Anglo-French Collaboration – The Present and Some Thoughts for the Future

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PART I. THE PRESENT POSITION

1. Introduction

The title of my lecture is 'Anglo-French collaboration — The Present and some Thoughts for the Future'. It divides into two parts and much of Part I, which deals with the Present Position, will be devoted to the most advanced example of Anglo-French collaboration — the Concorde.

It is over two and a half years since I last spoke in public and at length about Concorde.

In February 1964, giving the Brancker Memorial Lecture to the Institute of Transport, I said three main things:

1 There will be Supersonic Travel because what air transport sells is speed and its curve of progress in that respect would continue.
2 The Concorde, at a speed of Mach 2·2, came on this curve of aviation progress in 1970 by straightforward extrapolation.
3 Any future design of a subsonic cheap-fare vehicle did not affect the arguments for Concorde. There was a clear market for a big, low seat-mile cost vehicle and there was also a clear market for a Supersonic Transport. The two vehicles were complementary not competitive.

The passing of time has confirmed to me all three of those statements. I can say again now, as I said in 1964, that there will be Supersonic Travel in Concorde — if not in 1970 — then in 1971. I have also been confirmed in my expressed view that there was a clear market for Concorde, by the only kind of confirmation which Industry recognises — a good list of customers (Fig. 1).

	FIRST ORDER	RE-ORDERS	TOTAL
PAN AM	6	2	8
BOAC	6	2	8
AIR FRANCE	6	2	8
CONTINENTAL	3		3
TWA	4	2	6
AMERICAN AIRLINES	4	2	6
MIDDLE EAST AIRLINES	2		2
QANTAS	4		4
AIR-INDIA	2		2
JAPAN AIR LINES	3		3
SABENA	2		2
EASTERN	2		2
	44	10	54
AT 1966 PRICES = $1,000 M.			

FIG. 1 — Customer Lists — Concorde sales as at September 1966.

As for my third 1964 statement, that Concorde and big cheap-fare jets are complementary and not competitive; this very view has been stated by Eastern Air Lines when it chose Concorde — and has also been given point by Pan American — which chose Concordes — then Jumbo Jets — and then more Concordes.

I shall now turn to the details of this great enterprise — because it is through the detailed planning and control which we have jointly evolved that the success we have undoubtedly achieved up to the present time has been possible.

2. Concorde Collaboration

(*a*) *Basic principles*

I will remind you briefly that Concorde received the go-ahead from the British and French Governments in November 1962 after an identity of views had been established on the need for a supersonic air liner and roughly what kind of S.S.T. it should be. This agreement in fact evolved at official and industrial level in 1960 and 1961, and it was all brought together in 1962 — with B.A.C. as the British Airframe firm, Sud Aviation as the French one and with Bristol Siddeley and SNECMA doing the Olympus 593 engines. The whole project has always been an overall 50–50 one. Within that envelope Britain has a bit more of the engine work than France and consequently Sud has more of the airframe than B.A.C. All this history is well known — but I re-state it here for completeness of narrative.

The two airframe companies between them employ nearly 60,000 people and the two engine companies over 40,000 people. In terms of facilities, capacity and experience these groups are among the world leaders. The present planned joint production rate from this impressive grouping of talents and resources is three Concordes a month. Our first two years' production is already allocated at this rate — which is a rate of £200 million worth of aircraft a year. The pressure on early deliveries is causing us to examine the possibility of increasing the rate to five a month. This would have two benefits — a big jump in annual turnover — and, almost certainly a big jump in sales. This is a question of making the maximum bonus from our lead time in the supersonic field. Such an increased rate, however, clearly involves further joint initial outlay, and these things are now being earnestly considered on both sides of the Channel.

To have reached what I believe to be this healthy and viable position on Concorde we have had, in the past four years, to ensure that the great combined power of the four main firms involved has been properly deployed, meshed, planned and controlled — at official level and by the industrial leaders. Officials in the two countries and members of the four firms have now been working together on the Concorde project for four years. In that time the aeroplane has gone through the processes of enlargement and improvement normal in aircraft development. There are still problems but none for which we cannot see a means of solution. The same is true of the collaboration itself.

The basic 50–50 principle on which the collaboration was founded was simple. But the task of putting this relatively simple principle into effect has involved the setting up of a quite complex multi-layer collaborative organisation.

(*b*) *Management structure*

Overall supervision of the project on behalf of the two Governments which are financing it is exercised by a Standing Committee of officials. This Committee's main areas of responsibility are the general programme and technical progress and expenditure. In all these fields it reports, and where necessary makes recommendations, to the Governments. The two countries have equal representation on this Committee and the offices of Chairman and Vice-Chairman are held in rotation by a Frenchman and a Briton. This pattern is followed in all the other Committees in the management structure (Fig. 2).

Under the Standing Committee is the Technical and Administrative Sub-Committee responsible for co-ordinating the technical and financial aspects of work by the official services and the firms. The Sub-Committee's technical activities cover a wide field and bring in the Government Establishments, the Air Traffic Control Services, the Air Registration Board, and other bodies. There is also an Airline Advisory Committee, chaired in alternate years by

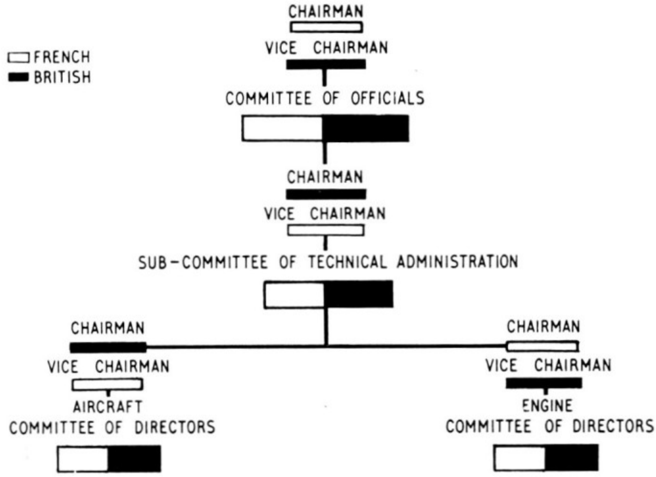

FIG. 2 — Concorde organisation

the Chairman of B.O.A.C. and the President of Air France, which from the early stages of the project has been a valuable link between the operators and the manufacturers.

On the industrial side there are two Committees of Directors, one for the aircraft manufacturers and the other for the engine manufacturers. I intend in this paper to concentrate on the aircraft collaboration because that is the side I am primarily concerned with, but the engine companies have plainly built up in their area as firm a collaboration as B.A.C. and Sud Aviation have done.

General Puget was the first Chairman and I wish to pay tribute to the outstanding contribution he made during those critical early years to Anglo-French understanding and co-operation. General Puget was a good friend of Britain well before Concorde got under way and during the collaboration we have found no difficulty in reaching a firm understanding. We work closely together and, when we are called on to do so, we take executive decisions jointly. Whatever it may say on paper, the Committee of Directors is, in practice, a double-headed rather than a single-handed structure.

This is an important point to make because it really sets the pattern for the whole collaborative management structure. At this level there can be no question of imposed decisions. Problems have to be talked out and one side has to take the other along with it. Agreement has to be reached, and the time spent in reaching it is time well spent because, at the end of it, all facets of the problem have been fully considered.

The majority of our B.A.C./Sud meetings are at this executive working level.

The Committee of Directors itself does not meet very often, and this could well be one of the secrets of the success of our collaboration.

3. Machinery of Collaboration

(*a*) *Cost-sharing arrangements*

To consider the machinery of collaboration in greater detail it is necessary to look at the way it operates in the various functional fields; cost control, engineering, production, and sales.

The future not only of this project, but of Anglo-French collaboration as a whole, depends on efficient cost control and equitable cost sharing. Cost-sharing must cover not only the prime contractors, but the sub-contract and bought-out work ordered by the prime contractors. The supporting work done by British and French Government establishments must also be balanced.

These problems are continually examined by working parties set up by the Ministries or the firms and a number of differences in, for example, accounting practices, have been resolved or reconciled. The SBAC and its French opposite number, the USIAS have set up their own working party to consider these matters and their implications for Anglo-French collaboration.

Arrangements for cost sharing and cost control — the two are inseparable — can be dealt with under two headings; (*i*) Commercial, and (*ii*) Financial.

(*i*) *Commercial aspects.* Commercial aspects of cost-sharing have been examined by a number of Ministerial or B.A.C./Sud joint working parties, with good results. We have achieved a large measure of agreement on the basic terms and conditions of Company purchase orders on suppliers. A mechanism was set up under which each major equipment supplier whose design development for Concorde work was to be supported by Government funds would grant equivalent industrial rights to both the British and French Governments.

(*ii*) *Financial aspects.* The two Governments' practices on funding a large research and development programme are close enough to prevent any serious difficulty arising in the launching phase of Concorde.

Cost control is the most important of all the financial aspects of collaboration. The two airframe companies, in conjunction with the respective Ministries, have evolved a computerised system of budgetary control and reporting. Programme monitoring methods based on PERT are used.

It is right that we should never lose sight of this subject of cost. It is the main preoccupation of everyone concerned in the management of the Concorde project. I know of no project where the costs are more minutely scrutinised or more continuously controlled, or where cost information has been so fully and promptly supplied to the sponsoring Government authority.

I have dwelt on cost and financing because the collaboration work in this field does not produce the visible, and sometimes dramatic, results shown in the engineering and production fields. But without a good understanding and agreement on cost control, the Concorde collaboration could not get off the ground.

(*b*) *Engineering collaboration*

The next area to look at is engineering. On the Concorde, design work is divided on the lines shown in Fig. 3.

