INSTITUTE OF THE AERONAUTICAL SCIENCES

FIFTH INTERNATIONAL AERONAUTICAL CONFERENCE

Los Angeles—1955

Fifth International Aeronautical Conference

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Foreword

THIS VOLUME contains the complete papers and discussions presented during the technical sessions of the IAS-RAeS Fifth International Aeronautical Conference. Held in Los Angeles during the last two weeks of June, 1955, this conference attracted 116 official delegates of The Royal Aeronautical Society and some 500 IAS members from all parts of the United States and Canada.

The four days of technical sessions were followed by more than a week of field trips, plant visits, and social events, which helped greatly to foster the spirit of friendship, cooperation, and technical advancement for which these joint conferences were created. A summary of the complete conference calendar appeared in the October, 1955, issue of the *Aeronautical Engineering Review*. This volume is confined strictly to the technical aspects of the meeting.

On behalf of the Council of The Royal Aeronautical Society and the Council of the Institute of the Aeronautical Sciences, thanks are extended to all those individuals and agencies on both sides of the Atlantic whose contributions and cooperation made this fifth meeting possible.

Special appreciation goes also to the authors of the papers that are included in these proceedings for their patience and cooperation in the difficult work of editing and preparing the manuscripts for printing.

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Youens, F. P., Advanced Projects Engineer, Short Brothers & Harland Ltd.

Opening Remarks

The following excerpts are taken from the addresses by the presidents of the two societies at the opening of the IAS-RAeS Fifth International Aeronautical Conference.

Robert E. Gross, *IAS President*

It is particularly pleasant for me to find myself the President of the Institute in a year when we have this fine visit by so many of our colleagues from England.

Not being an engineer by profession, I am very envious of the talents you men have, and so, perhaps it is appropriate for me to say a few words about a profession of which I have learned a good deal in my last 25 or 30 years working in this business. I have come to feel that engineering capability is the most precious element in the whole aeronautical apparatus, and the mastery of the air is being recognized more and more as the trump card at the conference table for world peace. Surely, this must make you conscious of your responsibility and also of your great opportunities.

These engineering capabilities are rare and hard-to-come-by attributes. We do not create these talents by forced draft methods. No amount of money or urgency will make an engineer overnight out of a raw man. He has to develop himself. To do the great work ahead of us in aeronautical research, we cannot build a mecca and merely whistle through our fingers and have a whole new complement of engineers at our gates just when we need them.

I know there is a great deal to be done to persuade young men that aeronautical work has a great future and is promising. There is still much to be done to train them slowly and surely. We must resign ourselves, I think, to the fact that we are not going to get many more new engineers now and that, therefore, we must make better utilization of the distinguished profession that you men represent.

I strongly suspect that there are rich returns indeed to be had by a better utilization of the present engineering population and that you, Mr. Rowe, and our British colleagues can tell us much and help us greatly in this direction. I hope that before you return we shall glean some words of wisdom from you in this area. Somehow I have the feeling, if we could get a better, simpler, and different approach to developing new types of planes, we might astound ourselves and our military and naval friends, too, as to what we could do with the people we now have.

All this makes me think that the papers and data you will exchange with us here this week will be important and of great interest. But the greatest asset that can emerge from the engineering crucible is not just the papers, but the exchange of human and personal ideas. Most of the papers to be presented this week are already written and printed. They could be mailed around to everyone. In a strictly intellectual sense, we could do some of the things we are now proposing to do by merely mailing letters across the ocean. In a deeper sense, however, a meeting like this accomplishes purposes that could be achieved in no other way than by bringing people together, face to face.

Probably there is no more material thing or more essential ingredient in world peace than world understanding. I think that today the airplane is building this world understanding, this world community (quite apart from all the things that governments can do), because it carries not just the leaders but also the little people. After all, down through the years, they are the ones who by better understanding and by allaying suspicions will, in the final analysis, determine the shape of things to come.

So, it is to you scientists and aeronautical engineers of the mid-Twentieth Century who can lay the basis for future world peace and understanding that I extend my personal and my official welcome at this time.

