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National Aeronautical Laboratory

Some Thoughts Towards the Establishment of a Civil Aviation Industry in India

RAJ MAHINDRA
Director's Unit

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SOME THOUGHTS TOWARDS THE ESTABLISHMENT OF A CIVIL AVIATION INDUSTRY IN INDIA

Summary

The paper gives a historical perspective of civil aviation in India and highlights the transport needs of third and fourth level airline services.

The paper projects the concept of a community aerial service to cover health service (including controlling epidemics and carrying out eye clinics, and immunisation campaigns), relief operations during floods, famines and other natural calamities, agricultural, forestry, animal husbandry, policing and patrolling functions, and transport of perishable and critical goods etc.

The paper suggests building an industrial base in India around three programmes; a 30-50 medium haul airliner, an 8-10 seat mixed role small passenger aircraft, and a twin seat ab initio trainer. Each aircraft programme is identified with a particular type of development and manufacturing agency to minimise financial and manpower investments.

Suggestion is made that requirements of fourth level airlines and community aerial service may be combined and a single basic aircraft model developed. A technical specification is drawn and the design concept of a single 8-10 seat aircraft combining the two requirements is offered for detailed feasibility study. It is proposed that this aircraft be operated by a new agency which will run an operational network on zonal basis, combining requirements of various States and Union territories in the country. The study excludes such issues as offsets for large aircraft, airport services, ground equipment etc.

Economics of the programmes are discussed and a broad estimate of investment is indicated. A fraction of the overall investment on civil aviation in the coming decade is shown to be adequate to launch programmes which would satisfy requirements of certain segments of civil aviation and also provide a sound base for the emergence of a civil aviation industry in India.

1 HISTORICAL PERSPECTIVE

Civil Aviation was born in India on 18 February 1911 when Henri Piquet flew a Humber bi-plane carrying mail from exhibition grounds at Allahabad to Naini Junction, a distance of 6 miles. Mr J R D Tata told this to his audience while delivering the Sixteenth Commonwealth lecture to Royal Aeronautical Society, London, on 18 November 1960. He also mentioned that there was inaction in this activity until World War I, and that in 1926 the Indian Air Board and Advisory Committee of the Government of India submitted a memorandum to the Government in which amongst others it proposed that landing grounds and other ground facilities should be established, a whole-time Director of Civil Aviation be appointed, a systematic survey of main trunk routes be made, and air service between Calcutta and Rangoon be incorporated.

Acting upon this advice, the first Director of Civil Aviation was appointed in 1927. Later in 1932 with the inauguration of Karachi-Madras flight, the Indian scheduled transport system came into operation. Mr Tata goes on to say that the Indian air transport system was totally geared to war needs in World War II and practically the entire capacity of the domestic and international airlines operating at the time was placed at the disposal of the Government and very little spare capacity was available for commercial traffic. Civil Aviation in India was restored to commercial status on 1 January 1946. Civil Aviation benefited much from World War II. Many new aerodromes equipped with long concrete runways were constructed; meteorological services, radio communication and landing aids were expanded; some 44 aerodromes with a network of radio ranges and beacons were set up.

In March 1953, India's Parliament passed the Air Corporation Act making provision for two Corporations: The Indian Airlines and Air India International. As a result, Indian Airlines Corporation, so records Mr Tata, was born in August 1953 absorbing eight separate airlines with varying standards of organisation, operation and administration.

Most of the Civil Aviation requirements of the country have been met through the import of aircraft from USA and Europe. The aircraft industry which was originally set up with the idea of indigenously developing aircraft both for the military and civil sectors, has historically concentrated on the military aviation, and even here, essentially on the development and manufacture of fighter and trainer class aircraft. Also, indigenous development has been a small effort compared to manufacture under licence.

As the threat perceptions changed, so did the military aircraft requirements. These multiplied to an extent that the aircraft industry in the Public Sector has had to depend heavily on building foreign aircraft under licence from East and West European countries in order to meet the service requirements. During this period, a variety of transport aircraft for military use were acquired. Also, several aircraft for civil use were imported and no assembly or manufacturing line was set up in the industry; thereby reliance was placed on outside support to sustain these aircraft by way of importing spares, ground equipment etc for airline operation. Maintenance facilities, however, were allowed to come up.

In the later 1950s, a manufacturing licence was obtained from UK for building the HS-748 for military and civil use. No design and development back-up was provided for absorbing technology and developing new aircraft indigenously. Realising some time in the mid-1960s the ever increasisng traffic demand on the domestic airline service as well as anticipating the Indian Air Force's future plans for augmenting its transport fleet, HAL considered a proposal to develop a transport aircraft which combined the passenger carrying role with the military cargo role and various other logistic duties of the Services. A fairly comprehensive feasibility study was carried out resulting in a design concept (see Figure 1 /9/). Also, as one recalls, this aircraft was powered by four turbofan engines and high lift devices were incorporated in the wings to achieve STOL characteristics. The aircraft was designed to cruise at high subsonic Mach numbers and could operate from runways in hilly areas and under high ambient temperature conditions. The aircraft was sized to carry up to 80 passengers for civil airline operation and in its military freighter version the fuselage was to be suitably fitted to accommodate military personnel, war materiel, logistic support equipment etc. This project remained on the drawing board for about a year but did not receive development go-ahead. Instead, the design team was directed to divert its efforts to the design studies of various combat aircraft. Much later in the early 1980s a manufacturing licence was obtained from West Germany for building the Dornier-228 both for military and civil use. At this time, a small back-up design team was involved at HAL for taking up airframe modifications to fit special role equipment and larger access doors demanded by individual customers to suit their operational tasks.