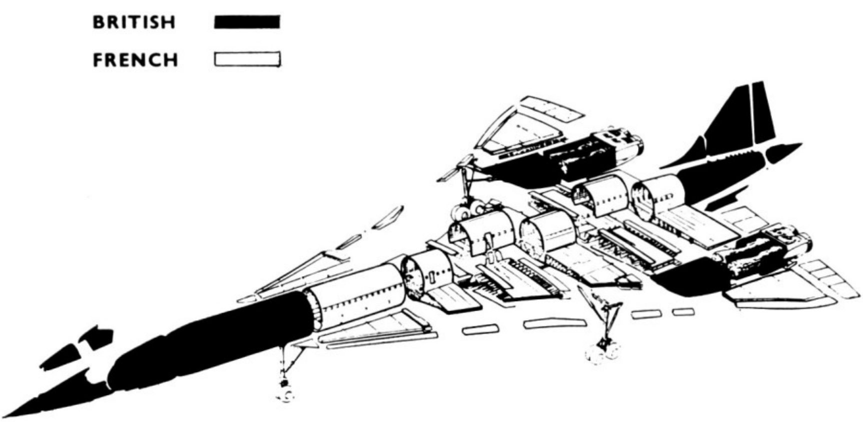

FIG. 3 — General manufacturing breakdown diagram

One of the factors in the original Anglo-French discussions was the Olympus turbojet, an existing British engine with the required development potential. This influenced the way in which the division of work was ultimately arranged, Sud-Aviation being allocated about sixty per cent of the airframe and B.A.C. about forty per cent, the overall fifty–fifty balance being achieved by the greater British share of the engine.

In structural design, B.A.C. is responsible for the front fuselage including the flight deck, the engine nacelles, air intakes and engine mountings, the rear fuselage, fin and rudder. Sud is responsible for the entire centre fuselage section, the wings, including elevons and the landing gear.

On aircraft systems, B.A.C. has responsibility for electrics, oxygen, fuel, engine instrumentation, engine controls, fins, air conditioning distribution and de-icing. Sud is responsible for hydraulics, flying controls, navigation, radio and air-conditioning supply.

Within this well-defined division of responsibilities, the two national engineering teams are able to work independently on detail design of the components and systems in their respective areas. All this work has to be controlled and co-ordinated at top level, with close liaison at all lower levels concerned with interface problems.

The necessary joint direction is maintained by close co-operation at the top, and especially within the Technical Co-ordination Group. This consists of three French and three British senior members of the two design organisations. All members of the Group have free access to both design organisations and the Group has authority to deal with day-to-day problems that do not warrant reference to the Directors.

Much of the detailed B.A.C./Sud engineering liaison work, particularly in the early days of the project, was concerned with standardisation. I say 'standardisation' rather than 'standards' because it covered not only nuts and bolts, but procedures, methods and documentation.

Our two companies have agreed on the use of UNF threads and we both conform to an identical drawing numbering system. Common practice on the dimensioning of drawings was harder to arrive at. It was not reasonable to expect the French to move away from the metric system, especially in view of British plans to 'go metric'. On the other hand, we had good reasons — cost, among them — for wanting to stay with the British system. The practice is, therefore, that Sud design and dimension their drawings in millimetres and we design in inches and, where necessary, put both inch and millimetre dimensions on the drawings. Drawings in join-up areas carry dimensions in both scales (Fig. 4).

Progress has been made on agreement on engineering standards. The objective is to strengthen Concorde's operational acceptability by adopting where possible the most widely accepted standards. In making the selection we have looked first to International Standards and second to American Standards. Only when we are unable to find an existing appropriate standard is a special Concorde standard produced.

We found there was a different approach to the subject of inspection and quality control. In France there is a greater degree of delegation to the companies, and the main contractor originates the inspection documentation. Their system is indeed similar to the American system where the main contractor takes complete responsibility for suppliers and sub-contractors. The U.K. inspection system is based on official standard documentation and the main contractor writes only the additional documentation necessary for a specific project. We have met this problem by including in our Concorde inspection documentation areas that would normally be considered to be covered by the basic U.K. rules.

Equipment selection and approval on a bi-national project has obvious thorny implications, but we hope we have contrived to steer between the thorns. The first task was to identify major and minor equipments. Minor equipment is chosen by the design team responsible. For major equipments, submissions are invited on a jointly-agreed specification and a list, in order of

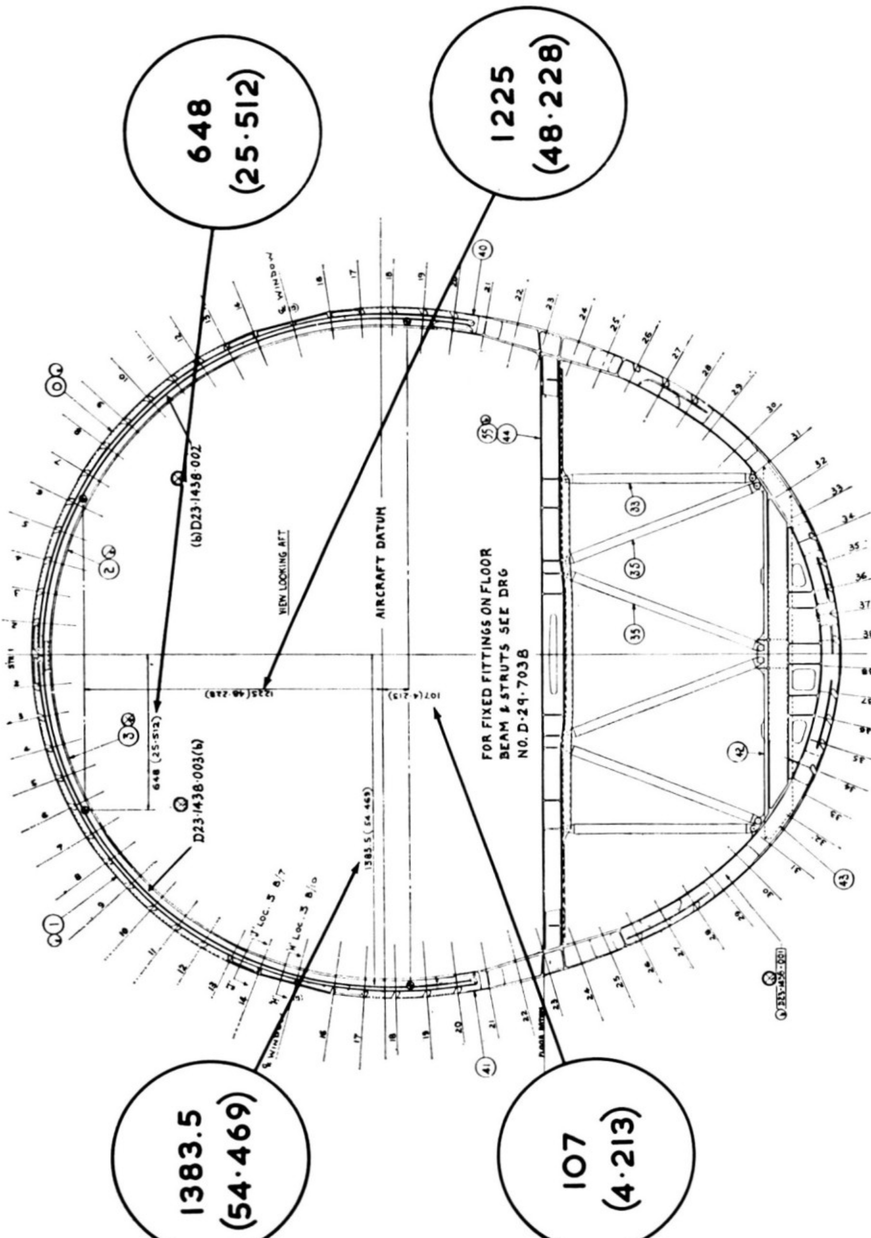

FIG. 4 — Typical Concorde drawing — French and British Dimensions

preference, of three approved manufacturers is drawn up by the responsible design team, with the agreement of the other side. The final choice is made by the Technical Committee of Officials in consultation with our two companies. There are good reasons why these decisions, which can have important political implications, should be taken at official level, and I would remind you of the protective arrangement, already mentioned, whereby major equipment suppliers whose Concorde design development work is Government-financed are required to grant equivalent industrial rights to both Governments.

Concorde test programmes, and the collaborative arrangements applicable to them, would form the subject of a long paper in themselves. By the time it goes into airline service, this aircraft will have been more thoroughly tested than any other previous air liner. There is time to refer to only a few of the main areas, starting with aerodynamics. In general, wind tunnel testing is of relevance to the aeroplane as a whole, since the investigations are into drag, handling and stability characteristics. This work is therefore controlled by the Technical Group, and each model and test is specifically approved.

Structures and systems testing are the primary responsibility of the team concerned, but test schedules for important specifications are jointly approved by the heads of the departments involved.

