don't think the Russians copied us. While there have been several articles in the press, the natural laws of physics lead to solutions which are closed. In fact they had a double-delta wing, which looks like the wing of Concorde but is less sophisticated in the compro-

mise between the required supersonic qualities and subsonic qualities. But the main difference in my view is in the propulsion system. There were two things. They chose a fan engine with too high a rate of dilution, and they suffered a loss of thrust in cruise which made the continuous use of re-heat all the way along inevitable, which is a disaster in terms of engine fuel consumption and aircraft range. As far as the air intake is concerned, they never believed that we achieved an intake which was half the length of theirs. That was a mystery for them, they were persuaded that our intake would never work. In their view, the intake has to be long enough to ensure a good distribution at the intake of the engine, so that the engine can swallow the air and not surge, but we had proven in wind-tunnel tests that it is not the length of the intake that matters. If you have a bad distribution immediately downstream of the shock system you will have it two metres downstream and also four or five metres downstream, in the subsonic diffuser. So they had a very heavy propulsion system. Those are the two things that determine the range, and the 144 had about half the range of the Concorde.

EDGERTON I wanted to come back to the question of costs. What was the expected selling price for Concorde in the very early 1970s when you had these options?

LOWE It was £35 million.

EDGERTON So it bore no relation to the production costs even then.

LOWE Its anticipated entry into service was in early 1976 at a £35 million expected purchase cost.

COSSONS So before this cancellation when Pan Am and then the rest all cascaded out of the debate it was £35 million?

LOWE With that expected entry-into-service date, and including some spares.

McENERY The essential point about the New York business is really quite simple. The Port of New York was terrified of legal action against it on account of noise by aggravated householders who lived near the airport in places such as Far Rockaway. Therefore, to defend themselves they had to be forced in law to admit Concorde: then they were covered against legal action. It was as simple as that. And that is why they had to fight it all the way to the Supreme Court, but I am sure that when the Supreme Court ruled against them they were very pleased, because it was good business for New York.

PERRIER

Caesar B. Pattarini. Director of aviation, the Port Authority of New York and New Jersey.

I am not too sure they were very pleased immediately after that. I remember meeting Mr Caesar Pattarini* two days after the Supreme Court decision and he was not very enchanted.

COSSONS

Within the range of decisions and permissions that were needed, to come back to your question, there was no point where you believed American airlines were working against the interests of getting Concorde on the line?

PERRIER

We did not have that feeling at the time.

BINNING

They were not of course working to favour the project and, to the extent that they had a range of contacts, no doubt they would indicate a coolness towards ordering the aircraft for commercial reasons which were not unique to them. One comment which goes back to the early negotiations for entry into the United States: of all the projects which required international consents, Concorde mobilised and used more 'public relations' resources than any other project I can think of, probably by an order of magnitude. It was for most of the time an interesting collaboration between the British and French. The political attitude of the Foreign Office and of ministers, as far as the British were concerned, was that they wanted to distance themselves to some extent from the detailed work going on in the United States. This was not true of the French to the same extent, but they had a problem initially as being perceived as *persone non gratae* in the States. But Aérospatiale in particular funded very large efforts by a range of consultants, who attempted to address all the technical concerns which were raised by the environmental groups. They funded the work on research and presentation, the British appeared in public to explain, and it worked rather well. The effect as far as the operation was concerned in the United States was that it had an independence which was very unusual in relation to a government-funded project. I think this was true on the French side, it certainly was true on the British side.

When one was there and one was taking part, the objective of the operation was absolutely overwhelming; and reporting back, which is the conventional thing to do, frankly took second place over quite long periods. That is unique in my experience and I think unique in most people's experience, in relation to a public relations exercise, which was after all overtly on behalf of the British and French governments. To give you an example, I recruited Bill Ruckelshaus, a distinguished lawyer, distinguished because he had been the assistant attorney general and had resigned over the Nixon affair, so he was whiter than white. He was recruited as the legal adviser to Her Majesty's Government. Now that is a very unusual situation, even more unusual now in retrospect than it was at the time. But it helped. He went on thereafter to be the head of the

US Environmental Protection Agency.

EPA,* so he had a highly credible record of environmental concern.

PATRICK KEATLEY

As a diplomatic correspondent I had contact with this project intermittently in the period we are talking about, and I then went off on trips and came back to London to find out the state of play. Between trips Concorde changed its name: it was a good British Concord when I was leaving on one occasion, and when I came back it was a suitably Anglo-Française project with an 'e' attached to the word. I wondered, was there some discord which became concord which solved the problem? I could never get a straight answer on when it changed and who pulled it off.

PERRIER

The 'e' I think was decided just before the roll-out session of December 1967 in Toulouse, on the suggestion of your minister.

COSSONS

Tony Benn (Anthony Wedgewood Benn), Labour politician. Postmaster-General, 1964-6; Minister of Technology, 1966-70.

Tony Benn* took credit for it, I know that.

PERRIER

A three engine jet long-range wide body aircraft built by MacDonald Douglas.

A two engine jet short to medium range wide body aircraft built by the Airbus Industrie.

As we are nearing the end of this session, could I say a few words on what was presented as a French domination of the aerospace industry. There is no will for French domination. It is very true that probably during the last 25 years or so the support from the government was maybe better in our country than in yours. But I think that the turning point in the balance between Toulouse and Filton or wherever is unfortunately the British decision not to be a partner in Airbus from the beginning. That was a decision in 1968, so Hawker Siddeley were still a subcontractor. Unfortunately, we chose the General Electric engine, the same engine and nacelle as on the DC10.* And you, as British industry, are joining only at the launching of the Airbus 310,* which was ten years later. I am not here to criticise the decision which was taken in 1968, but certainly it was one very important point.

As far as technicians are concerned, we have a very high level of confidence in our British colleagues and it was developed during the Concorde programme. Before that we had never worked together, and certainly we would have been prepared to work more closely together with our British colleagues rather than with the Germans.

COSSONS

I won't allow that particular avenue to open up but what I would like to do, as we are bringing to an end what has been an extraordinarily vivid seminar, is to invite two more comments from the floor, then any further comments from this side of the table as one-sentence sum-ups.

LOWE

For the record, as far as I know the only time there was any overt

interference by the American airlines as a whole was on 28 December 1983, when despite anti-trust laws TWA and Pan Am both filed with the CAB* a paper indicating that there should be at least a 25 per cent surcharge on Concorde in one case and 50 per cent in the other. That was the only time I know, although we have all heard the conspiracy theories of them working behind the scenes. To the best of my knowledge this was the only overt attempt somehow to interfere with and contain the Concorde operation. The fact that we were already charging more than 25 per cent surcharge at that time seemed to have escaped them.

US Civil Aeronautics Board.

As undoubtedly my final comment for the day, I would say that we still have to clarify in our own minds whether this project was our equivalent of the man on the moon (the Americans have not taken too many fare-paying passengers to the moon, but that does not mean that that was not a tremendously successful project) or whether we actually set out to make a commercial project on its own. I think separating those two things is still one of the most important issues.

RICHARD BECKETT

I am the current chief engineer on the Olympus engine. My job is to look to the future; today we have spent looking to the past. Last year we conducted an in-depth health check on the engine, checking it against today's technology so that we could underwrite Concorde to go on for a further 20 years as required. At that check the engines stood up remarkably well. That is a tremendous tribute to all the people who were involved in its design and its improvement. I believe a similar statement can be made on behalf of the airframe. Concorde is at about its half-life. The second half I am sure will be equally successful, and will be stopped only by economic or political reasons. I believe the technology is good for 40 to 50 years – a tremendous tribute to those people in this room who made it all possible.

Just one last comment. I was at Charles de Gaulle Airport* a week ago when a Concorde came up and parked. Everyone got up, got their cameras out and took pictures of it, and the comment was 'Isn't it beautiful?'. Again, what a tribute. A word I don't think we have heard today is the beauty of Concorde. Thank you to all those people who made it possible.

One of the two principal airports in Paris.

COSSONS

And thank you for such a positive final statement from the floor. Certainly, as I walk down Exhibition Road in the evenings, virtually everybody on Cromwell Road and Exhibition Road stops and looks into the sky when Concorde comes in on its approach into Heathrow.

DENZA

I don't think I have any legal points, but I was reminded by the comment on Bahrain as a route that I have an historical collection of cartoons about Concorde. The one that appeared the day that the Bahrain service opened shows the plane landing in the middle

of the desert with all the businessmen alighting and getting on to camels, and the caption is 'With a really fast camel you could be in the centre of Bahrain in 24 hours'.

DELL

Just one point. The latter part of the negotiations in the State of New York took place during the re-negotiation of the Bermuda 1 services agreement with the United States, which I denounced in June 1976 contrary to the advice from the Foreign Office. During that period, civil aviation relations with the US generally were not very good, in fact I understand they are not very good even now, 20 years after Bermuda 2. When we were on the inaugural flight to New York we were warned that when we landed there would be a demonstration against Concorde. When we arrived I looked around for the demonstration, and I perceived about half-a-dozen people carrying placards; that was the extent of the demonstration at that time.