For all intents and purposes, the original idea of developing India`s own civil transport aircraft remained unrealised even though several proposals for indigenous development of a transport aircraft suited to the country's operational requirements had been made from time to time by the design organisation of HAL. In one instance (1978-79), proposals for developing a light transport aircraft in collaboration with foreign partners on equal partnership basis had also been considered.

Even prior to signing of the licence manufacture of the 19-seater, unpressurised, twin turboprop Do-228 transport aircraft, the requirement for a 30-seater, pressurised, twin turboprop light transport aircraft for the third level airline operations had been perceived but the development proposal for such an aircraft, after a detailed project study was made, was finally shelved by the HAL.

With the Vayudoot's coming into being for the third level airline operation and registering year after year very high traffic growth coupled with the 10% consistent annual traffic growth on Indian Airlines' network, the situation has forced the planners in the Government associated with the air transport system on the domestic segment to have a fresh look into the short and long term needs of the Civil Aviation. Such an exercise, no doubt, will determine the likely aircraft acquisitions. This will, in addition, provide some insight into the associated infrastructural needs of the airlines. The study, when completed, will perhaps provide estimates of the financial burden that will have to be borne by the public exchequer for the aircraft assets and for running the airlines. This has subsequently been shown to be upwards of Rs.20,000 crores.

While these estimates are being made, it was felt important to determine the category of aircraft that must be imported outright because they are few in number, also determine the category of aircraft which could be manufactured under licence because they are required in reasonable numbers and therefore manufacture is economically viable, and lastly identify the category of aircraft which could be designed, developed and manufactured in the country because the acquisition time and the development time happen to be compatible and also the occasion offered a good case for creating an industrial base for civil transport aircraft manufacture and curtailment of foreign exchange outgo on recurring basis.

A study of the operations of Indian Airlines and the Vayudoot indicates that the Indian public have accepted air travel as a mode of transportation in the same manner that they accepted the train and bus travel many decades ago. Therefore, there should be no fear insofar as air traffic growth is concerned. In this connection, one may once again refer back to what Mr Tata had to say in his lecture in 1960: "In the case of domestic operation, the growth of traffic as represented by passenger miles flown has risen annually at a rate five times as great as the National Income of the country. If it continues to do so and assuming that during the current decade the real National Income of India grows at the rate of 4% - by no means an unrealistic figure - the demand for domestic air transport would grow on an average by about 20% per year. Taking passenger miles flown as an illustration, the figure of 329 million passenger miles (703,013 passengers actual) flown in 1959-60 might rise to nearly 1,000 million (1,205,110 passengers actual) by the mid-1960s and to over 2,000 million by 1970 (2,248,117 passengers actual). Even if actuals do not reach these estimates it can still be seen that with rising standards of living and immense potential in the domestic market with distances between major centres ideally suited to air travel and an enthusiastically minded air population, future growth prospects are bright indeed."

Mr Tata's projections /1/ have stood the test of time as 10-11% annual air traffic growth on the Indian Airlines /2/ has been witnessed for many years (see Figure 2). At the same time, 9-10% annual growth in air cargo has also been observed (see Figure 3). The Vayudoot has meanwhile airlinked 84 stations and has plans to connect 130 stations totally by the end of the current Five Year Plan. Whereas the Indian Airlines is carrying 28,000 passengers per day at present, it is expecting to carry 1.25 lakh passengers per day in the year 2000. At the same time, the Vayudoot is registering a yearly average growth of 50% (see Figure 4 /5/). This growth is phenomenal by any standard and even if such an average growth cannot be sustained indefinitely, high traffic growth is likely to be maintained for a long time to come.

As the country progresses in its economic, trade and political operations, the transport and communication needs would further grow. Tourism, starting from small beginnings, has developed into a full-fledged industry, becoming a sizeable source for earning foreign exchange and for domestic spending. As expansion of the scientific and industrial base takes place, the need for foreign professionals to visit India will also grow. The large public and private sector Corporations have begun to feel the need for greater mobility and time saving for their top and middle management executives. Besides this, State Governments and Union Government have many international dignitaries whose short visits are known to stretch over several engagements in several parts of the State/country, requiring special air travel arrangements, also Government Officers and Legislators keeping close contact with the districts.

All this has brought forward the need for the airtaxi/ executive role aircraft. This need has been accepted by the Government of India as legitimate, and serious consideration has already been given by the Government for aircraft acquisition and operation in the Private Sector.