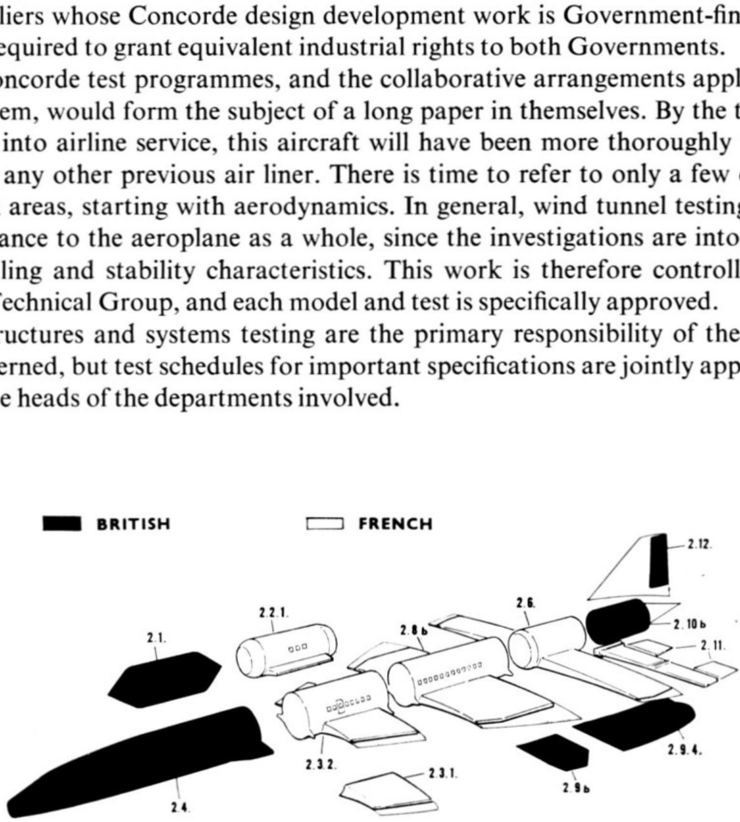

FIG. 5 — Structural test specimens

Figure 5 shows the main British and French structural test specimens. Test work on major specimens has begun and will lead ultimately to tests, under simulated supersonic heating conditions, on two complete Concorde airframes; one for static testing in the new laboratory of C.E.A.T. at Toulouse (Fig. 6) and the other, for fatigue testing, at the new R.A.E. structures laboratory at Farnborough (Fig. 7).

Discussions have taken place on the flight test programme and agreement

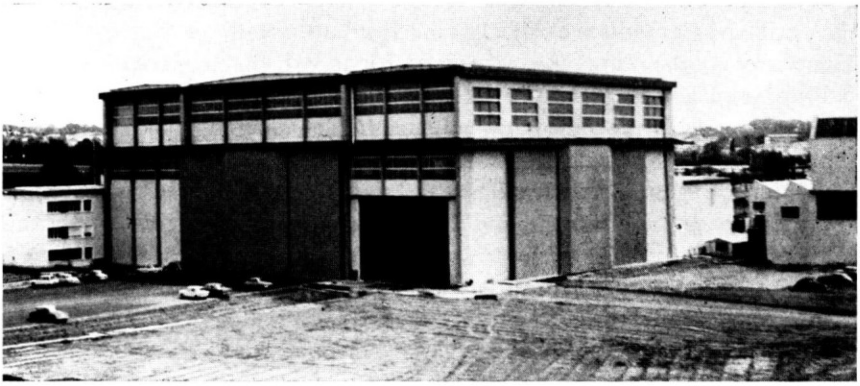

FIG. 6 — C.E.A.T. Laboratory, Toulouse

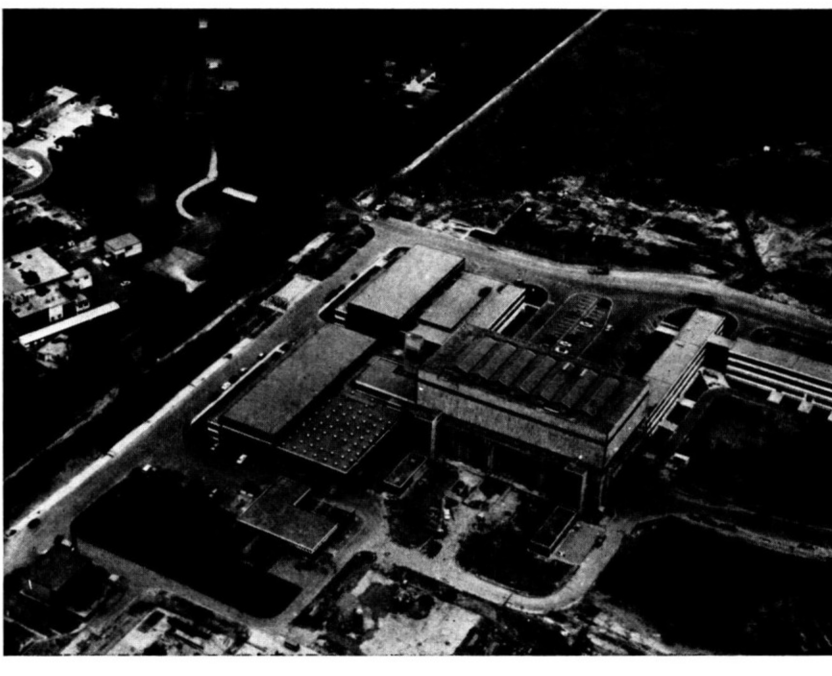

FIG. 7 — R.A.E. Laboratory, Farnborough

has been reached on the division of responsibility between the two flight test centres at Toulouse and Filton. You will not be surprised to know that the early flights are not likely to be made by mixed crews.

(*c*) *Production collaboration*

The third of the main fields of collaboration is production. The overall division of work is the same as for design, but Fig. 8 shows how the work of airframe component manufacture has been spread among a number of factories in Britain and France. There are three B.A.C. factories, Filton, Preston and Weybridge, engaged on Concorde prototype production, and four Sud factories, Toulouse, Bouguenais, Marignane and St. Nazaire.

Here I want to underline an important point. Although we shall have two final assembly lines, one at Toulouse and one at Filton, there is no duplication in the manufacture of these major sub-assemblies. For instance, B.A.C. Weybridge Division will build all the noses for both the Toulouse and the Filton lines. Sud Aviation's Marignane factory will build all the centre fuselage/wing sections.

The fact remains that there *are* two final assembly lines, and the suggestion is sometimes made that this is a costly and cumbersome way of organising the work.

Admittedly there are some additional transport costs, but these are marginal to the project as a whole.

To achieve a given rate of production one requires a given amount of capital equipment and a certain number of men, and in the long run it does not greatly affect production costs if this equipment and these men are concentrated in one place or in two. I have qualified that statement by saying 'in the long run'. In the short run, there *is* a difference. On two separate final assembly lines there are higher learning costs than would be incurred on a single line.

Practical action is being taken to mitigate this effect by reducing the time spent in final assembly. It is planned that major sub-assemblies will be finished and equipped to a more complete standard than is usual before they are moved to the final assembly line.

Had it been politically practicable to concentrate Concorde production in either France or Britain, there would still have had to be two assembly lines. We are talking of an enormous project — an annual output valued, at the present projected rate, at £200 million. In value terms that is equivalent to an annual output of 200 short-haul jetliners or 200,000 big popular saloon cars. No one single existing production facility in either country could do this without massive new investment in capital equipment and massive recruitment of new labour.

	COMPONENT	PIECE	PRODUCTION REALISATION	DESIGN ETUDE
10	FUSELAGE NOSE	POINTE AVANT	BAC WEYBRIDGE	BAC FILTON
11	FORWARD FUSELAGE	FUSELAGE AVANT	BAC FILTON	" "
12	INTERMEDIATE FUSELAGE	FUSELAGE INTERMEDre	SUD MARIGNANE	" "
13	FORWARD WING	ONGLETS DE VOILURE	SUD BOUGUENAIS	DTA UC
	CENTRE WING/FUSELAGE	PARTIE CENTRALE	SUD MARIGNANE	" "
14	Fr. 46 to Fr. 54 fus. / Fr. 46 to Fr. 50 wing	" "	" "	" "
15	Fr. 50 to Fr. 54 wing	" "	SUD TOULOUSE	" "
16	Fr. 54 to Fr. 60 wing/fus.	" "	" "	DTA UT
17	Fr. 60 to Fr. 63 wing	" "	" "	SILAT
18	Fr. 60 to Fr. 69 fus. / Fr. 63 to Fr. 66 wing	" "	" "	"
19	Fr. 66 to Fr. 69 wing	" "	" "	FIAT
20	Fr. 69 to Fr. 72 wing/fus.	" "	SUD St NAZAIRE	"
21	OUTER WINGS	VOILURE EXTREME	GAM DASSAULT	GAMD
23	ELEVONS	ELEVONS	ROHR	DTA UC
24	REAR FUSELAGE	FUSELAGE ARRIERE	BAC PRESTON	BAC PRESTON
25	NACELLES	NACELLES	BAC FILTON & ROHR	BAC FILTON
	NOZZLE	TUYERES	SNECMA	SNECMA
26	FIN	DERIVE	BAC WEYBRIDGE	BAC PRESTON
27	RUDDER	GOUVERNAIL	BAC FILTON	" "
51	LANDING GEAR MAIN	TRAIN PRINCIPAL	HISPANO SUIZA	HISPANO SUIZA
	NOSE	TRAIN AVANT	MESSIER	MESSIER

BAC	FILTON Division
ELECTRICS	ELECTRICITE
OXYGEN	OXYGENE
FUEL	CARBURANT
ENGINE INSTRUMENTATION	INSTRUMENT REACTEURS
ENGINE CONTROLS	COMMANDES
FIRE	FEU
AIR CONDITIONING DISTRn	DISTRIBUTION AIR CONDITIONNE
DE-ICING	DEGIVRAGE

SUD	TOULOUSE
HYDRAULICS	HYDRAULIQUE
FLYING CONTROLS	COMMANDES DE VOL
NAVIGATION	NAVIGATION
RADIO	RADIO
AIR CONDITIONING SUPPLY	ALIMENTATION CONDITnt D'AIR

