Future Air Travel

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When I was in school I read a poem which ran as follows:

Once there was a lady called Bright
Who travelled much faster than light
She started one day on her relative way
And came back the previous night.

It sounded like an exercise in fantasy then, and it gave me a good laugh. To-day we have come full circle because what seemed to be a fairy tale only a few years ago is about to become a fact of life.

The subject of to-days talk is SST, which is a trade-name for Supersonic Transport. The word 'Sonic' derives from latin 'Sonus' which means sound. Supersonic therefore means superior to the speed of sound. Now, the speed of sound, although it varies with the temperature of air thru' which it travels is accepted as standard at 660 mph or Mach 1 named after an eminent Austrian physicist who first propounded the theory of sound waves. Thus, just as we measure the strength of a car in horsepower, we measure the speed of an aeroplane in Mach numbers, that is, its speed in relation to the speed of sound.

Concord

There are two main development projects on this side of the Iron Curtain. The first is the Concord Project. It is now two years since the British Aircraft Company of England and Sud Aviation of France went into collaboration to design a supersonic aircraft. Vast development activity is going on in both the countries, under the guidance of Sir George Edwards, of British Aircraft Corporation, who is today ranked as one of the top two or three aeronautical designers in the world, and General Andre Puget, of Sud Aviation. These two are assisted by a parade of crack scientists, aeronautical engineers and experts in almost every phase of aircraft design and manufacture. The entire project is estimated to cost around Rs. 450 crores. The main performance characteristics of the Concord are as under:

Basic Metal	-	Alluminium
Max. Take-off wt.	-	3,40,000 lbs.
Length	-	184 ft.
Speed	-	Mach 2.2 = 1450 mph
Range	-	4000 miles
Capacity	-	118 pax.
Cost	-	Rs. 7 crores appr.
First Test Flight	-	1968
First Commercial Flight	-	1972
Orders	-	55 at the end of November 1964 (Air-India holds 2 delivery positions.)

American SST

The second is the American Programme. It was only in October 64 that after long deliberation, the Government of the United States gave a green light to two aircraft companies, Lockheed and Boeing and two engine companies General Electric and Pratt & Whitney, to submit their designs for consideration. The entire project is estimated to cost in the region of Rs. 800 crores. It was suggested by economic advisers to the President that 90% of the development costs may be borne by the Government, and 10% by the participating companies.

Lockheed are known to be working on a machine with a capacity of over 200 pax and a speed of Mach 3 = 2000 mph. Boeings — you know the name. They are by far the biggest jet manufacturers in the world today. Their model called Boeing 733 will have the following main performance characteristics:

Baisc Metal	-	Titanium
Max. Take-off wt.	-	4,20,000 lbs.
Length	-	203 ft.
Speed	-	Mach 2.7 = 1800 mph
Range	-	4500 miles
Capacity	-	150 pax
Cost	-	Rs. 18 crores
First Commercial Flight	-	Around 1974
Wings	-	Variable sweepback wings which are tucked in the fuselage at cruise speeds, and spread wide at landings & take-offs.
Orders	-	Around 95 (For a machine whose design has not yet been crystalised in terms of speed, range and payload capacity. So much for the fulsome confidence in American technology and know-how). Air-India holds 3 delivery positions.

Cabin Pressure

All supersonic planes, whether American or English will fly at 70,000/80,000 ft. altitude. The present boeings fly normally at around 40,000 ft. Supposing there is a loss of pressure due to a crack in the window, that would be nothing serious except for a painful blow in the ears. The emergency oxygen supply in modern jets is adequate to maintain comfortable breathing for a few minutes until the pilot dives down to a safe altitude. At 70,000 ft., however, such decompression would be catastrophic. Because, the outside air is so rarefied, and the oxygen content of the air at that altitude is so low that consciousness cannot be maintained for more than a few minutes. The integrity of the structure whether it be alluminium or titanium will therefore have to be total and absolute.

I shall now mention briefly the problems that beset the design and development of a supersonic commercial aircraft. They fall into four categories:

1) Sonic Boom
2) Heat Barrier
3) Cosmic Radiation
4) Economics

1) Sonic Boom

Sonic Boom is the sudden blast of pressure that hits the ground when a plane flies supersonically overhead. A plane flying faster than sound projects down to earth a ridge of pressure which is experienced as a boom of varying intensity. Varying because the weight and the volume of the aircraft affects the intensity of the boom. There is a continuous, invisible, but very tangible shockwave 25 to 100 miles wide, depending on altitude, which passes over the ground at the same speed as the aircraft and is heard as a thunderclap and felt as the hammerblow of an explosion. The result is destruction to man and property. A pressure of 1. 5 lbs. per sq. ft. will produce the rumble and vibrations of thunder. At 2 lbs. p. sq. ft. it would break windows, rattle doors, and shake up flimsy houses on their foundations.