2 NEW PERCEPTIONS

Even though many in the social and professional community have perceived the need for community aerial service, this has not received any formal attention from the Government. At the time of any emergency, military transport aircraft and helicopters are pressed into operation for rescue or other humanitarian missions on orders from the highest authority in the country but no proper organised civil aerial service for the good of the community at large exists at present.

Community service and humanitarian missions can cover transporting food and medical supplies, medical practice, innoculation campaigns, eye clinics, epidemics, life and death accident situations, agriculture, forestry, animal husbandry, irrigation, well-digging, crop-spraying, and air support in the event of earthquake, famine, flood, forest fire, pestilence. The service could also cover air support for policing and patrolling, anti-smuggling, crowd and riot control operations, and surveillance of refugee traffic across the borders, electoral processing, transport of postal packages, perishable cargo such as food, flowers and vegetables, and emergency drugs etc. Such services are known to be in operation in many parts of the world for a long time and are by no means restricted to developed countries (e.g. Doctor service in Australia, Bioforce in Africa, Alpine, and rescue service in Europe etc). The communities covered by these services have immensely benefited and much greater use is being made of aircraft and helicopters to provide instant relief and succour to those living in remote and inaccessible places. Air-mobility can add a new dimension to the health services in India which are penennially hard-pressed for funds for opening new hospitals, recruiting more doctors and nursing staff and raising fresh infrastructure. Also, there is the unfortunate compounding situation of a large number of professionals not willing to take residence in villages and under-developed towns. For this type of situation, community aerial service could be most effective for transporting professionals to the regions and outposts which would otherwise remain unattended.

3 EMERGING CIVIL TRANSPORT AIRCRAFT REQUIREMENTS

It is not the intention to deal in this paper with the transport requirements for the country's large carriers i.e., the Air India and the Indian Airlines. An attempt is made only to assess the third and fourth level airline category aircraft that could provide a sound base for an indigenous civil transport aircraft industry.

Judging from the fact that some 10 million passengers travel by rail and road daily and the per capita income of 50 million people in India is over Rs.60,000 per annum, it would be reasonable to assume that a large market for air travel exists which can be profitably tapped, provided due consideration is given to the travel habits of the population, to the regional growth of industrial production, to the trade pattern amongst the business communities, and to the travel times between distances etc. No doubt, various plausible criteria can be evolved to make forecasts for the third and fourth level airline operations but no single rational air traffic model can be offered in the absence of systematically acquired data in this regard. However, from the graph of the published data on the number of passengers carried by the Vayudoot airline during the last six years (Figure 4), it can be seen that the traffic handled by this airline nearly doubled between 1985 and 1987 and reports say that this trend is still continuing.

While advancing the rationale for the third level air service in India the Aerospace Almanac of India 1987-88 suggests that the prediction of traffic growth for the third level airline could well be based on air travel between towns and cities with a population of 80,000; cities and towns with existing airfields; inter-city distances of 150-500 km, and shorter distanced hilly tracts of Eastern India. The publication estimates 172 cities with associated set of 2300 city pair connections. This is in contrast with the DGCA study which is reported to have established a definite potential of 92 centres /10/.

Assuming that the Aerospace Almanac estimate may have encompassed some traffic from the Indian Airlines' network too, and the number of centres may be somewhat less than projected, the force of the logic that manifold increase in aircraft seating capacities is required, cannot be refuted. In fact, considering the relatively short life-span of the Vayudoot, this airline has had to revise its fleet requirements upwards more frequently than, for instance, the Indian Airlines had to. It is well to realise that a sizeable proportion of this increased seat capacity can be made good quite effectively by establishing a fourth level airline network which is discussed later in the text.

Viewing the Vayudoot operations, it has been increasingly realised that this airline cannot manage with a single category aircraft. The areas to be inter-linked vary geographically and the travelling public have different needs in different areas. The airline operates lean and dense air routes and it has very short to medium stage lengths to cover. It has a mixed travelling population which is anxious for personal comfort to varying standards. Some desire bigger personal baggage, some want shortest journey time, some increased travel frequency, and others more convenient timings for onward and return journeys.

Studying a cross-section of this airline's network, one observes that the Vayudoot has connected stations like Delhi-Agra, Delhi-Jaipur, Delhi-Ludhiana in the North; stations like Shillong-Guwahati, Tezpur-Guwahati, Agartala-Kamalpur in the East; stations like Bombay-Kandala, Bombay-Porbandur in the West, with stage lengths varying from 50 km to 500 km. Besides the abovementioned stations, it was also observed that several stations connected by Vayudoot were on Indian Airlines' network as well and is therefore competing with Indian Airlines on some routes. In many cases, the Vayudoot provides feeder services to stations covered by Indian Airlines. Traffic record shows that Delhi-Ludhiana, Delhi-Dehradun, Delhi-Chandigarh-Kulu, Bombay-Kandala, Calcutta-Jamshedpur etc are some of Vayudoot's high density routes earning good revenue and most of this coverage meets the socio-economic criteria mentioned earlier.