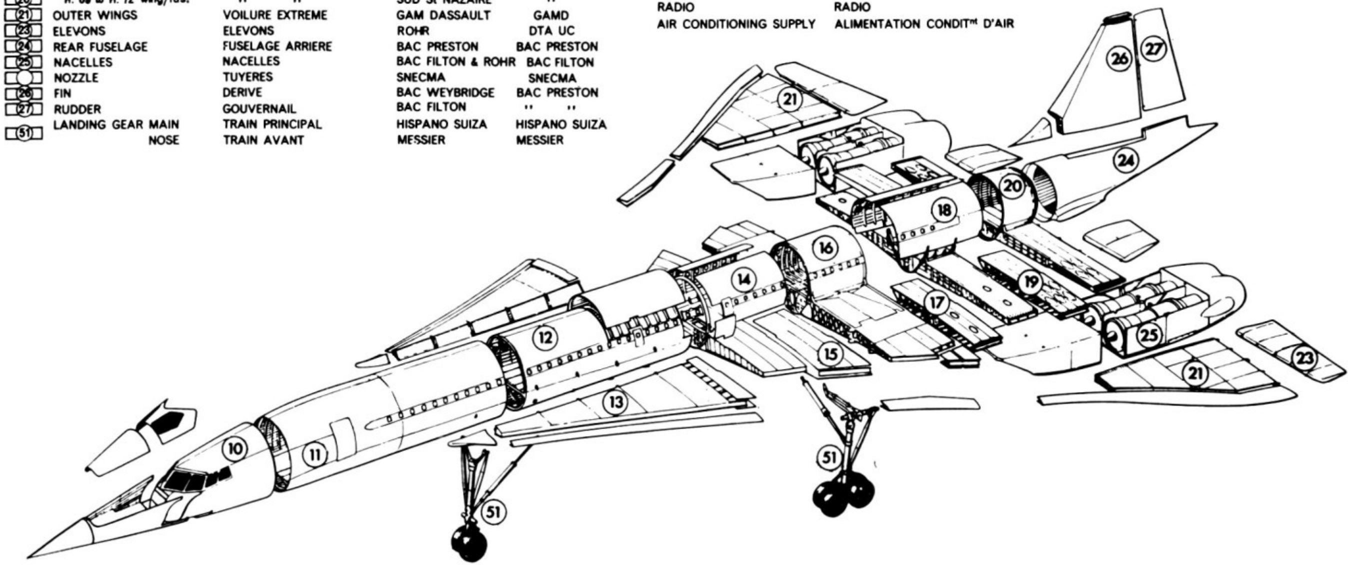

FIG. 8 — Manufacturing breakdown

(*d*) *Sales*

The last area to be considered is sales which, in the Concorde organisation, is a joint activity headed by French and British Co-Directors. The two sales organisations work together and sales presentations to airlines are normally done jointly.

It is proposed that product support for the Concorde should be undertaken jointly and the implications of this are being studied by working parties.

That, in outline, is the machinery of Concorde collaboration as it has evolved till now. It is a lively and vigorous growth, with the promise of further development in the future. Now I will turn to the end-product of the collaboration, the Concorde itself.

4. The End Product

This is the production Concorde aircraft which we are selling today — the world's first supersonic transport aircraft; designed to cruise at Mach 2·2 — 1250 kt., or 1450 m.p.h. at altitudes up to 64,000 ft (Fig. 9).

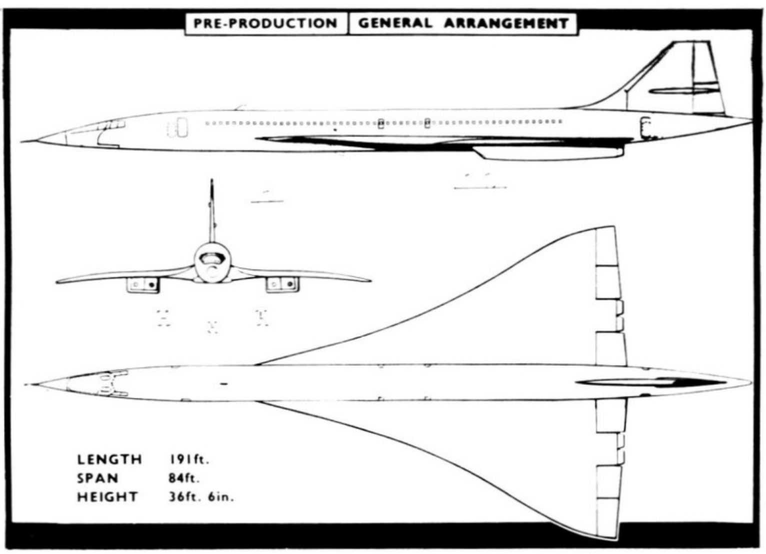

Fig. 9 — General arrangement with dimensions

It will carry about 140 economy class passengers over a 4,000 st. ml. stage with full airline safety and regularity reserves.

The fuselage is mounted on an ogee shaped wing.

Power is provided by four Olympus 593 engines, each of 35,000 lb. S.L.S.T. Two are contained in each of the nacelles mounted under the wing.

All this data applies to the aircraft which we are selling. The first aircraft which we are actually building at present is the 'prototype' (Fig. 10). As a

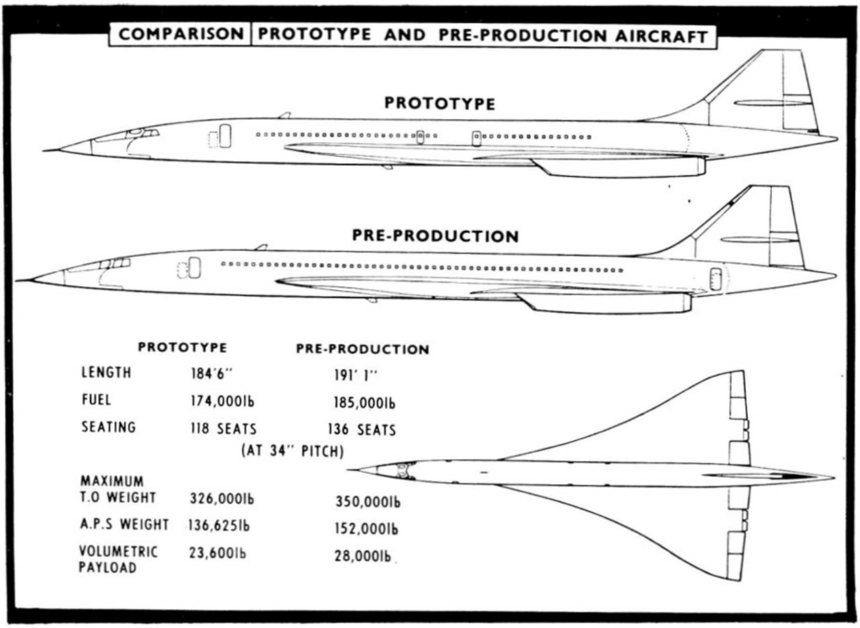

FIG. 10 — Prototype pre-production aircraft comparison

result of continuing developments in the design, it has been possible to make changes from the prototype aircraft which give significant operational advantages, better performance and improved economics without affecting the structural or systems design philosophies. These improvements are embodied in the pre-production aircraft which are to the standard offered to airline operators. The length of the pressurised cabin of the pre-production aircraft is 19 ft. 3 in. longer than that of the prototype, but to achieve this we have only increased the actual fuselage length by about 6 ft. 6 in. This has been done by extending the front fuselage forward by two window bays and by re-positioning the rear pressure bulkhead 15 ft. 8 in. farther aft. The rear fuselage cone has been lengthened by about 3 ft. to give the overall fuselage length of 191 ft. 1 in. This first stage stretch is consistent with what has been done on almost every subsonic aircraft.

The rear ventral door has been replaced by two lateral doors which are located in the pressure hull immediately forward of the rear pressure bulkhead.

The forward fuselage underfloor space between the nose and main landing gear bays has been re-arranged to provide a single baggage hold of slightly less total volume than the two-hold arrangement of the prototype. This arrangement has also allowed an increase in the fuselage fuel tank capacity, so that the total usable fuel capacity in flight has been increased from 174,000 lb. to 185,000 lb.

Systems equipment originally located in the unpressurised areas on either side of the ventral entry has been re-positioned on the pre-production aircraft to an unpressurised bay below the cabin floor.

The wing area is the same for both prototype and pre-production versions of the aircraft. The maximum take-off weight of the pre-production aircraft at 350,000 lb. is 24,000 lb. more than the prototype.

Two pre-production aircraft are being built, following immediately after the two prototypes and before the full production aircraft.

The longer cabin and the revised door and pressure bulkhead arrangements have improved the potential passenger carrying ability of the pre-production aircraft well beyond that of the prototype.

To the passenger the Concorde will not be dissimilar to present day subsonic jet transports. Comfort levels will be at least as good, if not better than at present (Fig. 11).

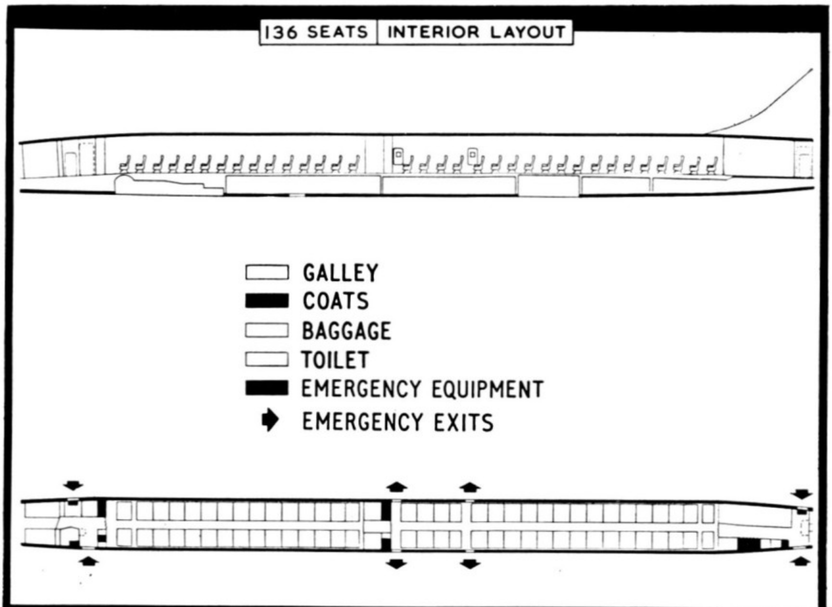

FIG. 11 — Typical seating arrangements

A typical interior arrangement comprises 136 tourist class passengers sitting four abreast at 34 inch seat pitch, entry being through the front and rear doors. Two toilets are located in the centre cabin area and one at the front. There are galleys front and rear.

