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SOME AVAILABLE TRAFFIC FORECASTS AND THE POTENTIAL DEMAND FOR COMMERCIAL SUPERSONIC AIRCRAFT*

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INTRODUCTION

THIS paper is the result of an attempt to consolidate some of the data and material made available to IATA relating to traffic forecasts and to the estimated potential demand for commercial supersonic aircraft. The object is to provide the 1961 IATA Supersonic Symposium with certain background material in summary form. It must be emphasized that it is not intended to present IATA forecasts or estimates.

Examination of the available studies reveals considerable difference of opinion as expressed in final figures. Traffic forecasts vary considerably, as do the estimates of potential demand for supersonic aircraft; even the years selected for particular attention are not always the same. While this tends to complicate the task of consolidating the data, it is to some extent simplified by the similarity of much of the reasoning and assumptions on which these forecasts are based.

At the outset, it must be stated that forecasting traffic and the potential demand for a particular type of aircraft ten or fifteen years ahead is not a simple matter. Nor is it believed can there be any certainty as to the reliability of the results. Most recent studies are therefore understandably hesitant about making positive statements, and contain numerous qualifications. In view of the preliminary state of knowledge on supersonic aircraft and associated parameters, the qualifications and assumptions on which forecasts are based must be made clear. This is all the more true in view of the many differences of opinion held. However, this paper attempts to cut through to the substance material and does not incorporate all of the many assumptions in the belief that it would thereby become unnecessarily lengthy.

Traffic forecasts on which estimates of the numbers of aircraft required are based, have concentrated on passenger traffic. Very simply, the normal procedure has usually been to estimate passenger traffic in terms of scheduled miles flown, with reference to either total traffic, international traffic or domestic traffic. Next, distinction is made between total traffic and that likely to be available to supersonic aircraft. This involves considerations of minimum stage lengths likely to be flown by these aircraft. Stage lengths of, for instance, 1,800, 1,500 and 1,000 statute miles have been selected, with allowances made for changes in their percentage share of total traffic. It is on the basis of forecasts of traffic over and above certain minimum stage lengths that estimates of the number of aircraft required have been calculated. Involved are estimates of annual aircraft

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productivity. These are based on assumptions mainly as to utilisation, block speed, seating capacity and average load factor.

I. Forecasts of Available Traffic

General Trends Affecting Traffic Development

Before going into details of actual traffic forecasts, a general outline of anticipated trends and assumptions as to conditions affecting the air transport industry in the nineteen sixties and early nineteen seventies is relevant. It is well known that the development of air transport is influenced by a large number of factors. Their influence has extended over the post-war years, in varying degrees.

One of the more significant factors in the recent development of air transport is the cost to the consumer; further reductions in air fares and substantial extensions of cheaper fares are expected in many parts of the world. ICAO has stated that the average price of air transport was maintained at about 6 U. S. cents per passenger mile in the 1951-1959 period. The fact that it was maintained at roughly this level in the face of inflationary trends averaging 2%-3% per year had the stimulating effect of similar price reductions of 2%-3%. ICAO has allowed for a 1% to 2% inflationary trend in airline costs and for the continued operation of older but largely depreciated aircraft in many parts of the world. ICAO consequently has assumed that the unit price of air transport will decline by about 20% by 1967.

The introduction of cheaper fare classes and special creative fares (e.g. family plan, excursion, off-peak, etc.) significantly added to the increased demand for air transport. The growing importance of economy or coach type services is generally accepted. They have become an important part of the total market on many routes. On the North Atlantic, an important potential area for supersonic aircraft, more than 80% of scheduled traffic already moves by economy class. This trend toward greater shares of total traffic is considered to have resulted from a general shift in emphasis by the carriers. Thus, although supersonic aircraft may, for a limited time, operate exclusively first class services, it is held that they must be capable of operating cheaper class services economically. Any future passenger aircraft, including supersonic, must be able to operate in a coach market.

Indirectly at least, the importance of the tourism element in air travel is not overlooked. Its share of world air traffic is growing steadily. The opening up of new areas to international air travel since World War II by the removal of political and economic restrictions has also been a factor in the expansion of air transport. Adverse as well as favorable changes are expected in the next ten years, but the net effect on the overall rate of expansion is expectd to be positive. World population is expected to expand steadily at about 2% per annum and the general level of prosperity is also expected to rise. The possibility of minor recessions is taken into consideration. Major recessions are not ruled out entirely, but have been excluded from traffic forecasts.

Changes in the quality of service offered in the air and on the ground also are considered to have had a definite bearing on the expansion of air transport. Improvements in the speed, safety and reliability of air transport have contributed toward its rapid development and this trend is expected to continue. The capacity available to the scheduled airlines will increase rapidly in the 1960-1962 period, with deliveries of new aircraft. It is believed that this may lead to expanded traffic in the early nineteen sixties by encouraging the airlines to reduce fares and rates to tap new markets. The increased availability of convenient space is also expected to play a part. ICAO anticipates that traffic will reach and possibly surpass the supply of capacity in the 1963-1967 period. This is based on the implication that additional aircraft may be ordered, but not in sufficient numbers so as to affect the expansion of the industry as a whole. Indeed, it must be mentioned that many new orders have already been placed for delivery in this period.