The emerging pattern in the third level air travel leads one to the conclusion that in order to provide a reasonably flexible and profitable service, the Vayudoot will need to operate various sizes of aircraft possessing varying operational qualities. It needs, for instance, 8-10 seat capacity, pressurised, twin turboprop engine aircraft for air taxi, group charter, executive and VIP travel, over short to medium stage lengths varying between 100-500 km. This aircraft should be well furnished, comfortable to sit in, and should be moderately fast. The airline also requires a 30-seat capacity, pressurised, twin turboprob engine short-haul commuter aircraft having high cruise speed and high cruise efficiency. It should be flexible enough to be profitable down to 50% load factor and stage lengths of 350-1000 km permitting alternating landing in time of inclement conditions and longer distances without intermediate hops if so required. For its denser routes, the airline would need a 50-seat capacity, pressurised, twin turboprob medium-haul regional airliner having high cruise speed and high cruise efficiency which, once again, should be flexible enough to show profitability down to 45% load factor and for stage lengths of 500-1500 km.

A closer scrutiny of the varying operational requirements suggests that it may be desirable for Vayudoot to concentrate on the legitimate third level air operations, and the operations requiring an 8-10 seater aircraft were assigned to what one might term as the fourth level airline service. This service need not be Government-run. In fact, it would be better if private companies are encouraged to handle this airline network. The primary goal of having such a network should be the eventual emergence of a minibus-like air scheduled service which could link small business centres, industrial townships, and tourist spots, and could also hire out aircraft for executive and VIP travels, and for unscheduled charter duties in any part of India. This type of service will have to be on a low overhead basis requiring fleet standardisation and an efficient ground engineering and maintenance organisation. It will have to be run by a professionally trained management which is cognisant of aircraft safety standards, procedures and practices etc.

It may be better at this stage, to refer back to the community aerial service which was highlighted under the heading "New Perceptions" and examine the category of aircraft that would suit the operational requirements of this service; also to examine whether there exists some common ground in aircraft specification for the two air services and if so, could one suggest developing the type indigenously.

4 AIRCRAFT FOR COMMUNITY AERIAL SERVICE

Community aerial service has many duties to perform and therefore its aircraft should have operational versatility. These aircraft have to provide mobility to men and material in reasonable comfort and with a high degree of safety and reliability. On many occasions these aircraft will have to take off from short and semi-prepared runways and will have to fly in all-weather conditions under varying topographic features found in different parts of the country, requiring special design considerations.

In order to provide a high degree of safety and reliability, it would be almost mandatory that the aircraft had two engines. For many months in the year various parts of the country undergo extreme temperature conditions followed by cloudy and rainy weather accompanied with precipitation and turbulence. Therefore, it would also be highly desirable to provide air-conditioning and pressurising systems, besides gust alleviation devices. Since the aircraft has to take off and land from short and semi-prepared strips, it is necessary to provide the aircraft with STOL capability, with rugged landing gears and low pressure tyres. Also, the aircraft will need advanced navigational and communication equipment for all-weather operations. The airframe interior will need to be suitably designed for the installation of various categories of mission equipment. It is obvious that community aerial service would attach high priority to health, immunisation, eye clinics, emergencies and rural uplift schemes. Therefore, the sizing of aircraft should be carried out keeping these aspects in mind while designing the aircraft. The aircraft will need to carry a doctor, nurses, attendant, medicine and surgical boxes, stretchers with and without patients, health and emergency aids etc. On the other hand, for the roles related to policing, patrolling, crowd and riot control etc, the aircraft will need to be furnished with photographic, sound and communication equipment, besides carrying equipment associated with anti-criminal activity.

To sum up, community aerial service essentially requires an aircraft which has adequate volumetric capacity for a mixed arrangement of passenger seating and cargo carriage. In other words, the aircraft should be able to seat 8-10 persons or a mixture of special role equipment and fewer passengers on an as-required basis. The aircraft should have excellent short take-off and landing characteristics above everything. It should also have rugged landing gears and low pressure tyres for operating from semi-prepared runways. A moderate cruise speed of 500-550 km/hr, and normal operating stage lengths of 100-350 km would be adequate. Pressurisation, air-conditioning and gust alleviation would be desirable for all-weather operations, high safety and reliability standards are to be maintained along with high level of aircraft availability, particularly for mercy missions.

5 INTEGRATED APPROACH

Ideally, an aircraft specifically designed for a particular operational role will be the optimal solution and this applies equally to the aircraft meant for the community aerial service. But in practical terms, many of the roles described for the community service would overlap and these could be so grouped that a design concept which would combine technical feasibility with economic viability of the project could be successfully evolved. It is conceded that community aerial service could even be started by importing one type of low priced aircraft from abroad (perhaps a secondhand refurbished one). It is also conceded that the fourth level airline service and community aerial service could have separate identities, each operating its optimally chosen aircraft. This splinter approach would however not provide us with a basis for setting up a civil aviation industry in the country. The cost of aircraft developed individually for each service will be higher and in the case of the fourth level airline network will tend to compromise airline's profitability. It is also to be appreciated that community aerial service like many other social welfare operations will require subsidies from the Centre and the States and therefore maximum care needs to be exercised to keep the unit cost low. It would be logical to view the fourth level airline and the community aerial service in an integrated manner if for no other reason but for the sheer number of single type aircraft that could be manufactured at reasonable cost. Technically also it is feasible to combine the two requirements, provided one does not grudge certain compromises in the concept which would be inevitable in any engineering system.