In order to measure the detrimental effects of the boom and the public reaction to it, extensive tests were carried out recently over Oklahoma City for a period of six months at all hours of day and night. And it is generally felt that unless the boom is substantially diluted in severity, supersonic flying may have to be confined over water and uninhabited areas of the globe.

2) Heat Barrier

The main problem connected with speed is heat. Just as by rubbing our hands we create heat, a fast-moving object going thru' the atmosphere creates friction and therefore heat. At Mach 2. 2 the heat generated would be 306^{o}F at Mach 3 it would be around 400^{o}F. This is known as the heat barrier, which is much more formidable and menacing than the sound barrier.

It is felt that the speed limit of Mach 2. 2 was selected by Concord as a compromise between costs and the achievement of an ideal supersonic transport. Because, that is the maximum speed that can be achieved while using alluminium as the base material. Anything faster than that would be too great for alluminium to bear without melting.

3) Cosmic Radiation

The surface of the earth is constantly bombarded by cosmic rays which are harmless to people on the ground and to flying objects up to 40,000 ft. There is, however, another source of radiation which emanates from storms on the surface of the sun, and which is harmless below 40,000 ft. These solar flares descend at the speed of light, 1,86,000 miles per second, and reach the earth in about 15 minutes. Since supersonic planes will cruise above 40,000 ft., the effect of such solar flares will be lethal to the planes and the occupants. In order, therefore, to enable the pilot to dive down to a safe altitude, elaborate warning devices will have to be set up on a world-wide basis.

Without in any way minimising the potential risks arising from such solar flares, it may be observed that these may not turn out to be very great obstacles. The experience gained by the American and the Russian cosmonauts can be taken as a guide. After all, they orbited the earth for a continuous period at very high altitudes, and still lived to tell the tale.

4) Economics

Economics or the economic viability of supersonic operations is the most controversial and the most critical issue of the whole lot. It can be divided into three heads:

A. Cost of development

B. Cost of the aircraft

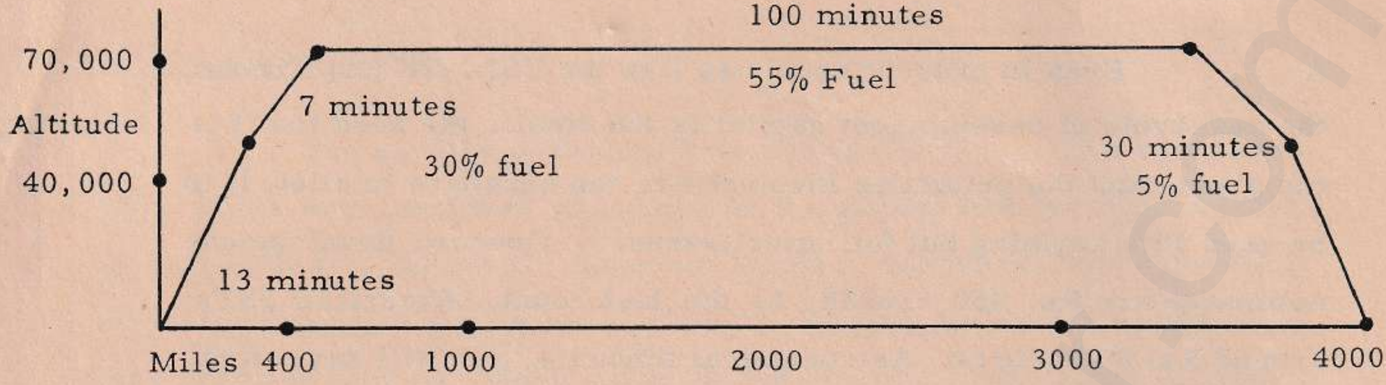
C. Cost of operations

A. Even in affluent countries like the USA, UK and France, the reservoir of development capital is too small, the need for it is too great, and the priorities involved are too sensitive to allow it to be used with anything but full effectiveness. Concord development estimates are Rs. 450 crores, at the last count. American SST's around Rs. 800 crores. Astronomical amounts, you will say. And, these are by no means the last estimates. The manner and the frequency with which they are revised, you feel, they would reach the moon before the planes ever take off.