Governments are considered to have greatly assisted air transport development in the past through the provision of airports and other ground services at less than cost, through the granting of direct and indirect subsidies, and so on. Protective attitudes over traffic rights in some instances may have retarded its rate of expansion. However, it has been said that governments have encouraged air transport so far as possible, consistent with orderly development and the interest of their own airlines. Operating rights also have been extended. It is assumed that these favorable attitudes will continue, provided problems such as excessive noise in the neighborhood of airports can be dealt with satisfactorily. It is moreover expected that governments will not increase airport and route facility charges to an extent likely to impair the rate of expansion of air transport as a whole. A reversal of this expectation, with repercussions on fare levels would adversely affect development.

No changes are anticipated in the competition from other means of transport in the next decade that are likely to affect air transport on a world-wide scale.

Forecasts of World Traffic

We now turn to general forecasts of total scheduled passenger traffic. This obviously constitutes more than is likely to be available to supersonic aircraft. Only one recent set of estimates of this traffic, prepared by ICAO, was made available. For purposes of comparison, traffic forecasts made several years ago are brought into the picture and included in TABLE 1 below. This will afford the opportunity of comparing previous estimates of 1960 traffic with the actual preliminary ICAO figure for 1960. Differences among the various figures for 1960 and among estimates for later years will be noted. It is important to mention here that references to world traffic in this paper relate to the world comprising ICAO Member States and specifically exclude traffic of the People's Republic of China and the USSR.

TABLE 1

Forecasts of World Traffic (Passenger Miles—Millions)*

	Boeing[1]	*Canadair*[2]	*Convair*[3]	*Douglas*[4]	*TP. Wright*[5]	*ICAO*[6]
1960	72,600	67,800	67,000	63,800	70,000	69,000[7]
1965	145,400	105,300	110,200	87,500	115,000	100,000[8]
1967	—	—	—	—	—	118,000
1970	235,900	147,200	156,400	—	—	137,000
1973	—	—	—	—	—	155,000

* "World" refers to ICAO Member States, with the major exclusions of People's Republic of China and the USSR.

[1] Boeing—1958.
[2] Canadair—1956.
[3] Convair—1957.
[4] Douglas—1957.
[5] T. P. Wright (Cornell Univ.).
[6] ICAO—June 1960.
[7] Preliminary ICAO figure.
[8] ICAO graph.

Historically, the trend in world air transport has been one of steady expansion with a progressive falling off in the rate of growth. Total passenger miles increased by 92% in the years 1949-1953, but only by 56% in the 1955-59 period. In making its forecast ICAO has assumed that a direct continuation of the decline in the rate of growth would produce an increase in traffic in the order of 50% in the 1959-1967 period (30% in the first four years, 15% in the second). This is provided the world "price" per passenger mile is to continue to remain almost constant, with general world prices rising 10% to 15% in the period. But the stimulating effect of reductions in the price of air transport, in association with abundant capacity, would result in an increase in passenger miles flown equal to twice the price reduction. Since the assumption is that there will be a 20% reduction in price in the 1959-1967 period, it is calculated that in the same period the volume of air transport will increase by about 100% (50% owing to assumed growth with price constant, plus 40% resulting from 20% price reduction). In this way, the ICAO figure of 59 million passenger miles for 1959 becomes 118 million in 1967. After 1967 it is anticipated that the decline in the rate of expansion will have stopped and that world passenger traffic will be increasing at a steady rate of 5% per annum. Passenger traffic is expected to reach 137,000 million passenger miles in 1970 and 155,000 million in 1973.

World International and Domestic Traffic

International air traffic volume has tended to increase more rapidly than domestic air traffic and this trend is expected to continue as reflected in traffic forecasts. However, the only available forecasts of total, as opposed to long-range, international and domestic traffic are once again those produced by ICAO. These are given in TABLE 2. A study produced by United Research Inc.,* relating to the traffic of U. S. flag carriers only, assumes that their international traffic will increase by 15% per year in the 1960-1965 period; 12% in the 1965-1970 period; and 10% from 1970-1975. It also assumes that the share of U.S. carriers in total international traffic will remain at around the current level. This implies similar growth rates for total international traffic. These increases have been applied to the 1959 world figure and the resulting

* The United Research Inc. Study was commissioned by the FAA.

data is produced in TABLE 2. This Table also contains forecasts of U. S. domestic traffic for comparison with the ICAO estimates of total world domestic traffic. The extensive share of U.S. domestic traffic will be seen.

TABLE 2

Forecasts of
International and Domestic Passenger Traffic Volume (passenger miles-millions)

	International		Domestic	
	ICAO	United Research[1]	World: ICAO	U.S.: United Resarch[2]
1959	20,000[3]	20,000[3]	39,000[3]	28,100[4]
1965	—	46,300	—	42,000
1967	47,000	58,000	71,000	—
1970	56,000	81,500	81,000	51,700
1973	68,000	108,500	87,000	—
1975	—	131,300	—	64,200

[1] Derived from United Research estimates of U.S. carriers' international traffic which were based on an annual growth rate of 15% p.a. until 1965; 12% p.a. from 1965-1970; and 10% p.a. from 1970-1975; on indicated assumption that U.S. carriers' share of total international traffic will remain approximately the same.
[2] United Research: Derived from updating of Curtis Report.
[3] 1959 ICAO figures.
[4] 1959 ATA figure—actual.