If a single-engine safety requirement is applied universally, then the genuine fourth level and the community service aircraft could both have twin turboprop engines. (The engines could be suitably derated to match the lower speed of the aircraft operated by community service.) Both could have pressurised airframe for meeting the all-weather conditions with sufficient volumetric capacity in the fuselage for the passengers and cargo for several roles and air missions envisaged for the type. It should be possible to store all the fuel in the wings to provide clear space in the fuselage for accommodating men and materials. The aircraft would naturally be optimised for the fare-paying role, as passenger comfort and airline profitability is paramount to make the programme viable. The aircraft should have reasonably high cruise speed and high cruise efficiency including good subsonic-speed aerodynamics and low fuel consumption engines. Low vibration turbo-propeller engines would be required. Ruggedness, reliability and safety are common to both the versions. The community service aircraft would be more demanding in STOL capability and this must be designed into the aircraft. Sophistication of wing profiles and flaps and other high lift devices will, no doubt, entail higher initial development cost but only marginally higher first cost. This technological challenge can be met by the scientists and engineers through a careful innovative approach to aircraft design and through the use of frontline technology. It is almost certain that this class of aircraft will also find use by the military services, for communication and light logistic duties as is the case in other parts of the world.

On the basis of this integrated approach, it is estimated that a requirement of 200-250 aircraft can be assumed for planning purposes. The aircraft industry all over the world thrives on export. It is usual for the aircraft industry, when taking up design of a new aircraft, to assess global requirement through market surveys and perhaps mathematical modelling. This helps to enlarge the scale of production and lower the price of aircraft. A similar exercise will be useful here also. Many developing countries will be needing this type of aircraft and would be willing to buy from India, provided the price was right and necessary field support for aircraft operations was as good as available from other countries. The ultimate number could therefore be much higher than the 200-250 assumed here.

6 THIRD LEVEL AIRLINE AIRCRAFT REQUIREMENT

Third level airline operations are being handled by the Vayudoot with a mixed aircraft fleet of Do-228, HS-748 and Fokker Friendship. Also, the Vayudoot is operating some routes as mentioned earlier which are served by Indian Airlines as well. It would be better for the airline to standardise as far as possible on a single aircraft in order to provide more efficient and economical service. It would also be sensible to rationalise the route structure to avoid unnecessary duplication within the nationalised airline network. For example, some of the medium haul operations could be delinked from the Indian Airlines and assigned permanently to the Vayudoot. This would also fit in with the Government's policy to increasingly allow the Indian Airlines to operate routes across the international borders to some of the neighbouring countries. Such readjustment would further help the

Vayudoot to plan its future fleet requirements more rationally.

As it is, to meet the high traffic growth on some of the routes already under operation and to cover additional stations planned to be connected in the near future, the Vayudoot would be seeking some augmentation to its fleet. The ageing HS-748 and the Fokker Friendship which incidentally consume much more fuel than even the other present generation turboprops, will have to be replaced by the next generation cruise-efficient airliners. The 19-seater unpressurised Do-228 will also need replacement in another decade.

Taking all the above factors into consideration, it is estimated that the Vayudoot will require an aircraft of about 30-seat capacity in the near term and of about 50-seat capacity in the longer term perspective. This aircract will require capability of operating from short runways situated in hot and high elevations besides having high operational efficiency over stage lengths ranging between 350-1500 km. This aircraft will have to show profitability down to 45-50% load factor.

A family concept in the category of short to medium haul airliners has already been demonstrated by various aircraft development companies abroad. To cite an example, DeHavilland Canada who initially offered 30-40 seat capacity Dash 8-100 to the international market is now offering Dash 8-300, a stretched version of the original with seating capacity of 50-60 passengers. It is considered essential that the next generation aircraft for the Vayudoot be developed indigenously on a family concept basis. Such an approach could result not only in the development of the most appropriate aircraft for the airline, but also in providing a much needed focus for the aircraft designers and the scientists in the country with which to start the civil aircraft activity. This requirement will further enlarge itself as numerous civil and military applications such as calibration, navigational training, surveillance and coastal security, and cargo loading needs can also be combined in the specification. It could be a future generation workhorse of the civil and military aviation as was the "Dakota" in yester-years. Hundreds of this category aircraft will be required in the country itself besides offering a very high export potential.