McENERY

I believe very strongly that the British aircraft industry has been underplayed in this seminar. If we go back to the Airbus decision in 1966-67, the government faced a real dilemma. There was the question of whether they would finance the development of the RB211 engine, or finance Hawker Siddeley in Airbus. For various reasons the decision went in favour of the RB211 and, although that engine subsequently brought Rolls-Royce down, in fact it has been the most successful engine in the history of the company. It is an extraordinary engine, it is dominating the world's airlines now.

But although we backed the RB211 we did not neglect the Airbus, and we went to enormous trouble to get Hawker Siddeley into that programme. I will tell you how it was done. We used to have a problem of offset with the Germans, that was, offsetting the currency paid out for the Rhine Army. We agreed with the German government that if they financially backed Hawker Siddeley, so that Hawker Siddeley could do all the development, then we would accept any future sales of the Airbus, to the extent of Hawker Siddeley's contribution, as offset against Rhine Army. This was perfectly reasonable, because we then would be getting foreign currency which we would not otherwise get. So this was actually a brilliant arrangement, because it enabled us on the one hand to stay in the project, on the other it helped Rhine Army costs and it also helped Airbus, because Hawker Siddeley had great expertise in wing design.

So we did not do badly there on the civil side. Consider also what we have achieved on the military side. France has got her Mirage 2000,* and it is a very good aircraft, but look at what we have done with the Tornado,* which is a very successful aircraft with very big export sales. It involves Germany, Italy, Spain and ourselves, and we now are fully engaged in the Eurofighter, as a continuation of the Tornado. So we are not doing badly.

A combat aircraft, produced by Dassault. One of the most successful fighter plane series ever built and used by airforces throughout the world.

A multi-role combat aircraft built collaboratively between the UK, Germany and Italy (Panavia).

PERRIER

Unfortunately I could not imagine Concorde having achieved only half of its life, which means 20 years more. I don't think, for technical reasons, that we have got the potentiality to go further than about 2010 with the present rate of operation by British Airways.

WALPOLE

Throughout today we have heard how very close Concorde came to being cancelled at various stages, from the 1960s right through to the mid-1980s. Never was Concorde closer to being stopped than in the negotiations between British Airways and government in 1982-84, when we were invited as an airline to pick up the support costs and to pay for the spares. In early 1984 there was an impasse on the price that we would have to pay for the spares and our acceptance of the support costs. I believe we were within about a month of having to say no to the unacceptable price and the downside liability of these support costs. We eventually resolved it with a payment, but I am told reliably by a source within government that the government view was that we were unlikely to agree to pick up the costs. In other words, the government did not expect us to pick up the costs. They expected us to stop, and I believe that I am justified in saying that, if British Airways had stopped, Air France may well have been minded to follow. And that would have been the end of supersonic civil aviation for a mighty long time.

BAKER

The US National Aeronautics and Space Administration.

One point that I would like to make for the record is the assistance of the American civil agencies such as NASA* and the FAA in the development of Concorde. It does not often get much advertisement. We have heard one or two suggestions that there was a lot of opposition in America. In fact there was in my experience more support, even amongst airlines. But the big support we were given was by NASA: the use of their advanced flight simulator, for example, and their Boeing 707 coming over to this country to allow us to do anti-icing trials. Not very well advertised at the time, because it was not thought a very good idea that certain people in the States should know that it was taking place. But they gave us a lot of support, and the basic aviation industry in America was very much in favour of Concorde, in spite of the fact that they might have been competitors.

JOHN

I can only conclude by saying, as one member of this enormous team associated with the Concorde, how it delights me to see our French colleagues here today because, above all else, the rapport and the relationships developed superbly between us all. I think you kindly said that to us and I want to say that we enjoyed it too.

COSSONS

Thank you very much indeed. I won't attempt to sum up. I think your comment, Derek, was the most appropriate summation of everything that today represented. May I thank you all for your enthusiastic participation in this seminar.

After Gonesse[1]

Kenneth Owen
Research Fellow, Science Museum, London

The Concorde's 24-years unblemished safety record in airline service was abruptly broken in the most public and tragic way on 25 July 2000, when an Air France aircraft, F-BTSC, crashed shortly after take-off from Charles de Gaulle Airport, Paris, killing 113 people. The Concorde had been chartered as Flight AFR 4590 to carry 100 passengers to New York.

The bald facts of the accident were summarised in the preliminary accident report published by the French *Bureau Enquêtes-Accidents* (BEA) the following month:

> During takeoff from runway 26 right at Roissy Charles de Gaulle Airport, shortly before rotation, the front right tyre of the left landing gear was damaged and pieces of the tyre were thrown against the aircraft structure. A major fire broke out under the left wing. Problems appeared shortly afterwards on engine number 2 and for a brief period on engine number 1. The aircraft was neither able to climb nor accelerate. The crew found that the landing gear would not retract. The aircraft maintained a speed of 200 knots and a radio altitude of 200 feet for about one minute. Engine number 1 then stopped. The aircraft crashed onto an hotel at *La Patte d'Oie* in Gonesse.

The report concluded with the recommendation that placed the entire future of the Concorde in jeopardy:

> The technical investigation into the accident to Concorde F-BTSC operated by Air France which occurred at Gonesse on 25 July 2000, conducted by the BEA with the participation of representatives of the AAIB [the British Air Accidents Investigation Branch], has so far established the following facts:
>
> During the take-off run the front right tyre of the left main landing gear was destroyed between Vl [decision point for take-off, in this case 150 knots] and VR [rotation speed, in this case 198 knots], very probably because it ran over a piece of metal.
>
> The destruction of the tyre caused damage, either directly or indirectly, to the aircraft structure and systems, leading to the crash less than one minute and thirty seconds after the destruction of the tyre.
>
> The damage sequence and the links between the various events are not yet fully established. Nevertheless, the following events occurred:
>
> – one or more punctures of at least one fuel tank with a major fuel leak;
>
> – ignition of the leaking fuel and an intense fire which lasted for the duration of the flight. The fire appeared within a few seconds of the destruction of the tyre;
>
> – a loss of thrust on one, and then two engines;
>
> The crew had no means to make them aware of the nature of the fire nor to take action to contain it.
>
> Moreover, the in-service experience shows that tyre damage during taxi, takeoff or landing is not an unlikely event on Concorde and that it may actually lead to damage to the structure and to systems. However, this had never caused a fuel fire.

1 Gonesse is the suburb of Paris which was the scene of the Concorde crash on 25 July 2000.

> The accident that occurred on July 25, 2000, has thus shown that the destruction of a tyre – a simple event which cannot be asserted not to re-occur – had catastrophic consequences in a very short time-scale without the crew being able to recover from this situation.
>
> Consequently, without prejudice to additional elements that may arise during the course of the investigation, the BEA and the AAIB recommend to the *Direction General de l'Aviation Civile* of France and the Civil Aviation Authority of the United Kingdom that:
>
> • The Certificates of Airworthiness of Concorde be suspended until appropriate measures have been taken to ensure a satisfactory level of safety as far as the tyre destruction based risk is concerned.

This recommendation was immediately accepted on 16 August 2000 by the French and British airworthiness authorities, and the Concorde's Certificates of Airworthiness were suspended. The next day an Anglo-French working group of senior government transport officials and civil aviation authorities was set up to co-ordinate work and review progress on restoring the airworthiness of the aircraft. Regular meetings of the group followed in September, October and November, in parallel with technical meetings by the recently renamed manufacturers – *Aérospatiale* had become part of European Aeronautic Defence and Space Company (EADS), and British Aerospace was now BAE Systems.

Since the Concorde's entry into airline service, there had been six previous cases of damage to the wing fuel tanks, five of which had followed burst tyres on take-off. None of these had caused a fire. The greatest damage was caused to an Air France Concorde on take-off from Washington Dulles Airport on 14 June 1979, after which improvements in the landing gear systems and operating procedures had been implemented.

On 24 July 2000, the day before the fatal crash at Gonesse, British Airways had grounded one of its Concordes temporarily after the discovery of a small crack in a 'non-critical' area of a wing spar. After the crash both airlines cancelled their Concorde services that evening, but British Airways resumed them the following day, reaffirming the airline's 'complete confidence in our Concorde aircraft'. (The Air France Concordes remained grounded). On 31 July BA reported three minor Concorde incidents over the previous two days: an engine surge on landing at Heathrow; a refuelling problem at Heathrow; and diversion of a New York flight to Gander, Newfoundland, after passengers noticed a smell of fuel in the cabin.

Also on 31 July, French and British airworthiness officials and Concorde airframe and engine manufacturers met in Paris. After the meeting, BA confirmed that its Concorde operations would continue, declaring 'No further information or facts emerged at the meeting to indicate that there is any safety, technical or operational evidence against British Airways continuing safe Concorde Operations'. These operations continued until August 15, when the airline was told of the imminent suspension of the Concorde's Certificate of Airworthiness.

In December 2000, a commitment was made to embark on design modifications to the Concorde which would improve its survivability. The full cause of the accident remained uncertain, however – it was known that the burst tyre had caused the puncture of the wing fuel tank, but the cause of the fuel ignition remained unknown. At the fourth meeting of the working group in London on 16 December, the authorities accepted 'a most probable scenario' for the crash that had been put forward by the manufacturers. 'Based on that', a joint statement continued, 'they [the manufacturers] presented a programme of work for the lifting of the suspension of the certificate of airworthiness which the group believes is sensible and achievable provided there are no unforeseen difficulties during the tests and analyses that have been planned'.