Total U. S. International and Domestic Traffic

In view of the market potential for supersonic aircraft amongst U.S. carriers, prepared by United Research Inc., are produced below in TABLE 3. Forecasts are in terms of passenger miles and seat miles. Additional data on the U.S. market is given in TABLE 9, prepared by Convair.

TABLE 3

Forecast of Passenger Traffic for Major
U.S. Scheduled Airlines—1960-1975 (in thousand millions)

	REVENUE PASSENGER MILES			AVAILABLE SEAT MILES[3]		
	Domestic[1]	International[2]	Total	Domestic	International	Total
1960	30.0	8.9	38.9	50.0	14.8	64.8
1965	42.0	17.8	59.8	70.0	29.7	99.7
1970	51.7	31.3	83.0	86.2	52.2	138.4
1975	64.2	50.4	114.6	107.0	84.0	191.0

Source: United Research Inc.

[1] Derived from updating of Curtis Report—actual.
[2] Based on annual growth rate of 15% per year until 1965, 12% per year from 1965 to 1970, and 10% per year from 1970 to 1975.
[3] Based on 60% utilization of seats.

World Long-Stage Traffic

While general conditions in the air transport industry have their importance, a distinction must be made between total traffic and that likely to be available to supersonic aircraft. This involves consideration of stage lengths. Range limits had to be set, but the existence of differences of opinion have affected both estimates of traffic and calculations of the potential market for these aircraft.

With certain qualifications and reservations, three different minimum stage lengths have been used as a basis for calculations in three recent studies: 1,800 miles by ICAO; 1,500 miles by United Research Inc.; and 1,000 miles by Convair. As to the relative accuracy of these figures, much will depend on the operating characteristics of supersonic aircraft and traffic conditions. Obviously, the lower the minimum range, the larger will be the estimated traffic available and the larger the estimate of the number of aircraft required, given similar aircraft productivity.

An assessment of the relative merits of different minima would take into account the following:

a) The cost and operating characteristics of high-speed aircraft;

b) the advantage of aircraft speed to air passengers which increases directly with distance;

c) the likelihood that the economics of any long-range supersonic aircraft may be such that its direct operating cost per seat miles will continue to decrease as sector lengths increase, and not level off as rapidly as it does in the case of piston and subsonic jet aircraft;

d) the expectation that operating costs will rise steeply as sector lengths fall below 2,000 miles.

Even if operating characteristics are such that it may be uneconomical to operate over stage lengths much less than 2,000 miles, a number of carriers would probably be prepared to include short or medium stage lengths in a long route, if this would enable them to obtain additional traffic. Load factors are extremely important in this connection as higher load factors may compensate for higher operating costs. A trans-atlantic carrier might well add a short sector at the European end of his route for the sake of serving two points with the same service. On a route such as the one from Europe to Australia the pattern of operation will not only be different for each operator, but will probably vary from service to service flown by the same carrier. All operators of supersonic aircraft will attempt to fly over the most economical stage lengths. But these stage lengths will tend to change from day to day so that as many traffic points as possible may be tapped within the limits of traffic rights or bilateral agreements. Occasional short sectors may also be included, again simply to service additional points on the same flight.

This pattern has in many ways been followed with current jet operations where carriers are foresaking short-stage traffic and deliberately seeking intermediate points in order to get better end-to-end timings. The general assumption is that supersonic aircraft cannot be used satisfactorily over very short stages. There will be severe economic penalties for not operating at adequate altitudes, and short stages will mean that these aircraft will spend too much time climbing and coming down. Time savings over more conventional aircraft will be reduced to such an extent as to become negligible, particularly when the time passengers have to spend on the ground is taken into consideration. This also means that the size of these aircraft will tend to be based on the traffic potential available over longer sectors. However much of the potential market for conventional aircraft lies with large domestic operators and their requirements are expected to be taken into account. They will wish them to have an economic range to suit their route structures. This is likely to start at something under the range generally required for international operations.

As indicated, certain sectors below 1,800 or 1,500 miles will probably have to be included for routing purposes, given suitable aircraft and facilities. Perhaps the absolute minimum practical range will be 1,000 miles. In general, however, operating economics are likely to be such that shorter sectors will be avoided as far as possible. This means that only part of shorter stage traffic will be carried by supersonic aircraft. Even if supersonic aircraft are to operate without too great penalties in the 1,000-1,500 mile area, their share of this total traffic will probably not be extensive. The extent of traffic penetration of supersonic aircraft must be taken into account in setting the floor for purposes of estimating traffic. Competition from subsonic aircraft will tend to increase as stage distances decline. On the longer sectors much will depend on the routes operated and the extent that subsonic jets may be phased out of service on competing sectors. Generally, it has been accepted that on the most suitable longer sectors where time savings can best be realized, supersonic aircraft would have the competitive advantage over their subsonic jet predecessors. Competitive situations similar to those experienced between propeller and jet aircraft are expected to develop. The degree of market penetration is therefore important to estimates of the number of supersonic aircraft that are likely to be required.