7 CIVIL TRAINING AIRCRAFT REQUIREMENT

The main purpose of this paper has been to outline civil aviation programmes that may provide opportunities for establishing a viable civil aviation industry in the country. In this connection, a brief reference to a twin seat Flying Club type trainer aircraft may be relevant as this forms a significant link in the civil aviation transport system. Commercial aircraft flying requires trained pilots. Government has recently set up an Air Academy for this purpose. But before training for commercial aircraft flying, students require to undergo ab initio pilot training on a simple trainer aircraft to obtain a private pilot licence as an entry qualification. There are some 23 Flying Clubs in the country which provide such training besides offering hobby flying to the enthusiasts. The Pushpak aircraft developed by HAL some 25 years ago has been the mainstay for this activity. More than 100 aircraft are being operated by various Flying Clubs scattered over the country.

Military, on the other hand, trains its pilots on twin seat ab initio trainer aircraft which are somewhat larger, are fully aerobatic, and are naturally more expensive to acquire and operate. Successive traianers viz. HT-2 and HPT-32 were developed by HAL for this purpose and are in use with the Indian Air Force Training Establishments. The age-old Pushpak now needs replacement with a more modern aircraft. Although it may be relatively easy to develop such an aircraft, it also has challenges for the aeronautical engineers in that this class of aircraft must be developed and produced on a very low budget since Flying Clubs which operate this aircraft are themselves run on shoe-string budgets. A very low overhead organisational set-up is required to bring out the next generation ab initio civil trainer aircraft.

Advances in aerodynamics and structures coupled with the man-made strong yet light composites that are now available will have to be imaginatively used to produce a robust but light trainer which handles well in air and can take necessary punishment when repeatedly taken off and landed from not very good surfaced runways at the hands of learners. And above all, the aircraft must be inexpensive, costing no more than Rs.2.5-3.0 lakhs or $ 20,000-25,000 to achieve which low cost powerplant, flight instruments and landing gear would be an essential feature. Manhours for producing such an aircraft will have to be strictly controlled.

8 ALTERNATIVE STRATEGIES FOR SETTING UP THE CIVIL AVIATION INDUSTRY

It is clear from the above survey that various categories of civil aircraft will be needed by the third and fourth level airline network as distinct from those required by Indian Airlines and Air India (wide-bodied medium to long haul airliners). The aircraft required, as seen above, vary from a twin seat ab initio trainer to a 30-50 seat medium haul airliner and in between there is the requirement of a mixed role 8-10 seat aircraft for covering the fourth level and community aerial services. It is now necessary to examine whether there is a case for establishing a viable civil aviation industrial base around these aircraft or not. In this connection, it is worth mentioning that simultaneous development of all the three aircraft by a single agency would be unrealistic. Alternative strategies will have to be considered to find a workable solution. Also, the civil aviation industry proposed to be created through any of the above identified aircraft projects should be so structured that in years to come the industrial base could acquire sufficient professional standing for it to handle programmes of a greater variety and complexity.

Consideration may also have to be given as to whether it was essential to design and develop all aircraft indigenously to create an indigenous base, or whether this could be done in stages. For example, it could be argued that the first stage could be a time limited licence phase when assembly and manufacture of the basic model of a particular category of aircraft was accomplished. During this phase, an infrastructure could be built up along with induction of manpower skilled in aircraft engineering practice and conversant with aircraft safety and reliability procedures. The second stage could then be devoted to developing variants of the aircraft for different applications as envisaged. During the third and final stage, development of the next generation aircraft could be taken up Whilst the first and second stages of activity were going on, visualisation of the next generation aircraft and associated technologies must be in place. Further on all the contemporary technologies must be in hand at the third stage; this is necessary to survive in the rapidly advancing fields of airframe, engine and avionic technologies, and also to reduce dependence on outsiders for developing modifications and increasing end use of the product.

In other words, the industry is suitably manned with design and development personnel capable of interacting with R&D institutions for aeronautical science and engineering right from the beginning, otherwise "licence culture" could set in for good which would seed technological obsolescence, as invariably the foreign companies would try to part with earlier generation technologies when offering licence manufacture of their well established aircraft. A note of caution must also be sounded here. Indigenous design and development of an aircraft is a long gestation activity requiring positive encouragement from the Management and Operating Agency. Therefore, this must be assured when a new programme is being launched.

Alternatively, it may be argued that it would be better to create an industrial base through a low cost simple aircraft programme like the ab initio trainer but all through an indigenous effort. This will have the advantage of grass-root development, manufacture and operation which will provide the necessary confidence to Indian engineers to attempt more complex programmes later. This alternative, however, has the disadvantage of considerably delaying the realisation of some of the other aircraft programmes identified earlier on. The delay could be as much as five years before any of those programmes could be attempted, and meanwhile various airlines in the country would have acquired their fleet through import from abroad leaving precious little for either indigenous manufacture or development in the foreseeabale future.