N. E. Rowe, *RAeS President*

Thank you, Mr. President, for the very kind way you introduced me, and thank you, also, for permitting me to be the last speaker. As a stranger in a strange land, I would not like to be put in, as you would say it in England, fat first. It is a little bit nerve-shattering, and I was very glad to know I was to be the third speaker and not the first.

It is a very great privilege to have the honor of being one of the speakers at the opening of the Fifth International Aeronautical Conference. It is a great privilege because I think these conferences are very deeply significant of some of the most important facets of our work, not only as engineers and scientists in our own countries but in relation to what goes on in wider fields.

Firstly, perhaps, these conferences are a great tribute to the wonderful spirit of association which has always distinguished the meetings between our two Associations—yours a young and vigorous and virile aeronautical body and ours with its roots rather deep in history but, I hope, still retaining some of the vigor that distinguishes your great industry.

This spirit of association is one of the important things of life, and it, perhaps, is also reflected in the way in which our two countries have steadily moved closer together in this great field of aeronautics and moved more closely together because success in aeronautics is the key to peace. It is the great weapon which will win peace for us. If peace is preserved, then aeronautics can go forward and garner the fruits by way of our transport and other means in which it can revolutionize the surface of things more rapidly than any other power we have today.

That is the significance of these conferences. It represents so much for us. To come down perhaps to more homely things, I would like to touch also on a point made by your President. These conferences have been great meeting grounds for people with common interests. When aeronautical people get together, there is always a tremendous stimulus of thought. They are dealing with pioneering matters, and they get together and find friendships. It is in the renewing of friendships and in the creating of new friendships that these conferences play one of their greatest parts.

Your own President, of course, told you the value of the papers and discussions and, perhaps even more, the tremendous value of these more intimate discussions that go on and make these conferences of very great value.

I would just like to mention that we tried to support the conference. I think we have a good delegation over here. The numbers, I think, are reasonable. I would like to say we have our three vice-presidents here, one of them only elected about a week ago, so that I feel that we are well represented, which is extremely important to give these things their true value. I hope that out of the scope and range of the papers, which cover practically the whole range of aeronautical transport, we will get discussions which will be of very great value.

Your President has welcomed you here. Time is running on. I think all I have to say now is to wish us all a very happy conference and a successful outcome to our papers, our meetings, and especially our friendships.

Operating Experience with Turboprop Aircraft

B.E.A.'s Results with the Operation of the Vickers-Armstrongs Viscount (Four Rolls-Royce Dart Turboprop Engines) with Some Thoughts on Future Possibilities

PETER G. MASEFIELD,* M.A., FRAeS, FIAS, M.Inst.T.

SUMMARY

An analysis is presented of B.E.A.'s commercial experience of nearly a quarter of a million flying hours with Rolls-Royce Dart turboprop engines, since B.E.A. flew its first commercial service with the Vickers Viscount V.630 prototype between London and Paris 5 years ago.

B.E.A. has now operated 57,000 aircraft hours and $11^1/_2$ million aircraft miles of air-line services with Viscount V.701 turboprop air liners during which some 570,000 passengers have been carried and a net profit of nearly $3 millions has been earned.

Mr. Masefield traces the history of the Viscount since its conception in 1945, records B.E.A.'s experience with the Dart turboprop engine in the course of its development to its present status of 1,050 hours between overhauls, and compares in detail its performance, maintenance costs, and reliability with those of equivalent piston engines. He sets out and discusses the economics of the Viscount in B.E.A. service—now running at a profitable, direct operating cost of some $300 per flying hour under European conditions.

The paper goes on to describe the characteristics of the new 65-passenger Viscount-Major V.802, due to come into B.E.A. service in 1956. Mr. Masefield discusses pilots' reactions to the operation of turboprop air liners, outlines some special problems encountered, and describes passengers' reactions, which have been encouragingly favourable—especially from Americans.