There are four emergency exists on each side of the cabin, two Type I and two Type III. Baggage is carried in the underfloor hold and in an upper hold at the rear of the cabin.

Alternative arrangements to the requirements of different operators make it possible to carry up to 148 passengers by re-positioning the toilets and reducing seat pitch.

The maximum payload of 28,000 lb. can be carried over distances up to 4,000 statute miles. Thereafter, as is usual, range can be increased by carrying fewer passengers and more fuel (Fig. 12).

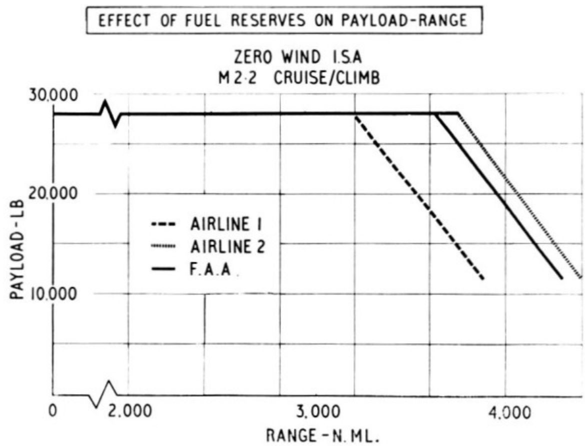

FIG. 12 — Payload-range diagram

This range is achieved using the optimum Mach 2·2 cruise-climb technique. Using a Mach 2·2 stepped cruise technique, such as that which might be necessary for Air Traffic Control reasons, the range is reduced by about 70 st. miles.

Of great interest to the operator is the range when the aircraft is not operating at its optimum design conditions. The range of the aircraft, with full payload, when flying at subsonic speed, is only very slightly less than at Mach 2·2. This is because the overall efficiency of the aircraft at the two speeds is very similar. This means that should, for any reason, the aircraft have to decelerate and continue at subsonic speed, it can always complete its mission safely. Only at extreme operational ranges would it be necessary to consume any of the normal fuel reserves.

Despite its greatly increased cruising speed, the aircraft will not require longer runways than those used by the present big subsonic jets. Typical runway lengths required are 10,000 ft. at maximum T.O.W. and 7,900 ft. for landing.

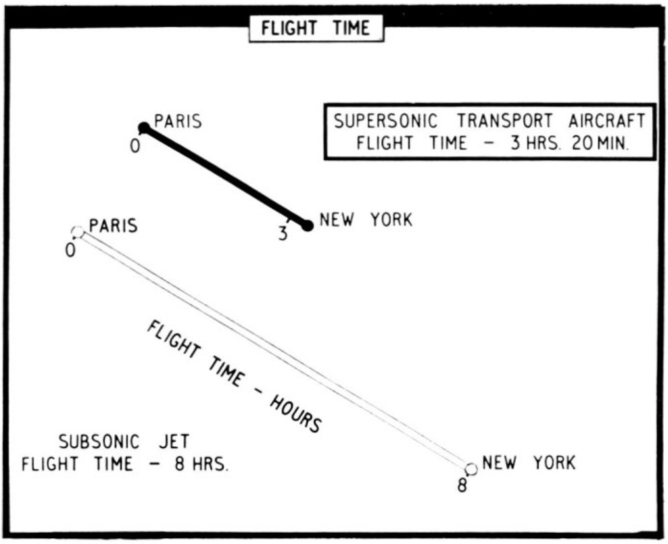

FIG. 13 — Journey time London/New York

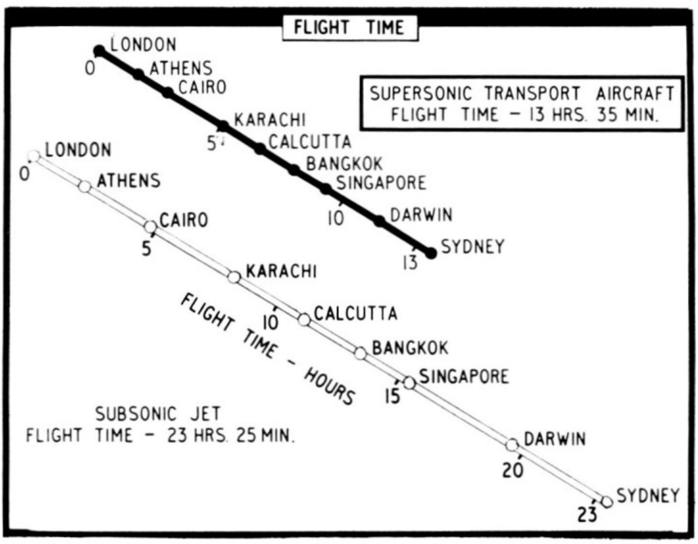

FIG. 14 — Journey time London/Sydney

The most dramatic benefit which Concorde will confer on its passengers will be the reduction in journey time. At present it takes 7 hours 20 minutes to fly between London and New York. Concorde will cut this to less than half — 3 hours 15 minutes (Fig. 13). The flying time between London and Sydney is now almost 23½ hours. By Concorde it will be reduced to 13½ hours (Fig. 14).

These attractions to the passenger are brought about by the aircraft's great speed, and it is this speed which gives the Concorde its excellent economic potential.

5. Report on Current Progress

(*a*) *Production situation*

At this point it might be as well to remind you that we are talking about a real aeroplane already being built. Production progress on the two prototypes is well up to programme and this achievement is the tangible measure of the success of our collaboration.

Concorde is quite recognisably taking shape as is shown by this picture of the centre fuselage (Fig. 15) and wing of the first prototype — 001 — in the Sud Aviation St. Martin factory at Toulouse. To date 90% of major

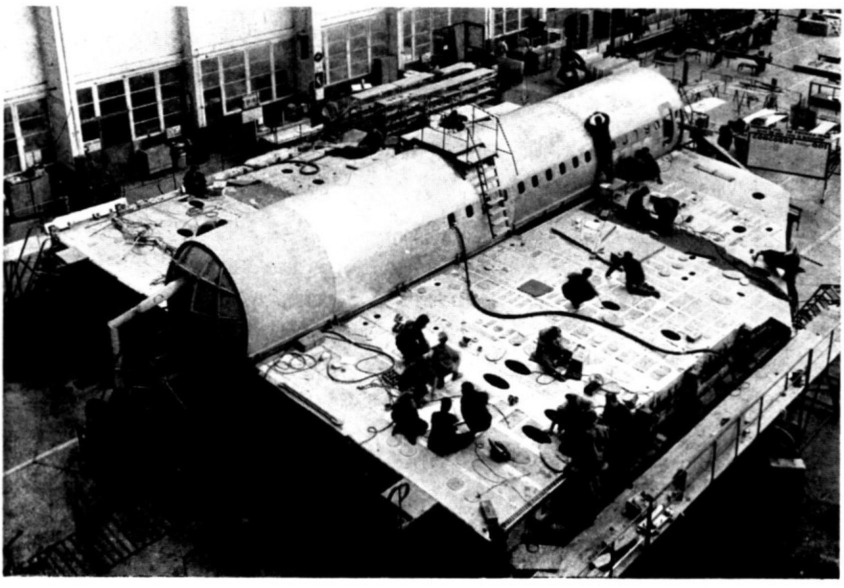

Fig. 15 — Toulouse centre fuselage-wing build-up

structural items of 001 have been made, and 78% of those of 002. Of a target to first flight of 35,000 manufacturing drawings, 29,600 have already been issued.

The notice boldly proclaims that the first flight date for 001 is 28th February, 1968, which is only eighteen months away. Many Frenchmen and many Britons are working hard to keep the project on schedule and to make that first flight forecast a reality. Computerised management techniques are helping to plan the production programme and to monitor progress continuously.

Figure 16 shows another recognisable piece of 001. At our Filton works the fin, made at B.A.C. Weybridge, is mated with the rear fuselage, made at B.A.C. Preston. After being equipped at Filton, these components went to Toulouse a few weeks ago. This month the first French-built components for the second prototype, 002, will begin to arrive at Filton. Fig. 17 shows one of the centre fuselage/wing sections.

Figure 18 shows the forward fuselage of 001 being prepared at Filton before despatch to Toulouse.

Engine nacelles are being built at Filton. The engine bay walls, seen in

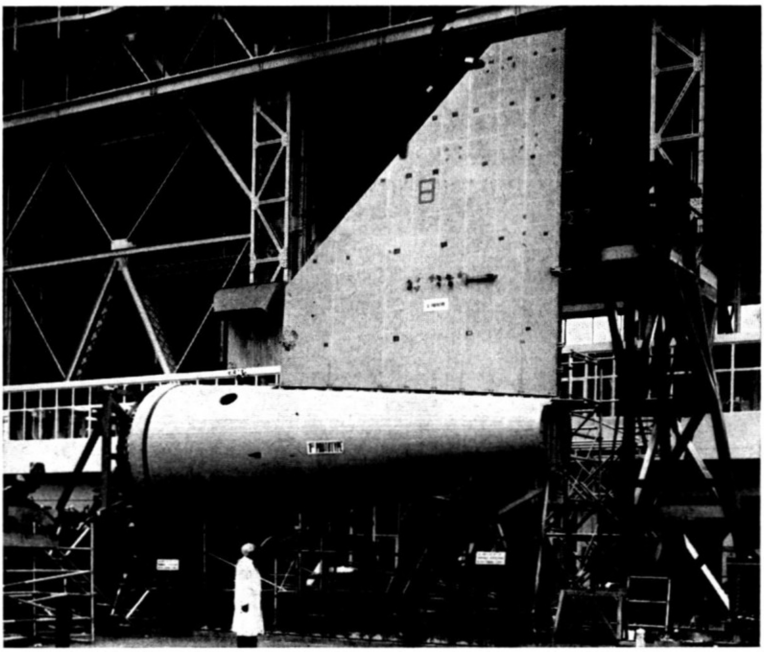

FIG. 16 — 001 Fin/tail fuselage

Fig. 19, are made of stainless steel honeycomb sandwich, one of the few areas of the airframe where material other than aluminium alloy is used.