9 CONSIDERATIONS FOR THE ESTABLISHMENT OF AN INDUSTRY FOR DEVELOPING AND MANUFACTURING CIVIL AIRCRAFT

As explained, there are several options to choose from for establishing an industry specifically to build various categories of transport aircraft for civil use. At present, HAL is the only organisation in the country which has been assigned the responsibility of designing, developing and manufacturing all categories of aircraft. HAL has been heavily engaged in the manufacture of aircraft under licence from East and West European countries. Most of the infrastructure and facilities installed at HAL have been used for manufacturing fighter and trainer type aircraft for the Indian Air Force with minor diversion for the transport aircraft made under licence for military and civil use. Indigenous development has also been concentrated on combat and trainer type aircraft and, judging from the present plans, the HAL design and development teams will remain engaged on the future generation combat aircraft for a long time to come.

The policies prevailing at HAL have been conditioned by the demands of military customers, and the technical and manufacturing expertise and the productivity and cost structure are far removed from those necessary for the commercially competitive civil aircraft market. Priorities at HAL, of necessity, are laid down by the military which traditionally has been its main customer and investor. The overheads tend to be high and productivity compared to international standartds tends to be on the lower side. Therefore, unless a radical change is brought about by segregating the civil aviation activity completely and organisational structure revamped, the economic viability of a civil aircraft programme cannot be assured.

The Kanpur Division of HAL can provide a manufacturing base for civil aircraft production (this has been demonstrated through HS-748 and Do-228 programmes), but the overheads associated with a large organisation are likely to make the products too costly. However, if restructured on strictly commercial norms, HAL, Kanpur could provide a viable manufacturing base for medium haul airliners with seating capacity of 30 and above.

HAL Kanpur is basically a "licence-based" factory without any orientation towards design and development activity much of which is concentrated in Bangalore and this, as mentioned earlier, is heavily committed to the next generation combat aircraft. It would seem wrong to take yet another licence for the manufacture of a medium haul airliner, requirement of which was indicated earlier for the Vayudoot's expanded network. Indeed, it would be more sensible to enter into design collaboration with an international industrial partner willing to cooperate in the development of an aircraft predominantly suited to Indian conditions and for its manufacture on an equitable basis, and finally for its sale in Indian and international markets, to enable HAL Kanpur to earn revenue in foreign currency to offset the outgo involved in the purchase of some of the materials and equipment from foreign sources for building the aircraft.

While making the above suggestion, it is assumed that at the present juncture it would be unrealistic to develop this aircraft single-handedly as the effort and resources required may be considerable and the development time could be too long to suit the Vayudoot's plans. The major aim of the venture should be to build a design and development base and not so much the manufacturing base, as HAL Kanpur already has the essential production facility and would need only augmentation here and there to take care of new production techniques that would be required for fabrication of the next generation airliner. A strong drive must be launched immediately for assembling a competent design team at Kanpur if the HAL Management and the Government of India are serious in selling an Indian civil aircraft to civil airline operators in the country and abroad from HAL's production plant.

There will be a requirement of 250 designers and technicians besides dedicated prototype shops, test facilities and the necessary personnel to man them which could be another 250 persons. Investments in capital will be relatively modest but in trained manpower substantial. These investments will, however, result in a sound industrial base from which many generations of aircraft can be designed and built to satisfy future requirements of civil aviation for this class of aircraft. No better alternative comes to mind as many crores of rupees will be required to establish infrastructural facilities elsewhere, whereas these already exist to a very large extent at HAL Kanpur. Necessary design development build-up, drastic reduction in overheads and commercial orientation to the unit's operations could provide a part of the industrial base for civil aviation that is being sought after.

If, on the other hand, HAL decided to concentrate all aircraft design development activity at the Design Complex, Bangalore, this could perhaps be achieved by splitting the Design Complex into Combat Aircraft Design Bureau and Civil Aircraft Design Bureau much on the lines of Engine and Helicopter Design Bureaux which are separate entities headed by individual Chief Designers with their own budgets etc. This alternative could provide some relief to the infrastructure build-up in the initial stages as some of the prototype shop facilities and some trained manpower with the Design Complex in Bangalore may become available for civil aircraft development activity sooner. This may, however, have to be balanced against the disadvantage of having the design activity away from the manufacturing centre entailing additional effort of translating prototype designs into production; also, additional time and cost on logistics which can be extremely tiresome if not handled properly. From the long term point of view, a Civil Aircraft Design Bureau sited alongside the production agency may be better.

Turning to the other two requirements i.e., ab initio trainer and the 8-10 seat mixed role transport aircraft, these two do provide programmes which could be structured in the Corporate sector. A simple trainer aircraft meant to replace the age-old Pushpak can be developed by an R&D institution such as the National Aeronautical Laboratory. However, a production agency willing to interface with the NAL at the prototype stage itself is necessary for taking up activities related to the technology absorption and to the production and marketing of the aircraft. This is a low risk, low budget programme requiring rudimentary infrastructure which should be well within the capacity of an entrepreneur who is enthusiastic enough to enter the aviation field. Many variants of the trainer could be developed for other applications such as remote sensing, surveillance, communications, flight research etc. The entrepreneur ought to have a small design development nucleus along with a compact skilled production team for this purpose. If suitably priced, the aircraft would sell in the international market also. A large production run, running into hundreds, can be envisaged for the domestic market alone, as besides the Flying Clubs there are the Air Wings of the NCC scattered all over the country which would be requiring such an aircraft to impart instruction to the coming generations of cadets. As mentioned earlier, the greatest challenge to the scientist, designer and the producer would lie in the unit cost of the aircraft which must be very low and that too without affecting the quality or reliability of the aircraft. Imaginative design and innovative production techniques would be needed to achieve this objective.