Work had been focused on four areas: (1) the lining of the fuel tanks; (2) the ignition of the fire and protection of the aircraft against similar events in the future; (3) damage to the hydraulic systems; and (4) the loss of engine thrust. The manufacturers intended to insert internal protective liners in the fuel tanks, and this modification should be tested on a British Airways Concorde 'around next February' (2001). As for the ignition source, the group reported:

> No precise scenario is yet known with regard to the origin of the fire. The manufacturers are proposing to shield the aircraft from potential arcing in the electrical harnesses in the landing gear bay and to demonstrate that, with the fuel tank liner modification, fuel links will be so small as to eliminate the risk of fire in the event of a similar occurrence.

Thirdly, work was underway to confirm the integrity of the hydraulic systems, though no need for any modification had been identified. Finally, investigation had shown that the amount of engine damage sustained would not have led to a catastrophic loss of thrust. No powerplant modification was planned, but further tests to simulate fuel ingestion would be carried out from Istres in the south of France.

Thus, at the end of 2000, the Concorde's makers and operators were hoping, all being well, that the airworthiness of the Concorde would be reaffirmed within a few months and that supersonic services could be resumed. Between those hopes and that resumption lay the severe challenge imposed by the tight design margins of the supersonic aircraft, in particular by the highly sensitive weight penalties that modifications can bring. And, even if a satisfactory technical solution could be devised and approved, the cost of the modifications might raise questions over the economic viability of the return of the Concorde to airline service.

British Airways appeared determinedly optimistic, and was aiming to bring forward a planned major re-fit of Concorde cabin interiors while the aircraft remained grounded. In the meantime, the formal process of investigation to determine the cause of the accident continued.

Commentary:
Concorde's Farnborough origins

Sir Arnold Hall
Chairman, Anglo-French committee of directors for the Concorde engine

When I became director of the Royal Aircraft Establishment at Farnborough in 1951 I initiated an establishment-wide study of transonic and supersonic flight as the possibilities would affect fighter, bomber and civil aircraft. The civil-aircraft study concluded that the region of Mach 2 was the best target area, on a balance of the aerodynamic, structural, and economic considerations. The aerodynamic study led to the ideas of the vortex wing as likely to offer a good compromise between subsonic and supersonic performance. Morien Morgan, who had been head of the guided-weapon department and became one of my two deputy directors, kept a watchful eye on the studies, and emerged a strong advocate for what became the Concorde conception.

I left the RAE in 1955 to join the board of the Hawker Siddeley Group, and in 1958 became the managing director of the newly formed Bristol Siddeley Engines, a merger of Bristol Engines and Armstrong Siddeley. Being totally convinced that if a supersonic civil aircraft was to come about, it would do so in a collaborative international setting, and noting the apparent USA preference for a higher cruise Mach number we concluded that the most likely outcome, if anything were to emerge, would be an Anglo-French arrangement, and I therefore arranged discussions with SNECMA, the French aero-engine company. These talks resulted in an undertaking by the two parties that if an Anglo-French project to design a supersonic civil aircraft were to emerge, SNECMA and Bristol Siddeley would together seek the engine contract. This agreement was signed in 1959. The agreement also provided that collaborative work would start immediately to define a suitable engine, and to reach agreement on the details of the most effective split of the design and eventual production work. The engine that emerged was the Olympus 593. When the Concorde treaty was set up in 1962, our planning was well advanced, and our submission gained the contract to design and supply the engines.

Commentary:
Concorde: questions and lessons

M. J. Michell
Department of Trade and Industry, 1969-88

I worked in the Concorde division of the Department of Trade and Industry from 1969 to 1973, after a period as private secretary to the Permanent Secretary. Subsequently (1984-88) I was head of the DTI's Air Division, which by then had subsumed the old Concorde Division. During that period I co-chaired what I believe was the final meeting of the Concorde Management Board. The Concorde Directing Committee had by then already ceased to function.

Why did the UK government not withdraw unilaterally from the Concorde project? The perceived risk of paying damages to the French, as judged by the government's legal advisers, was expressed only in terms of probability. I believe from conversations many years later that the French Ministry's legal advice was that the probability was they would not succeed in such an action. At various points this legal advice was more or less influential on decision-taking in the UK. Certainly the legal advice in 1964-65 was very influential in persuading the Wilson government not to proceed with the decision to withdraw which they had provisionally taken, although at that early stage it might have been hoped that any financial damages might have been kept fairly low. After all, the French had themselves pulled out of the Anglo-French Variable-Geometry (AFVG) aircraft with impunity.

A more positive factor which was always present was a desire to appear good Europeans, and specifically to gain favour with, or not to upset, the French. I am sure this was a strong factor in the original decision to launch in 1962. Thereafter it was almost uncanny how critical moments for Concorde would coincide with critical periods in Britain's aspirations to join the EEC or not to wish to appear 'anti-European'. Another reason why Britain never withdrew was that the sums involved, though large, were not back-breaking in annual expenditure terms, and there was always the feeling that if we could only just get over the next hump, all would be well. The financial savings, if any, from cancellation could always be presented as a poor bargain against the downsides. Maintenance of employment also was a factor, although I do not recall it ever having the same importance as the two key factors of European policy and technological leadership (except possibly during the time of the CPRS inquiry when I seem to remember they made rather a lot of it).

How did the Ministry of Aviation overcome the consistent Treasury opposition to the project? There was a sense in which the Ministry hardly had to. The foreign policy considerations, and what was thought to be the legal position, were sufficient to overcome Treasury opposition. One consequent casualty was British Government participation in the Airbus programme. This ceased in 1969, while participation in Concorde, the Multi-Role Combat Aircraft (MRCA, later Tornado) and other collaborative projects went on. The British Government rejoined the Airbus programme as a governmental partner ten years later.

Lessons

The great lesson of Concorde is how relatively easy it is for a large project to gain government support, whatever its economics, if it can be made to appear aligned with a political imperative of the moment. In the Concorde's case this was the pro-European- Community theme, coupled with the simple concept of the aircraft being necessary to maintain technological leadership. Both concepts were easy to grasp and inherently persuasive to a large number of politicians and the public. After all, it did not cost that much money, enabling skilful proponents to play on a third theme of

challenging criticism with a 'So are you saying Britain can't afford it?' line. Remarkably, therefore, the project seemed almost to gain in popular appeal and affection as the costs mounted. The basic lesson ought to be to avoid being beguiled by such arguments in future. Subsequent history suggests the lesson may have been only partially learned.

More specific lessons relate to the importance of well-founded contractual arrangements with collaborative parties, and of more accurate cost estimating. The second of these lessons probably has been quite well taken. The first one probably has not, and in the end a certain lack of contractual precision (particularly over termination arrangements) may be one of the necessary prices of international collaboration, particularly where projects with a high 'political' focus are concerned.

Clearly, one of the lessons of Concorde was the importance of making realistic market-research and sales estimates before a project is launched. Some estimates were done, but basically the project was launched on an assumption that people wanted greater speed. Historical evidence up to that time appeared to support this, including the still-recent introduction of commercial jets. More thorough and perceptive market analysis might have cast doubt on this assumption. The 'option' system led many to assume the commercial prospects were better than they were. The options were in fact virtually worthless, being no more than cheap hedging devices on the part of the airlines. It was only in 1969 that the two governments established a 'commercial working group' to start seriously studying the sales prospects (the French nominated an official from their defence sales organisation to be their representative, which seemed indicative of an attitude). The lesson of Concorde in this area probably was reasonably well learnt: for example, for the Airbus A320 and A330/340 launch-aid cases in the 1980s, the governments put quite a lot of effort into independent evaluation of sales prospects.

Undoubtedly the sonic-boom problem was underestimated – not perhaps so much in itself as in the way in which it could be used as a rallying symbol for environmental protest generally. In this respect the Concorde could be viewed as a kind of predecessor of the Brent Spar – i.e. a case of an environmental problem being identified and an appropriate solution being developed (in this case, no supersonic flying over populated areas) on the basis of sound research and consultation, but with a complete failure to anticipate how an emotional response to the issue could be manipulated against the project.

Ultimately, the lesson has to be simply to think a bit more carefully, and to avoid the trap of concluding that, when technology enables a thing to be done, it should be done. In 1988 I recall being visited by the representative of an international research institution canvassing views on the possible launch of a second-generation supersonic transport. He asked what would be the attitude of HMG to such a project? I said it would be one of great concern for the mental and pecuniary health of its proponents. The researcher replied that such a response did not fit his computer program, and could he interpret my comment as being that HMG would be against it? I said I guessed he could.

Documents

I

Covering letter dated 9 March 1959 from Morien Morgan, Chairman, Supersonic Transport Aircraft Committee, to Air Chief Marshal Sir Claude B. R. Pelly, Controller of Aircraft, Ministry of Supply.