Capacity operated and traffic carried over long-haul sectors has been increasing, largely as a result of technological advance in aircraft design and performance. The share of long-haul stages in the international sector is much greater than in the domestic sector. This is illustrated in Table 4 which relates to major United States scheduled airline operations over sectors of 1,500 miles and over, expressed in terms of seat miles and percentages. The U.S. case may not be typical, but it is indicative. Data may be compared with the ICAO data in Table 6. The figures in Table 4 are estimates based on an analysis of the airline schedules published in the Official Airlines Guide. Forecasts for the years 1965, 1970 and 1975 are also included. It will be seen that the percentage share of sectors in total international traffic of U.S. carriers increased from 32.7% in 1947 to 55% in 1958 and is estimated to increase to 60% in 1965; 63% in 1970 and 65% in 1975. In the domestic sector the share is smaller. It increased from 0.9% in 1947 to 15.6% in 1958, and is estimated to increase to 18% in 1965; 20% in 1970; and 22% in 1975.

TABLE 4

Seat-Miles Operated over Long-haul Sectors (1,500 miles and over) by Major U.S. Scheduled Airlines: 1947-1975

	NUMBER (Thousand millions)			*% of total seat Miles for All Sectors*	
Year	*Domestic*	*International*	*Total*	*Domestic*	*International*
1947	0.1	0.9	1.0	0.9	32.7
1952	2.0	2.3	4.3	11.0	47.2
1957	5.7	4.6	10.3	14.2	50.8
1958	6.3	5.6	11.9	15.6	55.0
1965	12.6	17.8	30.4	18.0	60.0
1970	17.2	32.9	50.1	20.0	63.0
1975	23.5	54.6	78.1	22.0	65.0

Sources: United Research Inc.; Official Airline Guide, March 1947, 1952, 1957 and 1958; schedules analysis.

Improvements in speed and the introduction of long-range aircraft have had their impact on air traffic and are largely responsible for the growth in long-stage traffic. The advantage of speed was most apparent on longer journeys and faster aircraft have therefore had the greatest impact on long-haul markets. Greater range made non-stop long-haul flights possible, thus also contributing to shorter journey times. Moreover, as traffic increased, it became possible to serve more and more points on non-stop flights instead of having to pick up traffic at intermediate points in order to maintain economic load factors. A further reason offered as an explanation of the growth of long-stage traffic is that the North Atlantic and other long-stage routes have tended to expand at a faster rate than the short-stage routes.

Finally, Table 5 below contains a number of available forecasts of world long-stage operations extending to 1975. As already mentioned, the limits and years selected vary. In order to bring some of these estimates closer for comparison purposes, data for 1,400 miles and 1,800 miles was compiled from Convair estimates that were broken down by mileage blocks.

TABLE 5

World Long-Stage Operations (millions—passenger miles)

	Convair 1,000 m.	*Convair[1] 1,400 m.*	*Convair[1] 1,800 m.*	*I.C.A.C. 1,800 m.*
1958	26,496	18,977	15,143	—
1959	—	—	—	12,100
1965	51,321	37,831	30,780	—
1967	—	—	—	35,000
1970	71,754	53,889	44,419	44,500
1973	—	—	—	57,000
1975	92,440	69,774	57,497	—

[1] Derived from Convair traffic estimates by mileage blocks.

International Long-Stage Traffic

As indicated in Table 4, the share of long-haul stages in the international sector is much greater than in the domestic sector. For further information on the scheduled international sector we can refer to 1959 ICAO data listing four main stage length groups, contained in Table 6 below:

TABLE 6

Distribution of Traffic Performed on Scheduled International Services in 1959 according to stage lengths

Stage Length Groups (miles)	*Total Passenger Miles (millions)*	*Distribution (percent)*
0 - 299	1969	9.6
300 - 599	2645	12.9
600 -1799	7731	37.7
1800 and over	8161	39.8
Total	20,506	100.0

It will be seen that sectors of 1,800 miles and over accounted for about 40% of the passenger miles flown on international services. This compares with about 34% in 1956. ICAO has assumed that the trend will continue and that these operations will account for 55% of international passenger miles by 1967, for subsonic aircraft only. The introduction of supersonic aircraft would, however, tend to increase the percentage suitable for these aircraft.

ICAO is of the opinion that stages of 1,800 miles and over are those that are likely to be of particular interest to long-range supersonic airliners. It recognizes that any long-range aircraft sometimes must be operated over stages shorter than the economic minimum. This points out that the utilization of supersonic aircraft will tend to be greater than might appear from the statistics of traffic on the long stage lengths. Moreover, the very existence of exceptionally fast long-range aircraft would cause airlines to re-arrange this service pattern so as to provide more express services with fewer stops, thus again somewhat increasing the volume of operations on the longer stages. The potential volume of passenger traffic on international services in 1967 suitable for long-range supersonic aircraft was therefore estimated at 60% of the total instead of 55%. This gives a total of 28,000 million passenger miles which they expect will be potentially suitable for supersonic aircraft on international services. The steady increase in the proportion of traffic represented by the operations on stages over 1,800 miles—from 40% in 1959 to 60% in 1967—would be expected to continue less rapidly up to 1970 and 1973, bringing the percentage to about 65% in 1970 and 70% in 1973.