(*b*) *Engine situation*

A situation report from Bristol Siddeley Engines shows that intensive

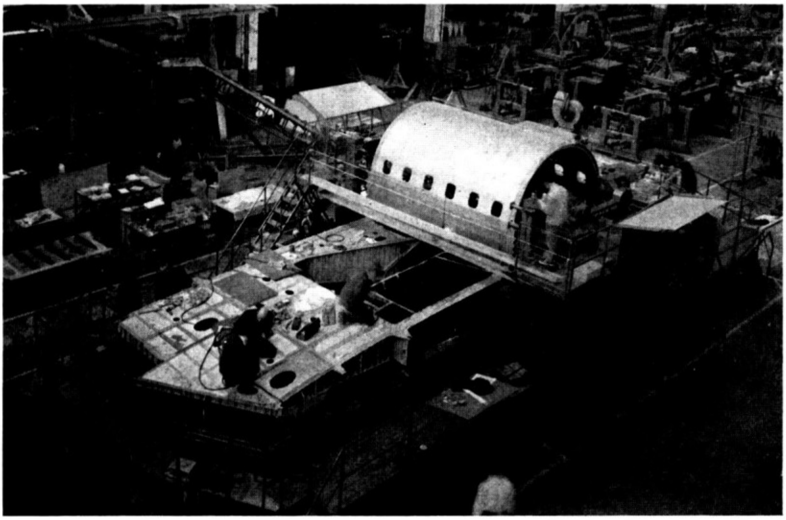

FIG. 17 — 002 centre section

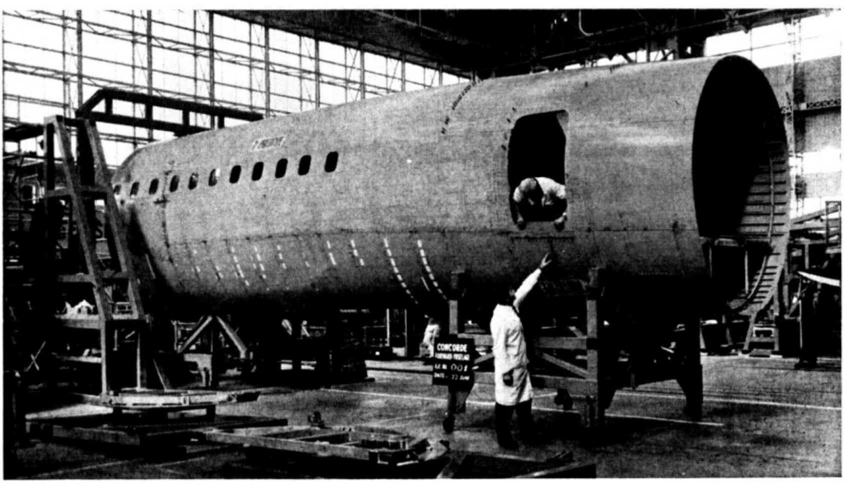

FIG. 18 — 001 Forward fuselage

FIG. 19 — Nacelle construction

development of the Olympus 593 turbojet for the supersonic Concorde is well under way. Seven engines have so far been built and total testing time amounts to some 600 hours.

A significant stage in the Olympus programme is flight testing of the Olympus 593 in a Vulcan aircraft which has been converted by Bristol Siddeley as a flying test bed. A fully representative powerplant — nacelle, air intake, engine and exhaust assembly — has been fitted into the bomb bay of the Vulcan, which is to carry out a complete exploration of the Concorde's subsonic flight envelope. The Vulcan's flight test programme of 250 hours, spread over two years, is now beginning.

Pre-flight Olympus development engines have been used for bench testing since July 1964 at Patchway and Melun-Villaroche. Full scale Concorde engine intakes have already been tested, and normal operational conditions in all flight phases have been achieved.

Several hundred hours testing have been logged with a full-scale jet-pipe, and already the thrust figures achieved — 33,600 lb. thrust dry, and 36,000 lb. with reheat — are above the specified figures for Concorde. Maximum thrust boost achieved with the afterburner has been 17·8%, again greater than specified.

Prototype nozzles are being manufactured, and tests show that predicted efficiencies will be obtained. Development on full-scale and model nozzles is continuing in an endeavour to produce still further improvements in nozzle performance.

The thrust reverser for the Olympus 593 has also been subjected to full-scale tests by SNECMA, using Atar and Olympus slave engines, and results are well in excess of Concorde requirements. At the Bristol test facility, the first of four new test cells specially designed for the 593 is now in operation, and free-jet endurance tests at simulated Mach 2·2 temperatures are under way in the high-altitude facility at Pyestock.

The 593 has run more than 30 hours under simulated supersonic conditions with intake preheater at Bristol, and the first run with thrust reverser has been made.

So, we and the engine manufacturers are making real progress on engine and airframe. But how will it perform in service? How profitable will it be for its operators? These are the yardsticks by which the collaboration and the aeroplane itself will finally be measured.

6. Concorde Profitability

Concorde, as I said in 1964, represents one of the most significant steps forward in the history of air transport — perhaps in any form of transport. It will have an immense impact on world communications, travel and trade. In addition it embodies all the ideals and gives the most tangible evidence of the possibilities of Anglo-French industrial co-operation.

For all this, Concorde is not, as has been suggested, a 'Prestige Product'. It is designed to make money, both for its operator and its manufacturer.

In the hands of a good and efficient operator Concorde will make satisfactory profits. The investment is high, but so is the return that the aircraft will bring.

Apart from our own detailed assessments of Concorde's potential there have been many other independent studies made, notably by the customers. Their views may be more impressive than ours because, as a result of them, commercial action was taken and they ordered the aircraft.

I am able to show you what one of our very hard-headed customers thinks. I am most grateful to Trans World Airways for allowing their confidential assessment of Concorde to be quoted.

T.W.A. — a U.S. international airline — is one of the world's largest and most respected operators, and its results are typical of those which are available to us.

Figure 20 shows the basic assumptions used in the assessment of T.W.A.'s economic analysis — and the results.

TWA ECONOMIC ASSESSMENT OF CONCORDE

ON IDEAL SUPERSONIC ROUTE STRUCTURE

ASSUMPTIONS	
FLEET SIZE	6 AIRCRAFT
AIRCRAFT BASIC PRICE	$ 16 MILLION
PRICE WITH DUTY ETC.	$ 17·5 MILLION
TOTAL FLEET INVESTMENT (WITH SPARES ETC.)	$ 142·5 MILLION
LOAD FACTORS	55%
No. OF SEATS IN AIRCRAFT	121
RESULTS SCHEDULED MILES/DAY	60,260 MILES
UTILISATION	10 HOURS/DAY
GROSS ANNUAL PROFIT	$ 25·38 MILLION
NETT PROFIT (AFTER PAYMENT OF INTEREST AND TAX)	$ 11·40 MILLION
NETT R.O.I	16% P.A
R.O.I BEFORE PAYMENT OF INTEREST	20·85% P.A

FIG. 20 — T.W.A. assumptions and results

TWA CONCORDE CONCLUSIONS

1 RECENT IMPROVEMENTS INCREASE RANGE WITH FULL PASSENGERS BY 150 MILES

2 PAR JFK OPERATION WITH FULL PASSENGER LOAD SHOULD BE POSSIBLE

3 SEAT MILE COSTS ARE EXCESSIVE DUE TO LIMITED SEATING CAPACITY

4 CRUISE ALTITUDE FLEXIBILITY IS LIMITED AND SHOULD BE IMPROVED

5 CARGO VOLUME IS INADEQUATE AND SHOULD BE INCREASED

6 THE CONCORDE IS TAKE-OFF WEIGHT LIMITED UNDER HOT DAY AND/OR ELEVATED AIRPORT CONDITIONS

7 THE CONCORDE SHOULD PRODUCE A POSITIVE RETURN ON INVESTMENT

FIG. 21 — T.W.A. conclusions

The annual gross return is $25.38 million. After payment of all interest and taxes, this drops to $11.40 million — representing a net return on investment of 16%. This is not an unhealthy amount at today's load factors and fare levels.

The T.W.A. conclusions — exactly as they were presented to us are shown in Fig. 21.

The first two conclusions demonstrate T.W.A.'s approval of the continuing development of the aircraft. The increase in range refers to the development of the aircraft from prototype to pre-production standard. The Paris–New York operation will be against all eventualities of adverse wind and temperature with adequate levels of fuel reserve.

No. 3 conclusion is a criticism. The best way of reducing seat-mile costs is to put in more seats. As with all aircraft, no doubt engine and airframe development will make this possible, but not by 1971.

No. 4 conclusion is a performance aspect with which we do not entirely agree. Cruise altitude flexibility assumes a lateral separation track system, as envisaged, the optimum cruise/climb technique will be permissible and greater altitude flexibility is not necessary. We could put it in, but this would compromise the present optimum performance.