Looking ahead, he compares the operating characteristics of three similar projected 75-passenger aircraft—one with turbocompound piston engines (350 m.p.h.), one with turboprops (400 m.p.h.), and one with turbojets (500 m.p.h.). He states his belief in the economic superiority of the turboprop vehicle, though he sees a place also for the turbojet in specific "blue-riband" operations for the future.

Finally, Mr. Masefield declares his belief that the performance of the Bristol Britannia long-range turboprop airliner will bring it prominently into the world market as a worthy colleague of the Viscount, which is essentially a medium-range aeroplane.

Mr. Masefield concludes that "the heart of an aeroplane is its engines" and that the success of future turboprop civil transport aircraft is bound up inseparably with the development of such engines as, not only the Dart, but also the Bristol Proteus and BE.25, the Rolls-Royce RB.109, the Napier Eland, the Pratt and Whitney T-34, and the Allison T-56.

"Our experience leads us to believe that these turboprop engines have, within them, inherent characteristics which can make them more attractive to hard-bitten air-line operators—equally on the commercial, the flying, and the maintenance sides of the business—than are any other rival types of power unit. They offer a challenge to the air-frame manufacturers to wrap around them the most efficient and attractive air frames they can devise, and, in so doing, provide a transport vehicle which can set before the travelling public means of communication substantially in advance of anything available today."

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* Chief Executive of British European Airways and a Vice-President of the Royal Aeronautical Society.

(1) INTRODUCTION

FIVE YEARS AGO—on July 29, 1950—British European Airways operated the world's first scheduled commercial passenger air service with a turbine-powered aeroplane—the Vickers Viscount V.630 32-passenger prototype. On that bright summer's morning it flew the 237 miles between Northolt Airport, London, and Le Bourget Airport, Paris, in 57 minutes from take-off to touch-down, carrying a pay load of 6,765 lbs., including 22 passengers, among them Sir Frank Whittle and George R. Edwards.

A week later a contract was signed between B.E.A. and Vickers-Armstrongs Ltd. for the production of a fleet of 26 developed Viscount V.701 47-passenger aircraft, each powered with four 1,547 e.hp. Rolls-Royce Dart 505 turboprop engines. The first V.701 was delivered to B.E.A. on January 3, 1953, 29 months from the signing of the initial contract.

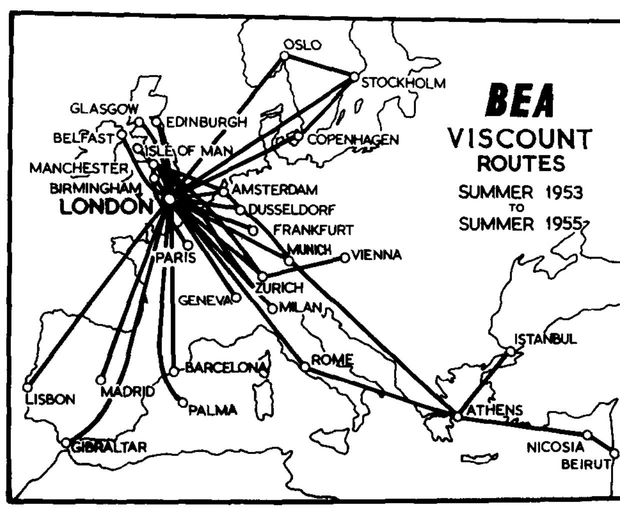


FIG. 1. The world's first turboprop network. B.E.A.'s 17,000-mile Viscount route network—April, 1953, to June, 1955.

Since then, and up to June 1, 1955, B.E.A. has flown a total of 57,000 aircraft hours and 225,000 engine hours with Rolls-Royce Dart propeller-turbine engines installed in 30 individual aircraft. Details of this flying, in five basically different types of aircraft, are set out in Table 1. The route network over which these turboprop operations have extended covers 17,000 unduplicated route miles and is illustrated in Fig. 1. This network has been superimposed, as a mirror image, on the North American continent in Fig. 2 to illustrate, in more topical form, the comparative distances it covers. Over this network, some 25,000 aircraft miles are now being flown daily by B.E.A.'s Viscounts.