International Long-Stage Traffic: North Atlantic

The North Atlantic route is frequently mentioned as one of the major routes for supersonic operations—certainly the most important as far as international operations are concerned. Moreover, expectations are that in 1970 it will account for 44-60% of international long-stage operations. In 1960 it may be estimated to have amounted to something in the order of 55%. It has been estimated that its share of the world air travel market will be about 20%. In view of its significance in terms of the supersonic market certain available data prepared by ICAO and Convair are presented in Table 7 below.

Variations in the North Atlantic figures provided by Convair and ICAO for 1958 and 1959 may be explained by the fact that these are estimates based on IATA figures which are not compiled in terms of passenger miles.

While both series of estimates begin close enough together it will also be noted that expectations as to development on this route differ. Convair has assumed a yearly growth variation for the period 1959-1975 of 16 to 4%. ICAO is more optimistic.

TABLE 7

Comparison of North Atlantic Traffic with total international long-stage traffic (over 1,800 miles) (passenger miles—millions)

	International Long-Stage	*North Atlantic*		*% North Atlantic*	
	ICAO	*ICAO*	*Convair*	*ICAO*	*Convair*
1958	—	—	4,740	—	—
1959	8,200	4,650	—	56.7	—
1965	—	—	10,712	—	—
1967	28,000	16,000	—	57.1	—
1970	36,500	22,000	16,163	60.3	44.3
1973	48,000	27,000	—	56.3	—
1975	—	—	19,812	—	—

These estimates relate to total traffic and are not concerned with the potential penetration by supersonic aircraft. Convair expects that supersonic aircraft would account for 90% of total North Atlantic passenger miles were they to operate in 1965, 1970 or 1975 (see Table 15).

ICAO estimates of total potential aircraft requirements for the North Atlantic route in 1967 are given in Table 14.

Domestic Long-Stage Traffic

Despite a lack of adequate statistics on other than the U.S. domestic sector, it can be said that the proportion of Traffic carried over long stages on domestic operations is very much lower than is the case with international services. Only the U.S. and Canada among ICAO States have large volume domestic air services. Even allowing for increases in traffic and in non-stop operations by 1967, doubts have been expressed concerning the existence of many other domestic air services in this category. French domestic air services to Africa include a number of such stages, but they are of relatively low frequency and volume. On the basis of published time tables ICAO estimate that long-stage operations, with stage lengths over 1,800 miles, represent 7-8% of total world domestic operations in 1959. Long stage length operating in all other domestic systems where such operations are possible (French Africa, Brazil, India, Australia and some territorial services classed as domestic) might bring the 1959 figure up to 10%.

ICAO suggests that the same figure of 10% should be used in forecasting for 1967, since the scope for the development of long air services into long-stage air services in the domestic field is relatively limited. Moreover, certain territorial services classified in 1959 as domestic operations will, by 1967, have to be placed in the international category, owing to the territories in question having become independent States. Taking 10% of the estimated world total of domestic operations in 1967 gives 7,150 million passenger miles for the traffic on stages over 1,800 miles. In view of the limited number of long-range routes in the domestic sector, the percentage is expected to remain about 10% in 1970 and 1973.

These assumptions made by ICAO concerning percentage shares of traffic over 1,800 miles in the international and domestic sectors produce the following estimates for 1967, 1970 and 1973, with figures of 1959 given for purposes of comparison:

TABLE 8

International and Domestic Traffic on Stages over 1,800 miles
(passenger miles—millions)

	1959	*1967*	*1970*	*1973*
International	8,200	28,000	36,500	48,000
Domestic	3,900	7,000	8,000	9,000
Total	12,100	35,000	44,500	57,000

World Traffic by area — Trips over 1,000 Miles

Some statistics on U.S. carriers traffic and North Atlantic traffic have already been given in Tables 3 and 7. Data on these and other world areas are given in a more detailed table (Table 9) prepared by Convair for the years 1958, 1965, 1970 and 1975, in terms of trips over 1,000 statute miles. This is a breakdown of forecasts appearing in Table 5 above.