Conclusion No. 5 asks for more cargo space. The revenue rate of a passenger per pound is far greater than that of cargo. Concorde is basically designed as a passenger aircraft.

Conclusion No. 6 is another performance one. We have acted on this, and since last November, when T.W.A. presented their study we have improved the take-off capabilities very considerably. A refinement of the design has had the effect of increasing the regulated take-off weight, at a given temperature, by 16,000 lb.

Finally, conclusion No. 7. As you have already seen, T.W.A.'s assessment on their supersonic network is positive and healthy.

The whole of this assessment is based on the premise that today's fares and load factors will stay where they are.

Should there be a supersonic surcharge we feel that it is unlikely to outweigh the advantages of the dramatic reductions in journey time and that, in practice, there will also be an increase of Concorde load factor.

The effects of a fare differential on the return on investment are seen in Fig. 22.

The T.W.A. revenue rate has been increased by 10%, and the effect of varying load factor and depreciation period is shown.

With the increased fare, T.W.A.'s 12 year write-off period and a 55% load factor the net R.O.I. rises from 16% to 24% per annum.

If, as we expect, the load factor also increases to, say, 60%, the R.O.I. is over 30% per annum.

I have given you T.W.A.'s analysis. A similar examination of the assess-

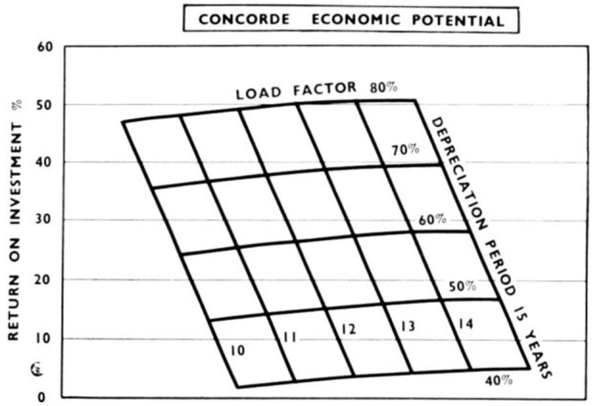

FIG. 22 — Return on investment

ments of four American operators and of one European shows a scatter of between 10 and 20% net return on capital investment according to stage lengths, fleet size, route network and operating costing methods.

So now you can see why it is that we, and our increasing number of customers, are confident of Concorde as a money making transport.

Before leaving Concorde I should like to try to sum up some of the main lessons we have learned in nearly six years of Concorde collaboration.

To begin with, before a collaboration like this develops into a reality, two conditions have to be fulfilled. First, the people concerned, at all levels (and these people *are* the collaboration) have to believe in the product. This is a question of morale, drawn from confidence, without which the collaboration will founder. The second condition is that these same people must realise that the collaboration has a much better prospect of achieving the objective than either of the partners could have if he were working on his own.

Both these conditions have been met in the Concorde collaboration. I have tried to show you why we have faith in the product. In the Concorde, we also have an air liner that will make our two countries the technological leaders in a key field of aerospace. This, I believe, is not unimportant. The French have no doubts about it.

The conviction that it was sheer common sense for France and Britain to join forces on this vast and complex project has, I believe, grown stronger as the collaboration developed. Both parties have come to know each other better, the mutual respect for each other's technical capabilities, which each felt at the beginning, has been strengthened. Both parties would now accept that the partnership is greater than the sum of its parts. It has had to withstand much ill-informed and sometimes perhaps malicious attack. It has done so.

Language is a problem and builds in some delays, but neither the problem nor the delays are as serious as might have been expected. The French are much better at English than we are at French, although many of us are trying to put that right. We have built up good translation and documentation services, and permanent liaison men are in the two main factories, Toulouse and Filton.

Documentation is of prime importance. This is an excellent discipline for Anglo-Saxons.

One of the important facts about the Concorde collaboration, and the point on which I should like to end this section, is that for us, it is an excellent discipline. It has been a bracing experience to work alongside the French — really to work alongside them in a way that few Britons have done before — to admire their confidence, their technical ability and their capacity for sheer hard work. There have been arguments and differences of opinion by the hundred but what we have done together can now be seen in tangible form. If anyone still doubts if collaboration can work a visit to the assembly sheds of Sud and B.A.C. provides an incontestable answer.

7. Jaguar

I now move on to our second Anglo-French project — Jaguar, in which we are partners with Breguet.

With our experience on Concorde to guide us it was easier to tackle the Jaguar project. Breguet, too, are experienced in International collaboration, being partners in the Atlantique Maritime aircraft with Germany and many other European countries.

Our association with Breguet is a harmonious one. The joint project started formally in 1965 with the Memorandum of Understanding signed by the French and British Ministers of Defence. By November of that year the joint Operational Requirements and the corresponding basic aircraft and engine designs and programmes were sufficiently well advanced to enable more detailed work to proceed. Six months from this point, and within twelve months of the original agreement between ministers, we were issuing drawings to our shops for the construction of major prototype components.

We and Breguet decided that in the Jaguar case it was appropriate to set up a joint Anglo-French operating company.

For the Jaguar airframe this is a French registered company named SEPECAT,† and it has a board of directors drawn from the executives of B.A.C. and Breguet.

Many advantages stem from the formation of a separate management

† Société Européenne de Production de l'Avion d'École de Combat et d'Appui Tactique.

company like SEPECAT (Fig. 23). First it represents a single unified body which negotiates with the customer. Second, it will be a simple matter to incorporate other national industrial partners in the programme should they wish to participate. Already there are signs of interest in this. Finally within SEPECAT it is simple to establish a single chain of command for all the

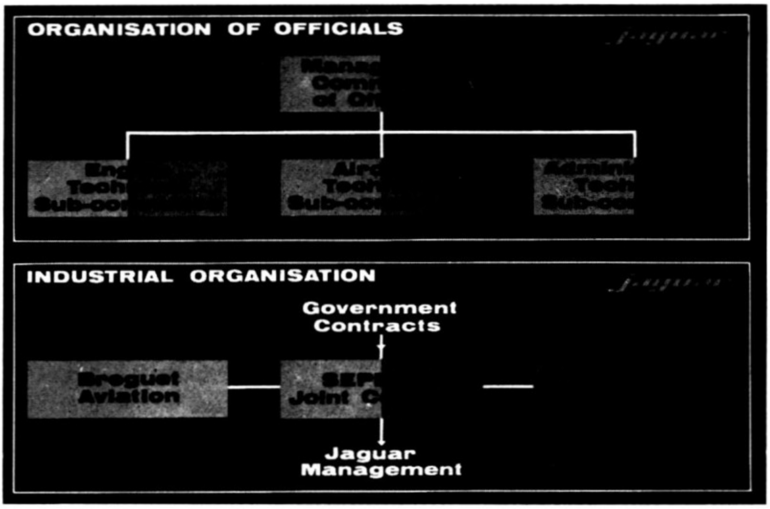

FIG. 23 — Jaguar family tree

principal activities on the programme. On Jaguar Breguet have the lead in technical and production questions, while B.A.C. have authority in matters of finance and sales.

On the Government side, Jaguar affairs are managed by a Committee of Officials and a series of sub-committees, each dealing with a specific subject such as aircraft technical matters, engine technical matters and administration. The Management Committee also represents the customers and has members from the French and British Air Staffs as well as from the Air Administrations of the two countries. On the Aircraft Management Committee decisions are executed by the D.T.C.A.,‡ the French equivalent of the Ministry of Aviation as it was. D.T.C.A. then issue contracts to SEPECAT to cover the work proposed. On the engine development side a parallel British based system is used, the companies involved being Rolls-Royce in partnership with Turbomeca.

I can, for security reasons, only talk about the aircraft in very general

‡ Direction Téchnique des Constructions Aéronautiques.

terms (Fig. 24). It is a lightweight aeroplane of about 21,000 lb, of relatively simple and straightforward design. It has twin Rolls-Royce–Turbomeca engines with reheat, and a shoulder wing of fixed geometry. A rugged long stroke undercarriage is fitted with low pressure tyres.

FIG. 24 — General impression of the Jaguar

Jaguar has a very good performance. It is superior in all important respects to its closest rival — 100 % greater radius of action, 50 % more ferry range and 33 % less take-off distance. On interception missions the radius of action is even better.

It is clearly important that any tactical aircraft has the minimum airfield requirements. Jaguar is on the border of STOL. It has a wing of modern design, with high lift devices, and twin reheated engines. The thrust to weight ratio is over 0·6. Operations from grass airstrips will be quite practicable.

FIG. 25 — Jaguar Hardware

The aircraft is needed by the Royal Air Force and the French Air Force for tactical strike and advanced training and there is a clear Naval application. It will come into service early in the 1970's. It is my view that in Jaguar we have a good and saleable general purpose battlefield weapon which can take over many tasks from more expensive and ultra-sophisticated equipment.

Division of effort

We have tried very hard to ensure an equitable division of effort between the two countries on each of the major categories, namely airframe, engine and equipment. Certainly on the airframe we are making every effort to secure the maximum advantage from collaboration by a clear cut division of work and responsibility, such that each major component is designed and manufactured by one team in one factory for the entire programme. We would thus hope to avoid duplicate jigging and tooling and to extract the maximum benefit from longer production runs.

A substantial part of the total cost of any project, and many of the problems, arise from bought out items and equipment. The two companies and the officials have together evolved a system which ensures fair competitive bidding and evaluation. The interesting thing is that there are strong indications that the opening up of competition over a much wider field, coupled with tighter bidding and evaluation procedures, may well reduce this element of cost significantly and improve the final product.

Work on Jaguar is making considerable progress (Fig. 25). At British Aircraft Corporation's factory at Preston there are completed wing and fuselage components. Drawings covering over one thousand seven hundred parts have been issued to the manufacturing shops here and in France. Prototype construction is advancing and we look forward to the first flight in 1968.