Public Record Office PRO SUPP 29/1

Sir,

Report of the Supersonic Transport Aircraft Committee

I have pleasure in submitting to you herewith the Report of the Supersonic Transport Aircraft Committee.

The Committee was set up to initiate and monitor a co-operative programme of aimed research designed to pave the way for a possible first generation of supersonic transport aircraft; and to make recommendations, when sufficient research information had been obtained and digested, on the character of such aircraft. Participants included representatives of Aircraft and Engine Firms, Airline Corporations, the Ministry of Transport and Civil Aviation and the Ministry of Supply. The research programme is being financed through the Ministry of Supply by individual research contracts.

Since the first meeting on 5th November, 1956, the Committee has met a further six times. A Technical Sub-Committee was formed, and this has met on twelve occasions. The Sub-Committee generated a number of Working Groups covering the more important technical areas; those held many meetings, both formal and informal. At key stages in the programme several all-day symposia have been staged at Farnborough.

A reasonably rounded programme of work was formulated at an early stage. All the results are not yet to hand - indeed, if we are to enter the supersonic transport field, backing up research must continue covering both first generation and more advanced supersonic transports. However, sufficient has been done to give far greater confidence in the potentialities of supersonic transports with reasonable economics – certainly much more confidence than could have been rationally justified at the outset of the programme.

A stage has now been reached at which Industry should start serious detailed design work on two supersonic aircraft:–

(i) An aeroplane carrying 150 passengers on the non-stop London/New York route, cruising at about twice the speed of sound.
(ii) A smaller aeroplane, carrying 100 passengers for stage lengths of up to 1500 statute miles cruising at 1.2 times the speed of sound.

Outline requirements specifying the characteristics of the aircraft are given. We recommend that, after the essential preliminaries of brochure competitions, firms should be selected and both aircraft built. There may be debate on the size and speed of the aeroplanes we have specified, but the Report will be found to contain substantial arguments in favour of our choice.

For the transatlantic range a high cruising speed of say three times the speed of sound has its attractions and may well come in due course, but we feel that a speed of about twice the speed of sound is as high as we should attempt in the first instance and is likely initially to prove the most economic supersonic speed.

At stage lengths of less than 1500 statute miles economic operation depends on producing the right compromise between the supersonic and the subsonic part of the flight plan. An aircraft cruising at 1.2 times the speed of sound, using sweepback to minimise shock losses, seems a logical next step beyond subsonic jet transports for the shorter ranges.

On general technical grounds it seems clear that the earlier supersonic transports will represent the start of whole new generations of very fast long range machines. Over the longer ranges we can certainly look forward with some confidence to speeds rising to four or five times the speed of sound. Each generation of supersonic transports will gain immeasurably from previous detailed experience, lacking which progress will be difficult.

We feel it right to proceed with the two supersonic aircraft outlined above and we must emphasise that a decision not to start detailed work fairly soon on the transatlantic aircraft would be, in effect a decision to opt altogether out of the long range supersonic transport field – since we would never regain a competitive position. This could have a profound effect on the pattern of our Aircraft Industry and on our position as a leading aeronautical power.

During the work of the Committee I have had the utmost help and co-operation from all those taking part – whether from the Firms, the Operators, the Ministries or the Establishments – and I would like to record my gratitude. I cannot refrain from mentioning the debt we owe to Mr. P. A. Hufton, who Chaired the Technical Sub-Committee; to the leaders of the Working Groups and to Mr. R.G. Thorne, who acted as Secretary throughout our proceedings.

Your obedient servant,

[M.B. Morgan]
Chairman,

II

Supersonic Transport Aircraft CommitteeCabinet, The Supersonic Airliner, Memorandum by the First Secretary of State [R. A. Butler], 3 November 1962

Public Record Office, PRO CAB 129/111

The Committee on Civil Scientific Research and Development, of which I am the chairman, have considered a proposal for a joint enterprise by British and French industry to develop an airliner with twice the speed of sound which would come into commercial service about 1970. We have not reached any final conclusion partly because we have not hitherto had adequate opportunity of comparing this project with possible competitors in the scientific field. It is fair to say that the Chief Secretary has reserved the Treasury point of view and that the Ministers of Aviation and Defence are in favour of the proposal. The Minister of Aviation wishes the matter to be considered by the Cabinet at an early date. I therefore set out certain considerations in this memorandum.

2. The Annex contains our appraisal of the facts and estimates concerning this proposal.

3. We have felt that the proposal is a natural manifestation of technological progress. Supersonic military aircraft are in common use already; and history has repeatedly shown that technological advance in military aircraft has been successfully applied in new types of civil aircraft at a rate faster than, on purely economic grounds, the airlines would have wished. We are inclined to believe that supersonic passenger travel is sure to come, though two reservations have been suggested: first, in other forms of travel – the railways and the motor car – there was at the outset rapid technological advance and then the pattern of passenger travel settled at speeds which were relatively moderate compared with what was technically possible: the same pattern might repeat itself in air travel, with the use of supersonic speeds as the exception rather than the rule. Secondly, most airlines are operating at a loss at present: there may have to be radical changes in the fare structure. It is at least possible that the changes would be directed to exploiting a new market – not so much for the businessman who can travel in luxury and must travel fast, but for the general public who want to go from place to place within what they can comfortably afford.

4. The prevailing opinion in my Committee, after their studies, is that because of the unusual degree of risk the case for proceeding with the proposal cannot stand on normal expectations of an economic return (Annex, paragraphs 2-14), nor to any great extent upon grounds of indispensability to the aircraft industry (paragraphs 15-18 of the Annex). The commercial judgment of the manufacturers is expressed in their keen advocacy of this project, and their willingness to commit a large part of their resources to it for many years, but against this some members of my Committee set the fact that the United Kingdom companies look to public funds to bear all our share of the pre-production costs (paragraph 2 of the Annex). I have also sought the views of the British Overseas Airways Corporation. They have explained that if they were looking at this question purely from the commercial point of view they would have preferred to enter into no commitment. They emphasised that what is important is to have the best plane rather than to be first in the field with a new plane. From this point of view, therefore, it would suit them best to sit on the side-lines while supersonic airliners are developed and to decide to order the most likely winner when developments are a lot further forward than they are now. On the other hand, they recognise that as a nationalised corporation they have certain obligations and that if the Government decide to go ahead with this project they and they alone can provide the operating experience and

advice which the builders will need. In view, however, of their recent heavy financial losses they cannot afford to do this unless the Government agree to underwrite the risk until such time as a commercial judgment can be made. They are accordingly ready to be associated with this development on the conditions summarised in paragraph 4 of the Annex. The Ministers of Defence and Aviation, however, consider that there is greater merit in the economic case than their colleagues in the Committee have found.

5. Suppose we went ahead with this project. There is room for doubt whether the technological advance could be fruitfully exploited for any length of time. It would not suffice for a further increase in speed to three times that of sound, because this would require different methods and different materials. The Americans, however, have been studying the possibility of this still more advanced and costly vehicle and if they decide to go ahead would hope to be producing it by about 1975. They have come from behind us in this way before, when their Boeing 707 followed our Comets and Britannias. Nor can we discount altogether the possibility that, despite our lead in a design for twice the speed of sound, they could even now bring a comparable aircraft into production good enough and soon enough to spoil our market (paragraph 9 of the Annex). The Russians too may be in the race. Moreover, while it might well be that except in partnership with the French (the Americans will almost certainly wish to 'go it alone') we could not tackle supersonic airliners at all, it might detract from any credit to our industry that the project had been undertaken jointly with the French, who would take the larger share of development work for the airframe and already know the aircraft as the 'Super-Caravelle'. On the other hand the venture would be an outstanding example of interdependence and would help to promote the integration of the aircraft industries of Western Europe.

6. In the techniques of civil passenger transport the proposed airliner would be a long stride ahead of any airliner flying now; journey times would be markedly reduced, especially on long flights; in company with the French we could get in first with the assurance of at least a substantial part of the European airliner market; if the project were both technically and commercially successful and completed on time a very substantial volume of export business would be obtained, and our aircraft industry would be assured of a place in the front rank of the world's suppliers of large civil aircraft, at least some way into the 1970's; in the competition for civil air passenger traffic some of our airlines at least could enjoy for a time some advantage from pioneering a very much faster aircraft, and we might expect on past experience to reap from the project advances in technology which could help industries besides the aircraft industry.

7. As for the technological argument, there are two other aspects to be considered. First, if we were to undertake this airliner would there be a risk of having spread our effort too wide, of completing projects too late or abandoning them half done ? We have noted the large nuclear programmes, the space research programme, our contributions to the European Launcher Development Organisation and to the European Space Research Organisation and the possibility of a civil satellite communications system. Subject to the views of the Chancellor of the Exchequer, whose position has been reserved in my Committee's discussions, we do not think it likely that if the supersonic airliner project went ahead successfully these projects or programmes would be affected. But while there is ample capacity in the aircraft industry and Government aeronautical establishments to undertake the project, we have noted also the effort devoted in various ways to civil scientific and industrial research and development, and we are not in a position to say that resources devoted to a supersonic airliner might not be better directed to other industries on which our future economy may depend more heavily than upon the manufacture of large civil aircraft.