B.E.A. was thus the first air line in the world to order and to operate a turbine-powered aeroplane. We did so because we believed in 1950 that the turboprop had important commercial, economic, and engineering advantages over the piston engine for air-line service. Our experience of more than 2 years of commercial opera-

TABLE 1

B.E.A. Turboprop Operations—January, 1950 to June, 1955

	Date	Aircraft Type	Engines	Operation	Where Operated	Aircraft Hours	Cumulative Aircraft Hours	Engine Hours	Cumulative Engine Hours
V.630	(1) Jan. & Feb., 1950	Viscount V.630 (G-AHRF)	Dart R.Da.4 (1,250 s.hp.)	Training and proving	Northolt	9	9	36	36
V.630	(2) July 29, 1950 (1st service) to Aug. 23, 1950	Viscount V.630 (G-AHRF)	Dart (R.Da.4)	Passenger service	London–Paris London–Edinburgh	127	136	508	544
Dart-Dakota	(3) June 9, 1951 (1st B.E.A. flight)	Dart-Dakota (C-47) (G-ALXN) (G-AMDB)	Dart (R.Da.3)	Training and development	London–Buckeburg London–Copenhagen –Milan, etc.	644	780	1,288	1,832
Dart-Dakota	(4) Aug. 15, 1951 (1st service)	Dart-Dakota (C.47) (G-ALXN) (G-AMDB)	Dart (R.Da.3)	Freight services	From Northolt	1,256	2,036	2,512	4,344
V.700	(5) Aug. 21, 1952 to Nov. 11, 1952	Viscount V.700 (G-AMAV)	Dart (R.Da.3) 505	Training and proving flying	Based L.A.P.–Rome and all B.E.A. routes	249	2,285	996	5,340
V.700	(6) Oct. 5, 1951 to Nov. 30, 1951	Viscount V.700 (G-AMAV)	Dart (R.Da.3) 505	Hot-weather trials	Khartoum and Nairobi	105	2,390	420	5,760
V.701	(7) from Jan. 3, 1953	Viscount V.701 (G-ALWE)	Dart (R.Da 3) 505	Training and development	London	780	3,170	3,120	8,880
V.701	(8) April 16, 1953 to June 1, 1955	Viscount V.701 (G-ALNE et seq.)	Dart (R.Da.3) 505 & 506	Air-line service	Based London Airport	53,800	56,970	215,200	224,080
V.700X	(9) from Oct. 8, 1953 to Oct. 29, 1953	Viscount V.700X (G-AMAV)	Dart 505 (Uprated racing engines 1,500 s.hp.)	London to New Zealand Air Race	London–New Zealand	164 (inc. Tour)	Total Aircraft Hours 57,134	656	Total Engine Hours 224,736

tions with the Viscount, during which more than half a million passengers have been carried and a profit of nearly $3 millions has been earned, has indeed convinced us that the turbine power plant is here to stay and that, for short-, medium-, and long-range operations, the propeller-turbine engine has a great potential future in world aviation.

The proved fact is that the turboprop is lighter and smoother in operation than is the piston engine; more economic and more flexible in service than is the jet. The maintenance costs of the turboprop give promise of substantial advances on previous experience. Its quietness and its low vibration levels make it popular with passengers. Indeed, experience shows that the turbine has, in this regard, important competitive advantages over the piston engine. Its use of low flash-point kerosene fuel enhances safety. The high power potentialities of the turboprop ensure that it is an engine for the future.