B. Concord is estimated to cost around Rs. 7 crores, and the American machine around Rs. 18 crores. These prices are known to be marginal. They do not contain the escalation factor. They do not take into account the fact the the circumstances at the time of delivery of the aircraft, 10 years from now may be totally different and possibly adverse from the circumstances prevailing at the time the costs were arrived at. With a price tag like that, imagine the embarassment of a small Middle-East state, with the size of a postage stamp and its financial resources slightly less, which, just in order to keep up with the Jonesses went and bought a couple of those. If, God forbid, they ran off the runway, economically speaking, the airline will break into two, so will the aviation ministry, and to boot the insurance companies which took the risk.

C. The average seat-mile cost of a Supersonic plane will have to be extremely favourable in order to provide for lower annual utilisation, lower overall payload, higher maintenance rates and higher depreciation charges.

I shall now refer you to a flight profile which will give you an idea of how a typical supersonic flight will operate from the point of speed, height and fuel consumption.



Time Minutes	Altitude Ft.	Speed Mach	Distance Flown — Miles	Fuel Consumption
13	Take-Off to 40000	Subsonic	400	30%
7	40000 to 70000	Mach 1		
100	70000	Mach 3	3200	55%
30	70000 to 40000 to touchdown	Mach 3 to Mach 1 to subsonic	400	5%
150			4000	90% (10% Reserve) For holding or finding an alternate airport.

13 minutes after take-off, it climbs to an altitude of 40,000 ft. reaching the speed of Mach 1 without fear of sonic boom effects. In the next 7 minutes, it accelerates to 70,000 ft. The elapsed time from take-off to cruise altitude is 20 minutes; distance travelled is 400 miles; fuel consumed is 30%.

Having reached cruising altitude, the aircraft now speeds upto Mach 3, and will continue to fly at that speed for about 100 minutes covering a distance of 3200 miles, using up 55% fuel.

About 400 miles away from destination it will start descent. At 40,000 ft. it will again enter subsonic speed and will slowly touchdown 30 minutes after leaving cruise altitude. Fuel consumed during deceleration is 5%. Total time from point-to-point is $2\frac{1}{2}$ hours, distance flown is about 4000 miles — Rome to Bombay. Block speed, or the average speed from point-to-point is 1600 m.p.h.

I have elaborated this point to show you the factor of fuel consumption, which forms a significant part of the overall cost of supersonic operations. You may have noticed that during climb and acceleration which takes a total of 20 minutes, the aircraft uses up 30% of its fuel. This percentage compares unfavourably with the present jets which use only 10% fuel to reach cruise altitudes. And the gulf becomes wider the shorter the sector flown. You may also have noticed that during a 150 minute flight, it has flown supersonically for about 100 minutes. The remaining 50 minutes or 33% of the time it has flown at subsonic speed like any ordinary jet. Thus, the actual supersonic utilization even on a sector of 4000 miles becomes relatively poor. And, the fuel consumption ratio being what it is, flying supersonic machines on short sectors would be ruinous — something like using a steamroller to iron handkerchiefs. Besides, the net gain in time/comfort would be marginal after the ground journey including waiting time at bus terminals and airports and the two seat-belt times have been taken into account. And, even this advantage is dissipated if the scheduling encroaches upon normal sleeping hours.

In late 50's when almost every airline worth its name muscled in to switch over to jets, the rush created such a surfeit of capacity over the available demand that could not be filled even in a statistician's dreams. Unless, therefore, the airlines are quite sanguine about the utilization devoid of any frills, jugglery or equivocation, until they have uncomplimentary doubts about the seatmile costs, unless the entire operation is unsuspiciously economic, and unless they are reasonably confident of filling up those recurring capacities, they would not be prepared to enter the spiralling stakes and risk reverses beyond redemption. So, inspite of the flattering log-book of delivery positions at both places, it is expected that the airlines will use a gimlet eye and hard-headed restraint, if only for competitive reasons.