8. To sum up, this proposal may well constitute a natural and inevitable step in technological advance, offering the benefits of such advance and a moment of opportunity to enhance British and French prestige, but we may find in later years that United States industry ousts it with something better, and we are left with too small a market for our pains. And some of us believe that the right lines of technological advance for this country to exploit cannot be selected without regard to commercial prospects. On the other hand to decide not to venture in this field while America and perhaps Russia and France go ahead could well mean contracting out of the large passenger aircraft business.

R. A. B.
Office of the First Secretary of State, S.W.1.
1st November, 1962.

Annex: The Supersonic Airliner

The Proposal

1. In the United Kingdom a substantial programme of applied research was begun in 1956, co-ordinated by the Supersonic Transport Aircraft Committee representing the Ministry of Supply, the Ministry of Transport and Civil Aviation, the aircraft industry and the Air Corporations. Feasibility studies were later commissioned from the airframe and aero-engine companies and resulted in 1960 in the decision to concentrate on a long-range aircraft with twice the speed of sound for operation by the British Overseas Airways Corporation on the North Atlantic. Meanwhile the French had also been carrying out research and preliminary design work on a medium-range aircraft with twice the speed of sound, with which they hope to follow up the Caravelle. The French Government have already authorised substantial funds to be committed for the development of such an aircraft. Negotiations between the United Kingdom and France brought these separate approaches together and the outcome is the proposal now before us for an aircraft that could be produced in two versions, long-range for the London-New York run (3,250 nautical miles) and medium-range for stage lengths up to 2,400 nautical miles. The work of building the aircraft would be divided between United Kingdom and French airframe and aero-engine companies. The British Aircraft Corporation and Sud Aviation would co-operate on the airframe; Bristol-Siddeley and SNECMA on the engines. The project would be controlled by a joint committee structure with equal United Kingdom and French representation, with the presidency, which would possess a casting vote, held alternately by the two nations. The broad distribution of work has been agreed. The aim would be to get as nearly as possible a 50/50 split in development, production and proceeds of sales, irrespective of whether the long-range or medium-range version gained more orders. On this basis Britain would have about 70 per cent of the work of developing the engine and about 40 per cent of the work of developing the airframe.

The cost to public funds

2. The whole of the pre-production work (that is, development and production of two prototypes and two pre-production aircraft, all associated development work on the airframes, engines and equipment, component tests, flight development tests to full Certificate of Airworthiness, together with the cost of jigging and tooling for production) would have to be financed by public funds in both countries. This has been estimated, after review of the British Aircraft Corporation's figures by the Ministry of Aviation and the Treasury, at £150 million, with a margin of error of at least £20 million either way, though an increase is thought more probable than a reduction. The United Kingdom and France would each take half shares of this expenditure, subject to minor adjustment

according to the actual division of work between the two countries. The United Kingdom share is expected to be about £1.25 million in 1962-63 rising to £8 million in 1964-65 and to a peak of some £12 million a year in the period 1966-68. The Government would seek to recover at least part of this expenditure by participating in the proceeds of sales.

3. In addition there might be some continuing expenditure for the Government in minor developments after a full Certificate of Airworthiness had been obtained. Moreover, during the currency of the project the Government aeronautical establishments would continue to give it support, to an average annual value in the United Kingdom of about £1 million.

4. While development was proceeding it would be necessary to identify the British Overseas Airways Corporation particularly with the long-range version, both to ensure the authoritative guidance of an intending user and to encourage other airlines to take a serious interest in it. A proposal has therefore been made to the Corporation that they should act as if they had decided from the outset to buy and operate the aircraft, including placing an initial order in 1964 for four-six production models. At a date to be determined, which would be about the end of 1966, the Corporation would be asked to make a firm commercial decision. If they rejected the aircraft, the Government would relieve them of their commitments up to that date, which might be of the order of £10 million. If, however, they confirmed their requirement for the aircraft, the Corporation would assume the full financial responsibility for the order.

5. To sum up, taking account of paragraphs 2 and 3 above, the Exchequer expenditure on launching the aircraft might be some £85 million spread over the period up to about 1970. In the event of the British Overseas Airways Corporation rejecting the aircraft at the end of 1966, the Government would become liable for production commitments of some £10 million, in addition to the development commitments incurred up to that date.

6. Looking further ahead, if the aircraft continues in production, in order to make possible early delivery dates it might be necessary for the Exchequer to underwrite other production in advance of orders. This is provided for in the policy announced to Parliament in February, 1960, but so far has been done only for smaller and less expensive aircraft.

7. The Exchequer would be required to find the capital for any purchases by the nationalised Air Corporations which were authorised, to the extent that the Corporations' revenue was not sufficient. There is little reason to think that the Corporations could make any significant contribution. Thus the cost of any premature retirement of subsonic aircraft would fall on the Exchequer, though market assumptions have throughout made allowance for the continuing use of subsonic aircraft on some routes in parallel with supersonic aircraft.

The market

8. The airliner would be expected to be ready to enter service shortly after 1970. By that time most airlines that were equipped with subsonic jets between 1960 and 1962 are expected to have written off their expenditure on that equipment and to be ready to re-equip, though there will be other aircraft, including the United Kingdom V.C.10s., which will have to come into service after 1962 and will not be due to be written off until well after 1970. The best available evidence suggests that by 1970 traffic on routes with stage lengths over 1,000 miles (outside Russia and China) may have grown by 120 per cent. On the extreme assumption that supersonic replace subsonic aircraft on all these routes (including the subsonic aircraft that entered service after 1962) the maximum requirement for supersonic aircraft in 1970 would be some 320; and, allowing for further growth of traffic, it would be rather more than 400 by 1975.

9. By 1975 the United States may be entering the market with an aircraft with three times the speed of sound; and the American market may be resistant throughout to the Anglo-French model if a reasonable alternative is in prospect. Discounting the American market altogether and allowing for 40 per cent of other routes with stage lengths of over 1,000 miles to continue with subsonic jets, the potential scope for the Anglo-French aircraft would be about 170 (estimated value, with spares, about £1,000 million). This might be further eroded if airlines outside the American market also preferred to await an American or Russian aircraft, and because some routes include stages which could not economically be flown by either version of the Anglo-French aircraft. And, finally, there is the risk that the operating costs of the supersonic airliner might prove to be such as to discourage sales.

10. In short, substantially less than 170 aircraft (estimated value, with spares, about £1,000 million) might eventually be sold; and the proceeds of these would fall to be divided between the United Kingdom and France.

Operating economics

11. The operating economics will depend to a considerable extent on the capital cost of the aircraft. This has been estimated at £3 million each for production and nearly £1 million each for pre-production costs if amortised over 170 aircraft. If pre-production costs (which would be borne by the Exchequer, as explained in paragraph 4 above) are written off, and if development goes according to plan, it is estimated that the operating cost per seat mile of the supersonic airliner might be rather less than that of a V.C.10 and, except on the longest runs, rather more than that of a Boeing 707.

12. The British Overseas Airways Corporation do not think that it would be right to base the project on the assumption that it would be possible to charge higher fares for the greater speed without reducing demand too far.

Operating requirements

13. The aircraft could use existing airports and would comply with present regulations about 'fly over' noise. But noise in the immediate vicinity of the airport on take off and landing would be higher than that of existing subsonic jets. During supersonic flight, the aircraft will create a sonic boom which could cause discomfort and annoyance to members of the public within a few miles of the flight path. It is thought that this would be reduced to tolerable levels if the aircraft were restricted to subsonic speeds up to a height of 35,000 feet, but further study and research is needed before any firm conclusions can be reached. The aircraft will normally cruise at not more than 60,000 feet, at which height neither passengers nor crew would probably be exposed to an unacceptable level of cosmic radiation in normal circumstances. However, aircrew would have to be classified as 'radiation workers' (to whom a relatively high 'maximum permissible level' of radiation exposure is applicable) and subjected to the appropriate safeguards it might be necessary to give passengers a medical check on the rare occasions when solar flares occur unexpectedly, and the aircraft cannot take avoiding action in time.

14. These requirements tend to impair the operating economics of the aircraft; and the airlines might seek an indemnity against them if they purchased the aircraft at the instance of the Government.

Effect on the British aircraft industry

15. The labour force of the industry stood at 308,000 in January, 1957. In 1958 a decline in military

work was forecast, but has been less than expected and in June, 1962, there were 293,000. A decline is expected now until June, 1963, when it is estimated that the total will be about 275,000. What happens there after depends on how many new projects, of which the supersonic airliner is one (the other large ones are mainly military), are approved in the meanwhile. The British Aircraft Corporation, who would be concerned with the airframe of the supersonic airliner, have estimated that their labour force which stood at 46,850 at the beginning of this year would drop to about 41,850 by the end of next year if no new projects had been approved by then. On the same basis, the other major airframe group, Hawker-Siddeley, estimate that over the same period their labour force would decline from 63,700 to 38,000.