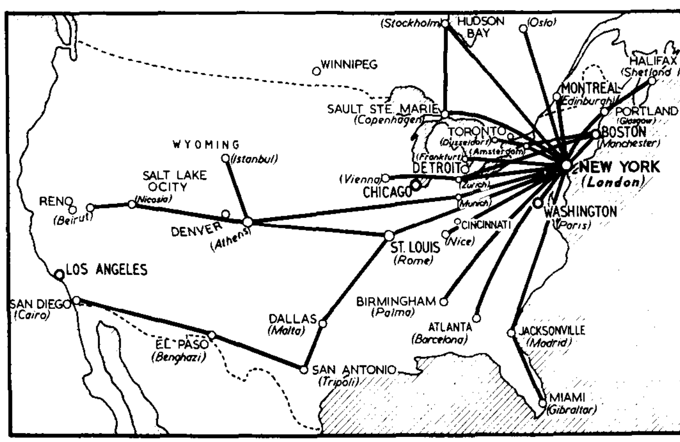


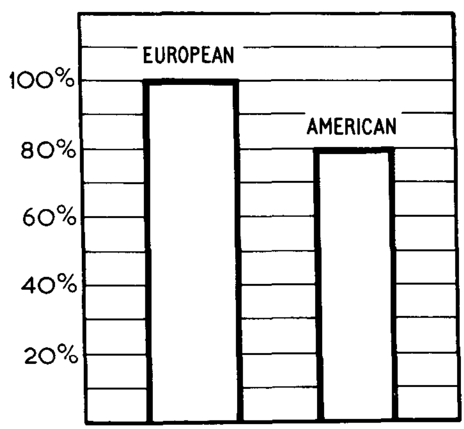
FIG. 2. "B.E.A. in U.S.A."—B.E.A.'s 17,000-mile network superimposed on North America. (66 traffic stations covering 22 separate countries.)

We believe that the propeller turbine power plant, in its developed forms, can be used efficiently and economically up to speeds in excess of 460 m.p.h., and for sector distances as short as 200 miles or as long as 4,000 miles. In fact, we believe in the turboprop, basing this belief on practical experience and some 350,000 man-hours of development and modification work expended on the Viscount and its Dart engines by B.E.A.'s Project and Development staff since 1946.

In this discussion, therefore, I intend to devote myself to a review of B.E.A.'s operating experience with the Dart in the Viscount and to an analysis of some future possibilities as we see them.

(2) Operating Results

In $25^1/_2$ months of scheduled commercial passenger services, from April 19, 1953, to May 31, 1955, B.E.A.'s fleet of production Viscount V.701 aircraft (which has averaged 17 in number) has flown $11^1/_2$ million aircraft miles and has carried a total of 570,000 passengers for 343 million passenger miles, together with $5^1/_2$ million ton-miles of mail, express, and freight. In this time.B.E.A.'s Viscount fleet, operating primarily at 57,000 lbs. gross weight, has earned a total of some $30 millions of revenue at a mean load factor of 66.8 per cent. In flying an average sector distance of 490 statute miles at an average block speed made good of 223 m.p.h., the total operating cost of the Viscount has worked out at a mean of $526 an hour and $2.36 a mile, including all overheads and depreciation and $4^1/_2$ per cent interest on the capital sunk in the aircraft and their spares. Revenue earned has amounted to $580 an hour and $2.60 a mile. These figures are gained under European operating conditions and at European prices. Similar operations under American conditions would result in some 20 per cent reduction in comparable costs. (See Figs. 3 and 4.)



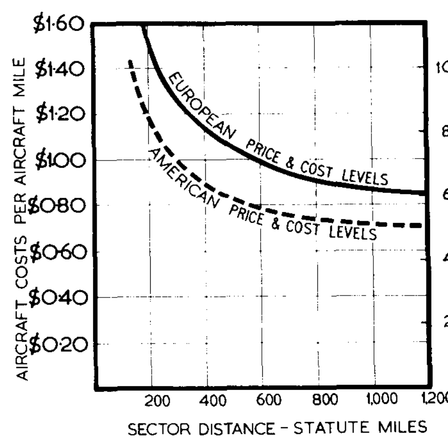


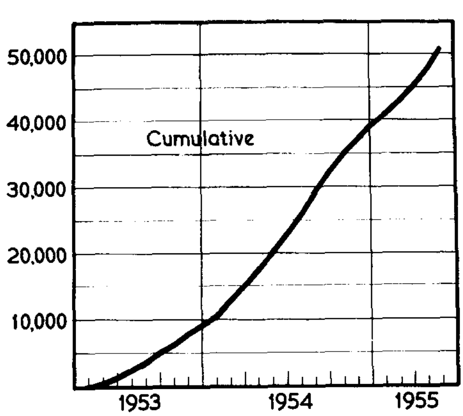
FIG. 3 (*left*). Comparison of typical costs per aircraft mile achieved under European operating conditions with those achieved under U.S. operating conditions percentagewise; assuming 1955 cost levels of aircraft utilisation, crew costs, fuel prices, and landing fees. FIG. 4 (*right*). Aircraft costs per aircraft mile of the Viscount V.701A, American and European equivalent cost and price levels.