Without entering into the inflamed areas of controversy, it may be mentioned that the cardinal difference between the two projects is the use of basic structural metals. Concord will be made of allumi-nium. It will fly at 1450 mph where the heat generated is around 306°F, which is very near the heat that can be tolerated by alluminium. There is, therefore, a consensus that the day it flies, Concord will touch the limit of its growth potential. The Americans on the other hand have picked a high-temperature metal — titanium, which has excellent tensile strength, fatigue life, corrosion resistance and weight stability. Having thus eliminated the limitation on metal they have crossed the first hurdles of speed and heat, and can now go on to other problems. This is the main reason why many American experts feel that when their machine comes off the line, it will be the torch-bearer of a new generation of supersonic planes rather than the last ultimate refinement in a long line of sub-sonic ones.

Whereas in the past a commercial aircraft seldom introduced more than one new design feature, the supersonic transport cannot be built without incorporating a multitude of radically new design features. Engines, wings, fuselege, structural metal, air-conditioning, insulating, aerodynamic heating and ballistic speed, all these and many others will be revamped, and this makes the risks incomparably greater.

Without frightening away prospective passengers on Air-India I hope, I have set out before you the broad technological problems that the industry will be facing for the next 10 years. These are by no means the end of the line. Rather, they are the tip of the iceberg. There will be a buzz of other problems that cannot be discussed to-day, as they cannot even be foreseen. But, with the fountainhead of knowledge at man's command, these problems will be met. And while we are talking of a machine that would possibly fly at Mach 3, a few American experts have already mentioned the possibility of a hypersonic aircraft which by using liquid hydrogen as fuel can fly at speeds of Mach 20. That speed will take you from Sydney to Bombay to London to New York a distance of some 13,000 miles in an hour and a half. First experience and technical break-through have already been gained in NASA's experimental research aircraft X-15. And, you should not be surprised if it becomes a reality in the very near future.

Whether all this phenomenal effort will be worth the conjectural market, only future will show. The first shots have already been fired. It is now a matter of pride and prestige, of man and science, of two Goliaths locked in fierce competition across the Atlantic, and of the staggering price to pay for a promising future which may not be all that promising.

Travelling at 2000 mph will have its small inconveniences. Everything will work at a very high speed and there will be no time for consolidation. So,if while enjoying the pleasure of the delectable companion on your right, you are savouring the chances of breaking the 9th commandment, you will have to look sharp about it, otherwise, you will reach your destination by the time you have got past christian names.

A word about paperwork. Everyone from the pilot to the passenger complains that there are just too many papers to be signed while travelling by air. Well, with the advance in technology, speed and price, it is but natural that the paperwork should increase too. Loadsheet, trimsheet, pillowsheet and a myriad other forms each vying with the rest for its inevitability, all to be filled in a satisfy the captain, the airline, the customs, the immigration, the ICAO and the IATA. In this regard, there is, however, a cheerful understanding between the ground staff and the commander. The theory is that when the paperwork is finished it is weighed, and if the weight equals the weight of the aircraft, OK, you can go! It was once said in jest, but now believed in earnest that if we could cut down the paperwork, the enthusiasm of the customs, and the ground time between town and airport, we wouldn't need no SSTs.

Travelling at supersonic speed, especially towards West, the time differential will play havoc with your sleep and digestion. On a typical flight leaving Bombay at 9.30 in the morning you will reach Cairo at 8, London at 7.30 and New York at 6, eating three variegated breakfasts on the way and getting up all over again. And woe be to you if you have the weakness that I have — of looking forward to a leisurely meal in a slow-moving train. By then, no more luxury repasts to be enjoyed against the backdrop of lush green countryside in motion, by then only a tray of food thrust onto your lap and outside not even a grazing cow to be seen, only clouds upon clouds down below which is alright if you happen to be William Wordsworth.

There will be a few redeeming features. People will be able to put more distance quicker between their wives and/or their creditors assuming that the above said personages have not got wise to supersonic travel. The airlines will be relieved to cut down in champagne, caviar, frayed nerves and the turnover of their hostesses. The more material advantages will, however, be that the world will shrink into a small globe wherein no city will be more than a few hours away from any other. The history of aviation reflects irrevocably that with every major increase in speed, the volume of passengers and freight traffic has stepped up bringing in its wake a proponderant increase in trade, tourism and prosperity. Even more valuable than this is an overriding conviction that by bringing more people of the world together oftener, it will dissolve the smoke-screen of suspicion, lift the iron curtains of ignorance, break down the barriers of fear and mistrust and in so doing will contribute a little bit towards bringing peace on earth and goodwill towards men.

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