16. The picture for airframe design staff is specially significant. The teams of the two largest groups, the British Aircraft Corporation and Hawker-Siddeley, numbered 8,750 at the end of 1961; and 150 of those in the British Aircraft Corporation were engaged on the supersonic airliner. By the end of 1963 this total would have run down to 5,100 on projects already approved, with the possibility of 2,850 being needed for projects not yet approved. Of these 2,850, 2,000 would be on military projects: 600 on the supersonic airliner. Thus a substantial decline in design staffs will occur in any event, and will be more severe if the supersonic project were not approved. At the same time, however, it is generally agreed that some rundown is appropriate and reasonable over the next few years.

17. On aero-engine design, Bristol-Siddeley have 2,800 staff at present. This will tend to build up, mainly on military vertical take-off projects, and at the maximum could reach 3,200 by the end of 1963. Rolls Royce design staff, on the other hand, which amounts to 3,500 at present, may decline, perhaps to a minimum of 2,600 at the end of 1963 if no new projects are approved. The extent of the variations depends on the approval of new projects. But, whereas Bristol-Siddeley already have Government financed work next year to the tune of £15.6 million (with a further £3.7 million as yet unapproved, of which £0.5 million would relate to the supersonic airliner), Rolls Royce – who are relatively far more dependent on non-Government work – have Government work in 1962-63 already approved for next year and work as yet unapproved which are respectively about half Bristol-Siddeley's figures. Forecasts of the Government-financed work of the two concerns in 1965-66 show possible expansion in both, but relatively more in Bristol-Siddeley than in Rolls Royce, even after discounting Bristol-Siddeley's work on the supersonic airliner which would then be running at about £4 million a year. The proposals envisaged that Rolls Royce would probably have no hand in development for the supersonic airliner, partly because the British Aircraft Corporation favour the Bristol-Siddeley engine, which would be a development of that used in the T.S.R.2. and partly because the French firm that would be concerned with the engines, SNECMA, is part-owned by Pratt and Whitney who are major American competitors of Rolls Royce. It would, however, be possible to arrange for Rolls Royce to participate in the production work.

18. It does not appear from the figures in paragraphs 15-17 that, however important in the long term, the supersonic airliner is indispensable to the life of the aircraft industry, at least in the short term; and, distributed as is proposed, it would do little to balance the degree of Government support between the major concerns – rather the reverse. On the other hand, it would fill some awkward gaps. Indirectly it would make it easier to provided some continuing aircraft production work for Shorts of Belfast.

November, 1962

III

Cabinet, Conclusions of a meeting held at Admiralty House, SW1, on Tuesday, 20 November 1962, at 11 a.m.

Public Record Office PRO CAB 128/36

(Extract: Item 2: Aircraft Industry. Supersonic Airliner)

The Cabinet had before them a memorandum by the Minister of Aviation (C. (62) 184) reporting the outcome of his meeting with M. Dusseaulx, the French Minister of Transport, at which he had stated that the proposal for the joint development of an Anglo-French supersonic airliner was in principle acceptable to the United Kingdom Government, subject to certain assurances.

The Minister of Aviation said that M. Dusseaulx had assured him that Air France would participate in the project as intending operators of the medium-range version of the airliner and probably of the long-range version also. M. Dusseaulx had been confident that other members of Air Union would also buy the aircraft in view of the influence which Air France would have with them. Our estimate of the number of aircraft that could be sold, assuming that a United States competitor came into the field early, had been about 170, the corresponding French estimate was 150-160. A larger number would be sold if the United States competitor did not come in until later, as would happen if, for instance, the United States preferred an airliner with three times the speed of sound. He had persuaded the French authorities that the aircraft should not be called the 'Super Caravelle'. Other names had been discussed, of which 'Concorde' (with and without the final 'e') seemed to be the best. He had discussed with M. Dusseaulx the draft of a proposed agreement on the lines already reported to the Cabinet. M. Dusseaulx had since indicated that he had now obtained the approval of the French Government and that he was ready to visit London to sign the agreement in the near future if the United Kingdom Government also approved the proposal.

The Chancellor of the Exchequer said that now that it had been established that Air France, and probably other European airlines also, would participate in the project it was right that we should proceed to sign the agreement with the French Government, subject to a final examination of its terms. But this should be without commitment on the arrangements to be made between the United Kingdom Government and the United Kingdom firms. He was not satisfied that an arrangement under which the United Kingdom Government would finance the whole of the pre-production costs, except some £2 million on building and plant and £14 million on the learning costs in producing the new aircraft, was satisfactory either in itself or as a matter of presentation to the public. Moreover, there should be an understanding that, if the companies made a profit on the sales of the aircraft, there should be some return from the proceeds of the sales to the Exchequer.

In discussion the following points were made:

(a) Further discussions had been held to explore the possibility of associating Rolls Royce with the project. It had been found that, not only were the United Kingdom companies opposed to this, but that there was strong resistance from the French side apparently because SNECMA, the French firm that would be engaged on the engines, was partly owned by Pratt and Whitney of America, who regarded Rolls Royce as one of their main competitors.

(b) Shipping and shipbuilding interests in the United Kingdom were inclined to criticise the extent to which the Government were supporting both the aircraft construction industry and the airlines. This should be borne in mind in framing the announcement of the signature of the agreement with France.

(c) A decision to proceed with the airliner would indirectly improve the prospects of employment in Short Brothers and Harland in Belfast, and an indication in this sense would be helpful to the Government's handling of a debate in Parliament on the economy of Northern Ireland within the next few days.

Summing up *the Prime Minister* said it was generally accepted that the agreement with the French should be signed as early as convenient. The aircraft should be called the 'Concord'. The details of the agreement and of the public statement to be made when it was signed should be settled by the Minister of Aviation with the Chancellor of the Exchequer and the Foreign Secretary. The Minister of Transport should be consulted. The Minister of Aviation and the Chief Secretary, Treasury, in consultation with the President of the Board of Trade, should also consider further the details of the financial arrangements between the United Kingdom Government and the United Kingdom companies engaged in the project in the light of the points made in discussion.

The Cabinet –

(1) Approved in principle the project for the joint Anglo-French development of a supersonic airliner, under the name 'Concord'.

(2) Invited the Minister of Aviation, in consultation with the Chancellor of the Exchequer, the Foreign secretary and the Minister of Transport, to settle the terms of the agreement between the United Kingdom and French Governments and of the announcement of the signature of the agreement.

(3) Subject to Conclusion (2) above, invited the Minister of Aviation to arrange with M. Dusseaulx for the signature of the agreement.

(4) Invited the Home Secretary, in consultation with the Minister of Aviation, to settle the terms of a statement on the relationship of this project to employment prospects at Short Brothers and Harland.

(5) Invited the Minister of Aviation, in consultation with the President of the Board of Trade and the Chief Secretary, Treasury, to consider further the terms of the development contracts between the Government and the participating companies, within the framework of the agreement between the French and United Kingdom Governments.

IV

Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the French Republic regarding the Development and Production of a Civil Supersonic Transport Aircraft

Public Record Office, PRO FO 93/33/475

The Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the French Republic;

Having decided to develop and produce jointly a civil supersonic transport aircraft;

Have agreed as follows:

Article 1

(1) The principle of this collaboration shall be the equal sharing between the two countries, on the basis of equal responsibility for the project as a whole, of the work, of the expenditure incurred by the two Governments, and of the proceeds of sales.

(2) This principle, which shall be observed as strictly as possible, shall apply, as regards both development and production (including spares), to the project considered as a whole (airframe, engine, systems and equipments).

(3) The sharing shall be based upon the expenditure corresponding to the work carried out in each country, excluding taxes to be specified by agreement between the two Governments. Such expenditure shall be calculated from the date of the present Agreement.

Article 2

The two Governments, having taken note of the agreement dated 25th October, 1962 between Sud Aviation and the British Aircraft Corporation (B.A.C.), and of the agreement dated 28th November, 1961 between Bristol Siddeley and the Société Nationale d'Etudes et de Construction de Moteurs have approved them, except in so far as they may be in conflict with provisions which are the subject of agreement between the Governments.

Article 3

(1) The technical proposals, which shall form the basis for the joint undertaking by Sud Aviation and BAC, comprise a medium range and a long range version of the aircraft.

(2) The Bristol Siddeley-SNECMA BS/593/3 turbojet engine shall be developed jointly for the aircraft by Bristol Siddeley on the British side and by SNECMA on the French side.

Article 4

In order to carry out the project, integrated organisations of the airframe and engine firms shall be set up.

Article 5

A Standing Committee of officials from the two countries shall supervise the progress of the work, report to the Governments and propose the necessary measures to ensure the carrying out of the programme.

Article 6

Every effort shall be made to ensure that the programme is carried out, both for the airframe and for the engine, with equal attention to the medium range and the long range versions. It

shall be for the two integrated organisations of the British and French firms to make detailed proposals for the carrying out of the programme.

Article 7

The present Agreement shall enter into force on the date of its signature.

In witness whereof the undersigned, being duly authorised thereto by their respective Governments, have signed the present Agreement.

Done in duplicate at London this 29th day of November, 1962 in the English and French languages, both texts being equally authoritative.