TABLE 9

World Air Traffic—Trips over 1,000 statute miles

	Revenue Passenger Miles (thousands)			
Area	1958	1965	1970	1975
U.S. Domestic	15,280,978	26,741,711	34,535,010	42,022,690
North Atlantic	4,739,762	10,711,862	16,162,588	19,812,205
U.S.—Caribbean, Latin America	1,844,781	3,505,084	4,685,744	6,216,912
U.S.—Honolulu	844,172	1,618,035	1,927,495	2,343,056
U.S.—Tokyo	478,255	956,510	1,348,679	1,927,368
Honolulu—Tokyo	101,907	203,814	287,378	410,685
U.S. West Coast—Europe	335,000	1,005,000	2,010,000	3,015,000
Honolulu—Oceania	103,655	217,310	306,407	437,880
Europe—South America	292,228	637,057	923,440	1,244,891
Europe—Caribbean	280,093	610,603	855,094	1,193,196
Europe—Africa	366,903	796,180	1,111,716	1,511,640
Europe—Middle East	669,959	1,453,811	2,029,976	2,760,231
Europe—Orient (Polar)	90,000	270,000	540,000	810,000
Middle East—W. Asia	383,151	963,220	1,859,604	3,263,153
Intra W. Asia	72,759	188,446	363,067	632,276
W. Asia—S.E. Asia	201,237	521,204	1,004,173	1,748,750
Intra S.E. Asia	71,515	185,224	356,860	621,465
S.E. Asia—E. Asia	65,674	170,096	327,713	570,707
Intra E. Asia	33,870	87,723	169,011	294,330
Australia—S.E. Asia	108,143	280,090	539,634	939,763
Australia—Africa	5,921	14,506	28,006	49,144
Australia—N. Zealand	70,697	183,105	352,778	614,357
TOTALS	26,495,660	51,320,591	71,754,373	92,439,699

Source: Convair.

On the basis of Table 9, Convair has set out the basic areas, their approximate percentage share of world air passenger traffic and the yearly percentage growth variation in the 1959-1975 period, as follows:

	U.S. domestic	N. Atlantic	U.S. to Orient	Rest of Free World
Approximate percent world market	50%	20%	5%	25%
Yearly growth variation (1959-1975)	12 to 4%	16 to 4%	15 to 5%	17 to 5%

World Long-Stage Traffic (over 1,000 miles) by Mileage Blocks

The distribution of traffic in terms of stage distances has an important bearing on aircraft design-range. Convair has conducted a useful analysis with the compilation of traffic statistics by city pairs, summarized by mileage blocks of 200 miles. This also constitutes a further breakdown of their forecasts appearing in Table 8.

Data for 1958 and 1975 have been extracted and appears in Table

10. The percentage distribution of traffic by mileage block is given, as well as the growth factors for each block, which list the expected growth of traffic for each block in the 1958-1975 period. For ease of reference, it should be emphasized that these are growth factors and not percentage increases (i.e., a factor of 10 represents a tenfold increase and not an increase of 10%). Furthermore, the traffic in the various blocks has come from many different areas of the world, each having its own growth rate.

TABLE 10

World Airline Traffic by Mileage Blocks

Range In Hundreds (St. Miles)	Revenue Passenger Miles 1958 (millions)	Revenue Passenger Miles 1975 (millions)	Percent of total 1958 %	Percent of total 1975 %	Expansion Factor 1958-1975
10-12	5,373	15,377	20.28	16.63	2.86
12-14	2,045	7,320	7.71	7.92	3.58
14-16	1,333	4,238	5.03	4.58	3.18
16-18	2,501	8,009	9.44	8.66	3.20
18-20	1,841	7,135	6.95	7.72	3.88
20-22	1,148	3,567	4.33	3.86	3.11
22-24	658	2,285	2.48	2.48	3.47
24-26	3,869	10,617	14.60	11.49	2.74
26-28	623	1,940	2.35	2.10	3.11
28-30	388	1,879	1.46	2.11	4.84
30-32	314	1,322	1.19	1.43	4.21
32-34	100	413	0.38	0.45	4.13
34-36	1,481	6,612	5.97	7.16	4.18
36-38	1,479	6,192	5.58	6.70	4.19
38-40	1,431	5,965	5.40	6.45	4.17
40-42	99	422	0.37	9.46	4.26
42-44	359	1,492	1.35	1.61	4.16
44-46	159	657	0.60	0.71	4.13
46-48	—	—	—	—	—
48-50	204	869	0.77	0.94	4.26
50-52	559	2,256	2.11	2.44	4.04
52-54	—	—	—	—	—
54-56	335	3,015	1.26	3.26	9.00
Over 56	96	859	0.36	0.93	9.00
TOTALS	26,496	92,440	100.0	100.0	3.49

Source: Convair.

Three points meriting attention are the following:

i) Some of the mileage groups are more important in the traffic picture than others. Convair has pointed out the four major points of traffic concentration which are expected to account for 77% of total passenger miles in 1975:

ii) Traffic above 4,000 statute miles, in 1958, diminishes quite rapidly and accounts for only about 10% of total passenger miles flown over 1,000 mile stages. However, the expansion factors for these ranges in the 1958-1975 period are the highest.

iii) On the basis of this analysis Convair is of the opinion that a supersonic aircraft should have a design range of 4,000 st. miles and the ability to operate at as low a range as economically possible.

TABLE 11
Traffic Density by Mileage Blocks—Major Areas 1975

Rank	Mileage Segments (St. Miles)	Major Market	Percentage of Total Pass. Miles
1	1,000 - 1,400	US Northeast - Florida	24.6%
2	3,400 - 4,000	US - Europe	20.3%
3	1,600 - 2,000	US Midwest - California	16.4%
4	2,400 - 3,000	US Transcontinental	15.7%
		TOTAL	77.0%

Source: Convair.

II. Potential Demand for Supersonic Aircraft

The foregoing section provides a statistical background to several forecasts that have been made covering the period up to 1975. This section is devoted to estimates of potential demand for commercial supersonic aircraft.