The first $25^1/_2$ months of the Viscount's operation has thus earned for B.E.A. a net profit of $2,789,100 at the rate of $54 a flying hour and $0.24 profit for every mile flown. The break-even load factor in B.E.A. service on aircraft (direct) costs has averaged 34.5 per cent and some 60.4 per cent on total costs including all overheads, interest on capital, and other finance charges. (Details of these statistics are set out in Table 2 and are plotted in Figs. 5 to 8.)

During this initial period of air-line service the longest regular sector operated by the Viscount on B.E.A. routes has been London to Gibraltar, 1,086 statute miles nonstop, scheduled to take a block time of 4 hours, 20 min. The shortest regular sector operated has been Manchester to Birmingham, 65 statute miles, scheduled to take a block time of 35 min. Over all these routes the Viscount has materially improved B.E.A.'s competitive position and has dramatically increased the ratio of traffic carried by B.E.A. against such excellent aircraft as the DC-6B and Convair, operated by rival air lines. For instance, between London and Geneva—487 statute miles—during the first year of Viscount operations, B.E.A.'s share of the total

TABLE 2
Viscount V.701 Operating and Traffic Statistics in B.E.A. Service
(On Revenue Earning Operations—April 19, 1953 to May 31, 1955)

Operating	
Average no. of aircraft	17.1
Revenue hours flown	51,430
Average daily utilisation (hours)	3.86
No. of flights	23,436
Aircraft miles flown	11,466,433
Average length of flight (stat. miles)	490
Average block speed achieved (m.p.h.)	223
Traffic	
Passengers carried	568,285
Passenger miles flown	342,802,746
Seat miles available	497,809,616
Passenger load factor (per cent)	68.8
Capacity ton-miles	58,231,923
Load ton-miles	38,924,658
Total revenue load factor (per cent)	66.8
Financial	
Revenue	$29,797,908
Expenditure	$27,008,764
Net profit	$2,789,144
Derivatives	
Cost per flying hour	$525.56
Cost per aircraft mile	$2.36
Cost per C.T.M.	46.32¢
Cost per seat-mile	5.43¢
Revenue per flying hour	$579.88
Revenue per aircraft mile	$2.60
Revenue per C.T.M.	51.10¢
Revenue per seat-mile	5.99¢
Profit per flying hour	$54.32
Profit per aircraft mile	$0.24
Profit per C.T.M.	4.78¢
Profit per seat-mile	0.56¢
Load factor required to break even on aircraft (direct) costs (per cent)	34.5
Total load factor required to break even on total costs (per cent)	60.4



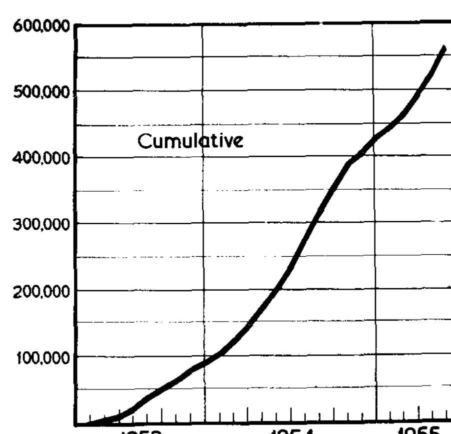


FIG. 5 (*left*). Revenue hours flown by B.E.A. Viscounts—April 1953, to June 1955.
FIG. 6 (*right*). Revenue passengers carried by B.E.A. Viscounts—April, 1953, to June, 1955.