For the Government of the United Kingdom of Great Britain and Northern Ireland:

(Julian Amery)
(Peter Thomas)

For the Government of the French Republic:

(Geoffroy de Courcel)

V

The Economic Situation

A statement by Her Majesty's Government, 26 October 1964 (extract)

HMSO

13.6 The Government will carry out a strict review of all Government expenditure. Their object will be to relieve the strain on the balance of payments and release resources for more productive purposes by cutting out expenditure on items of low economic priority, such as 'prestige projects'. The Government have already communicated to the French Government their wish to re-examine urgently the Concord Project.

VI

Statement by the Minister of Aviation (Roy Jenkins) in the House of Commons, 20 January 1965

Hansard, House of Commons Debates, 20 January 1965

We have now completed the review of the Concord project which we set in hand in October and we have exchanged views with the French Government.

We had, and we still retain, some doubts about the financial and economic aspects of the project. We have, however, been much impressed by the confidence of our French partners and my right hon. Friend the Prime Minister has informed the French Prime Minister that we stand by the treaty obligations into which the last Government decided to enter.

During the coming months we shall be discussing with our partners the detailed programme of development and production.

Now that the uncertainty over the future of this project has been removed I am sure that all those concerned with it on both sides of the Channel will press forward with a real sense of purpose. In this, they will have the full backing of Her Majesty's Government.

VII

Pre-Cabinet brief from Sir Burke Trend, Cabinet Secretary, to the Prime Minister (Harold Wilson), 29 June 1966

Public Record Office, PRO PREM 13/1308]

The Concord Project
(C(66)88, 89 and 90)

There are three memoranda before the Cabinet:–

(a) The Minister of Aviation (C(66)88) seeks approval to authorise the remainder of the development programme of the Concord up to certification of airworthiness, involving expenditure of a further £145 million over the next five years. He also seeks acceptance of the principle that the Government should either provide, or underwrite, working capital to finance production.
(b) The Foreign Secretary (C(66)89) draws attention to the adverse political consequences of withdrawing from the project.
(c) The Attorney-General (C(66)99) concludes that there is at present no legally defensible way of withdrawing and that, if we were to withdraw, we should risk a judgment in the International Court requiring us to compensate the French for the additional cost of completing the project on their own.

2. We have now reached, if we have not already passed, the point of no return on the Concord. The current estimate of the British share of the cost of development to certification of airworthiness now stands at £185 million, (over £100 million more than the original estimate). About £40 million has been spent so far. Development after certification and provision for additional contingencies brings the estimated cost of development to £250 million. And in a project of this kind, where the technology is completely new, there can be no certainty that the cost will not turn out to be even higher.

3. The current forecast of the selling price of production aircraft is £6.5 million each. If one accepts a forecast of sales of 150 aircraft and assumes a development levy averaging 7 per cent, about £65 million of the development expenditure might be recovered in sales, of which presumably half would come to the British Government. At best therefore we cannot expect to recover more than about £30 to £35 million of our £250 million; and it might well be even less. It might however be worth asking how far the estimated selling price itself could be too low, as the cost estimates may be.

4. The operating economics are questionable. Operating costs are likely to be 25 to 35 per cent greater than those of subsonic aircraft. This differential will be offset only if the Concord has sufficient passenger appeal to operate at higher load factors than subsonic aircraft and there is agreement that supersonic aircraft may charge higher fares than subsonic aircraft: two fairly big provisos. Operating costs may be adversely affected still further by restrictions on optimum use because of the sonic bang.

5. Sales prospects must depend on a combination of purchase price and operating economics (as affected by sonic bang). They are impossible to predict with any certainty, although Lockheed are

known to think that 150 or more Concords might be sold. At this rate our balance of payments would benefit to the tune of something like £500 million, if half the sale proceeds accrued to this country.

6. On economic grounds alone the case for withdrawing from the Concord project is stronger than ever. The countervailing considerations are:–

(a) Technological: The Concord represents our entrance fee for the supersonic stakes. If we were to withdraw, we should probably be contracting out of supersonic aircraft technology and business, and leaving it all to the Americans.
(b) Industrial: The Concord is an important element in the future of the aircraft industry, particularly on the air-frame side.
(c) Legal: If we withdrew, we might well have to pay very dearly; and we might find ourselves subsidising French development without getting any technological benefit ourselves.
(d) Political: We should shake our credit with the French, and other European countries, if we withdrew.

7. On the *technological* point, the Cabinet have to consider whether we want to be in the supersonic business. Everything suggests that the stakes are very high and the rewards uncertain. The same amount of effort put into subsonic development might put us in a very strong position in the market for subsonic aircraft. It must be at least questionable whether enough members of the travelling public will be prepared to pay the high price demanded for the additional margin of speed (and the accompanying discomforts) represented by supersonic flight. On the other hand it is clearly a very difficult decision for Britain to contract out of a field of technological development of this nature; and, if we want to stay in supersonic development, we must expect to incur equally heavy expenditure on something else, if not on Concord.

8. The Concord represents a major factor in the development and production of the British air-frame *industry* over the next five to ten years. If Concord goes, the industry faces a very sharp contraction. A decision taken now to go ahead with Concord would thus to some extent prejudge decisions on the future of the air-frame industry. Decisions on the Concord and on the future of the industry ought really to be taken together. The Minister of Aviation is not yet ready to come forward with proposals on the future of the industry; but I gather that he is likely to do so before the summer recess. It is argued, however, that a decision on Concord cannot be postponed, partly because existing authorities expire on 30th June and decisions are required to enable work to go forward, and partly because of the French Prime Minister's visit. If so, however, the Minister must be prepared to give the Cabinet at least some idea of the proposals for the reorganisation of the industry which he will shortly be putting forward.

9. The Attorney-General's statement on the legal position seems to make it clear that it could cost, in financial terms, nearly as much to withdraw as to stay in. This is a powerful, if negative, argument for going ahead. The moral is clear: agreements for international co-operation of this character should in future as far as possible prescribe a cost ceiling, in order that, if costs rise intolerably, there may be provision for reconsideration.

10. The *political* arguments against withdrawing are without doubt very strong, particularly after we have already tried once to withdraw from the project and have been persuaded to stay in. It is arguable that the French have not shown much compunction about breaking faith with their European allies; but after the ELDO affair we are not immune from criticism on this score ourselves. Moreover, we genuinely need European co-operation in technical development in this and

allied fields. Indeed, we want it on a wider basis than merely with the French. It may be that co-operation between national firms will prove to be technically less satisfactory than the creation of international firms. But our reputation for reliability will be damaged if we now withdraw from Concord (however good the reasons); and our chances of developing international co-operation on any basis will be less if we allow this damage to happen.

11. The conclusion may well be that in practical terms we can withdraw from the Concord project only if the French agree. The Minister of Aviation has learned from M. Pisani that the French Government, though greatly concerned at the rising financial commitment, remain committed to the project and will only reconsider the matter if new technical or commercial factors arise. But one cannot help wondering why the French Government think that the project is worth continuing; indeed, one cannot help wondering whether they would really be very reluctant to be able to call a halt, if they could throw all the blame on the British Government. It might perhaps be possible for you to probe M. Pompidou's position a little more deeply when he comes, without giving the impression that the British Government are once more seriously contemplating withdrawing. You could say that the British Government have felt the same concern as the French Government about the rising financial commitments, which must raise doubts about the economic case for the project. The ensuing discussion might enable you to discover whether the French Government would have any interest in setting limits to the cost or to the programme, or in enlisting co-operation or at least contributions from other countries. Probing on these lines might at least lead to negotiations on revisions of the agreement; but it would still imply a willingness in principle to go ahead. It might therefore be inadvisable to embark on discussions of this kind with M. Pompidou without a prior Cabinet decision that, if it became clear at the end of the day that the French Government were immovable, the British Government would agree to go ahead.

12. Thus the best conclusion at tomorrow's Cabinet might be an agreement in principle that, unless the French wish to withdraw, our obligations leave us no option but to go ahead with the Concord project but that you should take soundings with the French Prime Minister about the French Government's attitude to the rising cost, about the possibility of limiting the programme in some way and about the possibility of extending international co-operation in order to spread the cost.

Burke Trend
29th June, 1966

VIII

Pre-Cabinet brief from Sir Burke Trend, Cabinet Secretary, for the Prime Minister (Harold Wilson), 24 July 1967

Public Record Office, PRO PREM 13/1309

Concord
(ST(67)6 and 10)

This is a gloomy report. The four major aspects – weight growth, engine noise, cost-escalation and sonic bangs – all get worse every time we look at them. The cost-escalation of *development* is particularly alarming. The estimate of £500 million has given way to a revised estimate of £550-600 million; and the Minister suggests that even this 'may be an underestimate'. In addition ST(67)10 shows that our share of the cost of financing *production* is likely to be of the order of £140 million; that commercial sources will not contribute more than £20 million of this total (and even then only on the basis of a Government guarantee); that we shall have to provide the balance ourselves in the form of loans, together with an indemnity to the borrowers if they find that they cannot repay them; and that the provision of credit for export sales will probably involve driving a coach and horses through normal ECGD policies and criteria.