It will have been noted that there are differences of opinion as to the traffic that will be available to supersonic aircraft. For this reason alone it may be expected that forecasts of numbers of aircraft required will differ. This they do. However, different estimates of aircraft productivity, in terms of seat miles per annum, have combined to accentuate the differences.

Four sets of estimates will be dealt with below—produced by ICAO, Convair, Boeing and United Research Inc., in that order.

Potential Supersonic Requirements—ICAO

Preceding pages and tables have listed ICAO forecasts of traffic. Estimates of potential aircraft demand are based on their estimates of traffic on long stages of over 1,800 miles.

Aircraft considered are 100-seat Mach 3 and Mach 2 types with respective estimated annual productivity of 280 million and 190 million passenger miles, based on the following assumptions:

a) Load Factor: 60%
b) Utilization: 3000 hours per annum
c) Block Speeds: Mach 3 — 1550 mph
Mach 2 — 1025 mph

This produces the estimates listed in Table 12 for the years 1967, 1970 and 1973.

TABLE 12
ICAO Estimates—Number of Aircraft Needed to Accommodate Potential Traffic on all Stages over 1,800 miles: 1967-1970-1973

	1967	1970	1973
Mach 3 (100-seat)	125	159	202
Mach 2 (100-seat)	188	238	303

For 1967 a breakdown is given between international and domestic sector requirements in Table 13. It will be noted that those for the international sector are far greater.

TABLE 13

Market for Supersonic Airliners (Long-Range)—International and Domestic Sectors—1967

	Mach 3 (100-seat)	Mach 2 (100-seat)
International Sector	100	150
Domestic Sector	25	38
TOTAL	125	188

A distribution of supersonic aircraft requirements over major trunk routes was made for 1967 with the results presented in Table 14. Operations on the North Atlantic route are expected to account for almost half of the world requirement in 1967—about 58 Mach 3 aircraft or about 87 Mach 2 aircraft, each of 100 seats. The United States and Canadian transcontinental services would constitute the next important market with about 22 Mach 3 (100-seat) aircraft. It is pointed out that on those routes with low traffic density probably considerable pooling of other forms of cooperation would be required in order to permit the operation of supersonic aircraft.

TABLE 14

Number of Mach 3 (100-seat) Long-Range Airliners Possibly Required on Main Trunk Routes in 1967

Routes	Number of Aircraft International	Domestic	Total
North Atlantic	58		58
Mid and South Atlantic and Polar	7		7
Europe—Mid and Far East—Australia	11		11
Europe—Africa	4	2	6
US and Canada Domestic	—	22	22
North America—South America	7		7
North America—Pacific	9		9
Trans-Europe	2		2
All other	2	1	3
	100	25	125

It must be stressed that the above ICAO estimates are *totals* assuming that *all* suitable routes are to be operated by supersonic aircraft. Spare aircraft are excluded. It is pointed out that purchases would not be expected to approach these figures in the three years mentioned. Table 15 incorporates ICAO estimates of the number of supersonic aircraft that could be absorbed in the particular years 1967, 1970 and 1973 by the annual need for new capacity, assuming no other new aircraft were delivered at the same time. It will be noted that no mention is made of the annual demand in the intervening years (i.e. 1968, 1969, 1971 and 1973). However, further consideration was given to how these estimates would be affected by different assumptions as to size, speed, economic range, operating costs, etc.

TABLE 15

Number of Supersonic Airliners required in 1967, 1970 and 1973 to supply capacity to cover annual expansion and losses

	1967	*1970*	*1973*
Mach 3 (100-seat) a/c	42	49	51
Mach 2 (100-seat) a/c	63	73	76

Potential Supersonic Requirements—Convair

Given forecasts of long-stage traffic, Convair places emphasis on the extent of market penetration by supersonic aircraft; they expect these aircraft to capture markets in a similar way to the jets.

Convair forecasts of total long-stage traffic over 1,000 miles appear above in Tables 5 and 9 to 11. It is further recognized that only a proportion of this traffic will be available to supersonic aircraft. Certain penetration factors are therefore assumed in order to arrive at estimates of the traffic that will be available to supersonic aircraft. The date is set out in Table 16.

TABLE 16

Supersonic Penetration and Traffic Available (Traffic over 1,000 statute miles)

		Traffic Available (RPMs)		
Area	*Percent Penetration*	*1965 (000)*	*1970 (000)*	*1975 (000)*
U.S. Domestic	65%	17,382,112	22,447,757	27,314,749
N. Atlantic	90	9,640,676	14,546,329	17,830,985
U.S.—Orient	75	2,083,769	2,672,664	3,510,832
Rest of Free World	30	3,326,598	5,247,967	7,777,109
Total	—	32,433,155	44,914,717	56,433,675
Percent of World Total	—	63%	63%	61%

On the basis of its anticipated levels of traffic in 1965, 1970 and 1975, Convair has assumed a median range of 2,900 statute miles, and applied the block speed for this range to the various seat configurations (70,100 and 130 seats) at a 65% load factor. No mention of utilization is made. However, it is understood that annual utilization in the order of 3,000 hours was assumed. The resultant productivity was divided into the estimated numbers of revenue passenger miles and the following results were obtained:

TABLE 17

Convair Estimates of the Potential Number of Supersonic Aircraft Required

Mach No.	*70 Passenger Aircraft*	*100 Passenger Aircraft*	*130 Passenger Aircraft*
		1965	
2.0	199	141	108
2.5	171	121	93
3.0	154	109	83
3.5	143	101	77
		1970	
2.0	276	195	149
2.5	237	168	128
3.0	213	150	115
3.5	198	140	107
		1975	
2.0	346	245	187
2.5	298	211	161
3.0	267	189	145
3.5	249	176	135

On the basis of Tables 16 and 17 prepared by Convair it is possible to derive estimates of the potential number of supersonic aircraft that might be required for three areas of interest specified in Table 16, i.e. U.S. domestic; North Atlantic: and U.S. to Orient. Taking at random a Mach 3 100-passenger aircraft with the annual productivity estimated in Table 17 and relating it to the traffic estimates in Table 16 produces the following results:

Potential Demand for Mach 3 100-seat Aircraft

Area	*1965*	*1970*	*1975*
U.S. domestic	55	75	91
North Atlantic	32	49	60
U.S.-Orient	7	9	12

Some of the above data might be compared in a very rough and ready manner with the ICAO data in Table 14 and United Research data in Table 18 below.

Potential Supersonic Requirements—Boeing

A recent Boeing paper confines its attention to the international market as far as forecasts and estimates of demand are concerned. A continued steady growth of air travel is considered necessary to achieve reasonable production runs.

Emphasis is placed on the sonic boom as a limiting factor with respect to traffic forecasts. It is assumed that the sonic boom will limit traffic available to supersonic aircraft by 20% in the area of 1,500-2,000 Nautical Miles and over.

Boeing has made two estimates of international seat miles available for supersonic production by 1972. The first, on the basis of a 15% growth rate, amounts to 225,000 million seat miles; the second, on the basis of a 10% growth rate, amounts to 150,000 million seat miles. This is estimated to be the equivalent of 450 and 300 Mach 3 transports respectively.

Estimates are based on the following main assumptions:

a) 60% load factor
b) 140 passenger capacity
c) 3,000 hours utilization
d) all long-stage traffic over 2,000 n.m., plus some in the 1,500-2,000 mile bracket
e) 20% sonic boom critical factor

It is stated further that a delivery rate of 100 of these aircraft per year starting in 1970 would not catch up demand of the lower (10%) growth rate until about 1975.

Potential U.S. Supersonic Requirements—United Research Inc.

As previously indicated, this particular study is confined to the market amongst major U.S. scheduled carriers for supersonic aircraft. Accordingly, it is estimated that the following numbers of Mach 3 (150-seat) aircraft would be in demand in 1970 and 1975:

TABLE 18

Potential Demand Amongst Major Scheduled U.S. Carriers

	Domestic Flights	*International Flights*	*Total Flights*
1970	25	49	74
1975	35	81	116

Applicable seat miles were calculated by applying the percentages of total seat miles flown over 1,500 miles in Table 4 to the forecast of total seat miles in Table 3. Productivity of a 150-seat Mach 3 aircraft was estimated at 675 million seat miles a year on the basis of 3,000 hour utilization and on average block speed of 1,500 m.p.h.

Conclusion

Throughout this paper different views and assumptions have been outlined. It will have been seen how these differences have culminated in varying estimates of the potential demand for commercial supersonic aircraft. Given these differences, Table 19 is an attempt to bring together some of the estimates of the demand for Mach 2 and Mach 3 aircraft.

TABLE 19

Estimates of the Potential Demand for Mach 2 and Mach 3 Aircraft, 1965-1975

	MACH 2				*MACH 3*				*United*
	ICAO (*100-seat*) *World*	*Convair* (*100-seat*) *World*	*Convair* (*130-seat*) *World*	ICAO (*100-seat*) *World*	*Convair* (*100-seat*) *World*	*Convair* (*130-seat*) *World*	*Boeing*[1] (*140-seat*) *Intern.*	ICAO (*100-seat*) *Intern.*	*Res.* (*100-seat*) *U.S.C.*
1965	—	141	108	—	109	83	—	—	—
1967	188	—	—	125	—	—	—	100	—
1970	238	195	149	159	150	115	(a) (b)	—	74
1972	—	—	—	—	—	—	450 300	—	—
1973	303	—	—	202	—	—	—	—	—
1975	—	245	187	—	189	145	—	—	116

[1] Boeing estimates have since been revised.

Variations in each set of estimates are entirely possible if the assumptions on which they are based are changed. The figures will be affected by different assumptions as to such factors as speed, size, economic range, available traffic, load factor, utilization and operating costs.

Finally, one extremely important factor must be mentioned which could impose severe limitations on commercial supersonic operations, thus affecting available traffic and the potential number of supersonic aircraft that may be required. This is the sonic boom. It must be emphasized that only one of these available forecasts has taken the sonic boom into consideration. The remainder, and indeed this paper, must therefore be examined with this in mind.