The situation report on this Anglo-French project therefore is simply that the two nations agreed what it was they wanted. We and Breguet then set up the joint machinery to design and build it. This we are now doing and we are on programme. Jaguar joins Concorde as tangible proof that international collaboration can and does work.

8. Anglo-French Variable Geometry Aircraft

The Anglo-French Variable Geometry aircraft was the second aircraft covered by the Memorandum of Understanding of 1965. Following a comprehensive statement of the draft requirements, separately funded feasibility studies were required from B.A.C. and Dassault with a commentary on any difference of approach which was found. The two companies found their ideas running along very similar lines.

So, helped by our experience of co-operation, we were able to ensure consistency of assumptions, mode of operation and finally, the weight and drag breakdowns of a common proposal by the end of October 1965. This process was undoubtedly eased by the very similar background of experience within two firms, which have produced the only European operational supersonic fighters and supersonic bombers.

Despite the stringent demands of the draft operational requirement, which covered strike, interceptor and naval applications, it was found possible to meet these in a single airframe and engine combination. The common proposal of October 1965 has been confirmed in all the subsequent answers by both companies to official questionnaires. Proposals for the engine thermodynamic cycle were confirmed in January 1966 — again jointly.

A great deal of thought and work has gone into the design of this aircraft including the fruits of years of general research on variable sweep within B.A.C. A wide range of wind tunnel tests have been completed covering many different configurations and including those specifically proposed. Both companies have pooled their knowledge of materials, intakes, stability and supersonic performance gained by many years of practical experience on supersonic military aircraft in this class. Full-scale test rigs have demonstrated the integrity of the hinge design and a full-scale mockup is available.

When the task concerned has been defined, our co-operation with Dassault has been excellent. At present, however, we await a number of official decisions. We now believe that the question of cost has been raised. The whole aeroplane has in fact been subjected to a careful study to see that materials, design and bought-out items are to the simplest and cheapest standard to meet the requirement and it is possible that sufficient account has not been taken of this. Furthermore the programme would be strictly cost controlled throughout by the new procedures we have developed and which are now in use on several aircraft.

If further savings are looked for by the Governments they can only come from a reduction in the standards of the joint operational requirement.

The importance of this aircraft was stressed in the 1966 Defence White Paper which said that operationally and industrially it was the core of our long term aircraft programme. Later a spokesman for HMG told Parliament that it was the keystone of our future aircraft programme. We too believe that this aeroplane has a great potential in many operational roles and, in relation to aircraft purchases from other sources abroad, it would represent very good value for the money expended.

PART II. THE FUTURE

I have tried in Part I to show the progress we have made on the three Anglo-French aircraft projects with which I have been associated. I have dealt with the airframe side of the joint projects in which British Aircraft Corporation is the British instrument. This is because I know most about these but I believe that most of the conclusions and comments that follow would apply equally to any other joint major undertaking. I have endeavoured to show the way in which the two sets of Government and Industrial organisations have learned to work together, and the actual progress which has been made on the projects themselves, notably the Concorde which is the oldest and the biggest.

In this second part, I hope to draw some conclusions from Part I and make a few observations about the future of Anglo-French co-operation, as I see it.

We have established over $5\frac{1}{2}$ years on the Concorde, and a much less time on Jaguar and Variable Geometry aircraft that, although it is painful, it is practical to design and manufacture large, technically advanced aircraft, and keep to a programme.

Joint civil projects such as the Concorde have problems differing from the military ones like Jaguar for reasons I shall develop later, but we are also satisfied that we have made the Jaguar set-up work as a first joint military aeroplane, and there is no reason why the Anglo-French Variable Geometry project should not, in its turn, be successfully developed as a joint undertaking.

In the face of the obvious difficulties, some of which have been overcome and some which, in some measure, must still be present in any bi-national technically advanced programme, one asks ones-self 'Why do it this way at all?' It certainly cannot be justified as an attractive sounding political platitude to be at the mercy of the diplomatic mood of the moment. The only basis upon which these things should be embarked upon is that they will provide the two countries jointly with an attractive commercial venture, the launching costs of which would be too great for any one country to bear alone; or, that they are the means of supplying the armed forces of the two nations with a piece of equipment which they need, with the advantage of larger quantities and shared development coming from such collaboration. From the industrial viewpoint, the significant advantage of bi-national projects is that they are very difficult to start and are certainly very difficult to stop.

Stability of programme is something which a long-term technically advanced industry such as ours cannot live without, and I believe that bi-national programmes are more stable because two Governments have to take the same decision, to start, or to stop.

This is not to say that the joint projects have been without their alarms and excursions. An illustration is the White Paper of October 1964 which stated that the object of the Government was 'to release resources for more productive purposes by cutting out expenditure on items of low economic priority such as "prestige products" ' and that 'they had communicated to the French Government their wish to re-examine urgently the Concorde project'. This many people thought covered a strong desire on the part of the British Government to get shot of it. A desire resisted by the French.

It is also fairly clear that the Variable Geometry project will go through some choppy water before it is set on a stable course.

However, the Concorde is going on, as was confirmed by the Prime Ministers of the two countries, and in the 1966 Defence White Paper the British Government said of the A.F.V.G.: 'Industrially and operationally, this aircraft is the core of our long-term programme'. Also a British Government spokesman, Mr. Merlyn Rees, Under Secretary of State for Defence for the R.A.F., said in Parliament in May 1966, 'The keystone of our future aircraft programme will be the Anglo-French Variable Geometry aircraft'.

This spells stability to me.

Not that there is any lack of vigilance on the part of either Government about costs. The ingenuity of both sets of Officials in requesting procedures for cost control and the documentation to expose the relationship between estimates and achievement is something to be marvelled at. I believe that these cost control procedures now being imposed on these joint projects are the most rigid and detailed ever used on an aeroplane in Europe and, from what one hears, not too bad in relation to those employed in the United States.

It has been said that the extra cost involved in collaboration between two countries minimises the saving on sharing the development. I am quite certain this is not so; taking the total programme, there are advantages to be drawn from collaboration, especially on military projects, where the initial market is doubled by having the armed forces of the two nations as first customers for the aeroplane. Here we are able to cover something of the gap which exists between European and American production programmes. In this country, we always seem to operate at the thick end of the learning curve because the home market is too small for us ever to get down to the thin end and, therefore, the average cost of the project is high. When the home market is doubled, with only reasonable increases in development costs as a result of collaboration, the average unit cost is bound to be significantly less than that of the single nation product, based only on its own home market. This lower average cost provides a good base from which to launch forth into export markets where a price based on a long production run is a major competitive factor.

There are special problems related to joint projects for military aircraft because there is likely to be a spread of requirement and the overall development costs will be higher than for the project aimed at one single armed force, so some compromise must be found between the requirements of the various armed forces.

Apart from the lowering of costs on the civil project there is not the same dramatic increase in the home market as with the military because the flag carriers of Britain and France do not in themselves represent a large market. With the Concorde, however, (and this would apply to any joint civil aeroplane) there is value in the initial operational flying being carried out by B.O.A.C. and Air France. I would like to think that joint European civil projects would be supported by European airlines. I recall that, at the Air

Bus Symposium held at London Airport in October 1965, the airlines of Europe were expressing concern at being left to the mercies of the American manufacturers. I see little signs of them doing anything about it and it seems to me that B.E.A. are likely to be the only major European operator not largely committed to American aeroplanes.

I have always believed that any form of international collaboration (and I have said this many times in the United States) can only be based on mutual respect. I think I can say that this exists between the industrial teams of Britain and France. My colleagues and I have been mightily impressed by the ability and energy of our friends in France. We have been even more impressed and filled with considerable envy by the determination of the French Government to maintain a strong and active aircraft industry in their own right. I do not recall hearing a French Minister say that it would not be possible for France to undertake projects on her own any longer and that they could only start if she had a colleague country on which to lean. It is no good going to the negotiating table with one's own Government openly professing inability or unwillingness to go it alone.

It is not for me, in this paper, to dwell on the different methods of Government in the two countries or the process of training and selection of the whole of the Government Service. However, some of us have been impressed at the way in which systems introduced in Napoleon's time such as the Ecole Politecnique can today produce Government Officials well equipped to deal with the problems of the modern technological age.

We have also been impressed with the dedication with which the French set about their business and the passion which they really feel about France. A touch of old-fashioned fervour drifting across the Channel at this time would not be a bad thing for this country.

Also, we have been envious of the air of respectability which surrounds our colleagues in France when they are doing a job which is part of the Government policy and of the grand plan. They are supported and encouraged because it is the National Policy and they are the instruments of that policy. They are treated as professionals doing a difficult job which the Nation wants done, and not as schoolboys having fun and games at the Nation's expense.

When we began the Concorde 5½ years ago I doubted if it was possible for us to maintain the ambitious programme we had set and still finish with a viable operational aeroplane at a reasonable cost. This, however, we have done, and I believe that the biggest single ingredient has been the mutual trust which has grown up between the professionals. We sometimes think that our methods might have had a little more success towards making the 'entente' more 'cordiale' than the more formal diplomatic ones. This is a step towards joining Britain to the rest of Europe on a working level. One has the impression that the trust and confidence which now exists between the Companies does not necessarily exist between Governments. Were it to be so, then I believe there is great scope for such international collaboration to continue and expand. Those of us who have played some part in this past 5½ years could then be proud to have made some contribution towards such international achievement.

I would like to thank Mr. Charles Gardner and Mr. F. G. Clark together with others concerned in B.A.C.'s Filton Division and in Sud Aviation who have all contributed considerable effort towards the preparation of this Lecture.

Finally, I would state that these are my personal views and do not necessarily represent the views of B.A.C.