2. In these circumstances, and despite the view of the Concord Directing Committee that the project should continue, Ministers may wish to consider *de novo* whether the time has come to try to jettison it (particularly since there are good reasons for supposing that the French themselves would be thankful to be rid of it). There are, of course, powerful objections to doing so. But are they quite as powerful as we have hitherto supposed? Thus:–

(a) We are legally bound; and we cannot evade the obligation. But is it really in prospect that the French would take us to court (which court?) and obtain damages if we broke off in present circumstances?
(b) We should inflict a setback on our application for membership of the European Economic Community. But it is surely doubtful if abandonment would make French opposition any worse. Carrying on certainly has not made it any better!
(c) We should damage our own aircraft industry, including its chances of future co-operation with Europe. This is perhaps the most serious implication of terminating the project; and it would have to be carefully studied before a final decision was taken (although it would be difficult to do this quickly, since it would inevitably have to be linked with the large scale review of the aircraft industry which is now being undertaken in the light of the abandonment of the AFVG). But, in brief, could we in any event contemplate maintaining an aircraft industry at all if its price were a continuing commitment not merely to Concord itself but to the other 'super-Concord' type projects which will surely succeed it?

3. If Ministers decide that, despite these arguments, the project must go ahead, the simplest course would probably be that, as the Minister recommends, he should now discuss the implications with his French colleague and report back. But, if they feel that the prospect is now so appalling that we should make a further attempt to bring it to an end, we shall have to try to find some means of doing so which attracts the minimum of odium to the Government. A possible method might be to remit the project to the Central Advisory Council for Science and Technology or the National Economic Development Council or both and ask them to arrange for an independent, unbiassed

review (which they could undertake themselves or entrust to some specially constructed body of their own selection) in order to ascertain whether the game was likely to be really worth the candle or whether the resources which it will pre-empt, measured against the probable return in the face of United States competition, might be better deployed elsewhere. This would be in line with your recent decision that the Central Advisory Council should be invited to give specific guidance on the relative priorities of individual projects competing for scientific and technological resources; and, since a review of this kind would be likely, at worst, to sit on the fence and, at best, to find unambiguously against the Concord, it would arouse public opinion and give the Government a stronger base on which to argue that, however desirable the enterprise might be on merits, it was simply not acceptable politically in the United Kingdom. And, if the arguments leading to this conclusion appeared over the names of eminent scientific and industrial experts with no commercial axe to grind, they might find a corresponding echo in comparable French circles; and the two Governments might then have a not unrespectable alibi for dropping the project by mutual consent.

4. The idea may be worth consideration. But, whichever way the decision goes, it might be wise to inform the Cabinet on Thursday and to promise them the opportunity of a fuller discussion in the autumn. Given the reductions in departmental programmes which some Ministers have recently had to accept, they cannot be expected to acquiesce without protest in the way in which the Concord estimates continue to leap upwards at £50 or £100 million a time!

Burke Trend
24th July, 1967

IX

Conclusions of a meeting of the Cabinet held at 10 Downing Street, SW1, on Friday, 5 January 1968, at 2.00 p.m. (extract)

Public Record Office, PRO CAB 128/43

Concorde

The Foreign Secretary said that a group of Ministers under his chairmanship had considered the case for withdrawing from the Concorde aircraft project. They had before them the memorandum by the Minister of Technology and the report by officials which were attached to C(68)4. There were at present no grounds on which the Government could legally terminate the treaty which governed their participation in the project. If nevertheless we were to abrogate the treaty unilaterally, the French Government would be able to bring an action before the International Court who could be expected to award damages against us which might amount to as much as £200 million. We should also have to pay cancellation charges amounting to some £50 million to the British firms involved in the project. This nugatory expenditure would probably wipe out the savings to the Exchequer from cancellation which might be of the order of £200 million. If we continued with the project until the spring or early summer of 1969, there might then be an opportunity of abandoning it without risking liability for damages, if the technical problems proved to be so great as to make the aircraft virtually unsaleable: it would be clear by that time whether or not this was the case. Meanwhile, however, the Government would have spent a further £100 million on development and production, and would still incur cancellation charges of £50 million to British firms.

Against this background, his colleagues had not been able to reach agreement on the course the Government should follow. Some felt that, given the amount of damages for which we should be at risk, the impact of unilateral abrogation of the treaty on our international standing and the effects of cancellation on our position as an advanced industrial Power, it would be wrong to withdraw at this stage and we should continue at least until the spring or early summer of 1969. Other Ministers felt that we should he justified in withdrawing now, given the virtual certainty that the costs of the project would escalate further, the overriding need for savings in the next two years, and the fact that cancellation would undoubtedly secure substantial savings in those years whereas it would probably be three years before we had to pay any damages.

It had been suggested that we might seek to mitigate the amount of damages which would be awarded against us by offering technical assistance and facilities to the French if they wished to carry on alone. His own view, however, was that it would be unacceptable to opinion in this country to make any such offer.

Since his discussion with the Ministers concerned, he had obtained the views of our overseas posts on the likely reaction to our unilateral abrogation of the treaty by the Governments of the European Economic Community (EEC) other than the French. The view of our representatives was that the Governments of the Five, with one exception would be likely to react adversely: they would probably interpret our action as being motivated mainly by pique at the French veto of our application to join the EEC and as a sign that we were no longer seriously interested in European collaboration in the technological field.

The Attorney-General confirmed that there were no legal grounds on which we could terminate the treaty at the present time. If we were not prepared to offer assistance to the French to help them to complete the project alone, we could not expect any mitigation of the amount of damages which would be awarded against us. If on the other hand we continued until 1969 and it became clear by that time that the project was not likely to be commercially viable, this would provide us with legal grounds for abrogating the treaty; and if in those circumstances we were to withdraw unilaterally the Court would be likely to find in our favour. In the light of these considerations, his advice as lawyer to client would be against cancellation at the present time.

The Minister of Technology said that he was opposed to cancellation now, not only because of the political and financial implications, but also because of the consequences for the airframe and aero-engine industries. By the spring or early summer of 1969, it would be clear whether the technical problems had been sufficiently overcome to make the project viable and this would be reflected in the extent to which the airlines were prepared at that time to place firm orders for Concorde. The right course was for him to hold discussions now with the French authorities with the object of laying down conditions which would have to be fulfilled if we were to continue with the project after the spring or early summer of 1969. These conditions should be expressed in terms of a minimum number of firm orders for the aircraft. If the French Government agreed to such conditions, but when the time came were not prepared to abide by them, it should then be possible for us to abrogate the treaty unilaterally without risking the award of damages against us. If the French declined to accept the conditions in the first place, he would still recommend that we should withdraw in 1969 if the conditions were not met, and the fact that the French had declined to accept such conditions should then tell in our favour in any legal proceedings.

In discussion it was argued that the estimates in C(68)4 of the additional expenditure which the Government would incur if the project continued for a further 18 months were almost certainly too low. Moreover, it was unlikely that it would be possible in 1969 to demonstrate conclusively that the technical problems were such as to render the project no longer viable: it would always be urged that, given more time and money, the technical problems could be overcome. On the other hand, if we cancelled now we should be securing savings in the short term which would be offset in later years by payment of damages: this would simply be tantamount to raising a forced loan from the French. That was an unattractive prospect, and the Government should not put itself in

the position of being held accountable for payment of heavy damages across the exchanges in 1970 or 1971. As regards the objection that we should be told in 1969 that any outstanding technical problems could be overcome given more time and money, this would lose its force if conditions for the continuance of the project could be established on the lines proposed by the Minister of Technology: any substantial delays to deal with technical difficulties would progressively reduce the lead which Concorde was now expected to have over the American supersonic transport, and this would be reflected in a reduction in the number of firm orders for Concorde; if this went far enough, the conditions for continuing the project would not be met and we should have a clear case for withdrawal.

The Prime Minister, summing up this part of the discussion, said the Cabinet agreed that we should not at this stage unilaterally abrogate the treaty governing the Concorde project. The Minister of Technology should consider with the Attorney-General the drafting of conditions, preferably to be expressed in terms of a minimum number of firm orders for Concorde, which should be met if we were to continue with the project beyond the spring or early summer of 1969; this should be the subject of early discussion with the French.

The Cabinet –

(17) Agreed that the Government should not at this stage withdraw from the Concorde project.

(18) Invited the Minister of Technology to consider, in consultation with the Chancellor of the Exchequer, the Attorney-General and other Ministers concerned, what conditions we should seek to agree with the French Government for continuance of the project beyond the spring or early summer of 1969.

X

Written answer by the Prime Minister (Harold Wilson) in the House of Commons on 23 July 1974

Hansard, House of Commons Debates, col.429

President of France (meeting)

Q7. **Mr Blaker** asked the Prime Minister if he will make a statement about his recent official meeting with the President of France.

The Prime Minister: The President and I had talks in Paris on 19th July. We discussed a wide range of bilateral, European and international subjects, in a friendly and constructive manner.

On Concorde, we agreed that the 16 aircraft, whose production had already been authorised, should go ahead but no further commitment was made. We agreed that a difficult problem over the delimitation of the Continental Shelf in the Western Approaches should be settled by impartial arbitration. We also discussed the Channel Tunnel.

The two Foreign Ministers joined us for discussions on the Community and also on world problems such as energy and inflation, as well as the present crisis in Cyprus. Finally, I had a meeting with the French Prime Minister, Monsieur Chirac.