The 8-10 seat multi-role transport aircrafat envisaged for the fourth level airline network and for the community aerial service is considered as the aircraft which would provide the essential framework of the industrial base with which to shap the indigenous capability in civil aviation. This class of aircraft requires the basic simplicity of design but also demands a high standard of technology without which this aircraft, deemed to be the backbone of civil aviation, would not capture the vast market that is awaiting it.

Even the USA, a country which has led the general aviation aircraft industry in the world, is having to reform this industry. Many of its aircraft are two generations old which were conceived and developed using technologies in aerodynamics, structures, materials and systems based on the scientific work that had gone on in various R&D institutions in that country a decade and a half earlier. This aspect is dealt with appropriately by Stengel in his paper "Time to re-invent the general aviation aircraft" /11/. Advanced concepts of the type have already started emerging from USA and Europe. Beech Aircraft's Starship, Avtek Corporation's AVTEK 400A, and Piaggio's Avanti are three examples that immediately come to mind. Piper, Cessna, Mooney, Swearingen, DeHavilland Canada, Shorts, Sia-Marchetti, Socata, and a host of other companies in USA and Europe would no doubt be busy in their design offices evolving new concepts using advanced technologies to join their forerunners in revolutionising the general aviation aircraft.

It is also clear that no foreign company will easily part with the technology recently assimilated by it on its newest aircraft. Furthermore, a new product has to be with an operator for some time before his fleet experience with it can be fed back to the manufacturer for making necessary improvements. Approximately, a span of five years would elapse before a licensee could hope to venture building a new generation aircraft. On the other hand, there are a number of successful joint ventures of aircraft companies wherein they have collaborated from the design development stage through to the series manufacture. In such joint development ventures, risks and costs have been shared and so the profitability. Experience has also shown that a partnership among equals has a better chance of success because each company tries to bring to the partnership its very best in design and technology and stimulates healthy rivalry for achieving higher goals.

In the Indian case, no doubt many foreign companies would be very willing to offer a licence for their somewhat older generation 8-10 seat aircraft and for all practical purposes such aircraft could have a useful operational life in India's airline network and generate profit for the company which would assemble and manufacture this aircraft and for the operator, who would operate the service with it. Such a licence, if put to use sensibly, could no doubt provide a suitable production base for future generation aircraft also. But unfortunately, past experience has shown that if deliberate steps were not taken for developing an indigenous aircraft at the beginning itself, the "licence culture" would come to stay with the agency permanently and bring in technological obsolescence, spelling doom to the company's natural growth which could only be sustained through its own product development albeit incorporating newer technologies from various institutions in the country and abroad.

Knowing that the capital and manpower investment is substantial while the programme gestation periods relatively long and profits not available immediately, only a private industrialist of considerable means and financial stamina could be expected to undertake this business. A project of this nature would require an outlay of Rs.15-20 crores for development and an equivalent outlay for production activity. Even if a private industrialist were to come forward, he would only be tempted to enter the aviation sector provided he had an order book, an aircraft of proven credentials, and the backing of the Government and the financial institutions to commercialise it. It would therefore be unrealistic to expect him to underwrite any development activity which might add to his financial liability and to endanger his company's industrial and economic viability. In these circumstances, it might be more reasonable for the private industrialist to undertake this venture in partnership with Government/Government-backed institutions. In other words, this component of the civil aviation industry could well be created in the joint sector.

The suggested approach could bring together the commercial and marketing expertise of the private sector, the resource mobilisation capability of the Government institutions/public undertakings, and the scientific and technical capability of the R&D laboratories. Although there cannot be a guarantee that involvement of the Government and R&D institutions right from the inception would never let this company degenerate into a licence-run organisation, however, given the right environment and vigorous infusion of local design and scientific inputs, even a licence-established company could be imparted the necessary momentum and made to thrive on the vitality of an indigenously designed aircraft.

It is also to be noted that directly or indirectly the Government will always be involved with aircraft business in the country either for regulatory and certification purposes or for providing operational facilities such as runways, communications, and navigational aids etc. Moreover, even before this vital segment of civil aviation industry could be set up in the joint sector, both the private industrialist and the Government would have to discuss in detail the several aspects mentioned above. The company could be so structured that high calibre professionals from the technical, manufacturing, financial and marketing disciplines constituted the Board of Directors which would then direct the company's operations on well-defined goals, one amongst which would be developing an aircraft to generate national wealth and ensure reasonable profitability so that the company is able to make greater investments to maximise use of home-grown technologies and concepts.

10 OPERATING AGENCY

This paper will be somewhat incomplete if some consideration is not given to the operational side of the venture. In this connection, reference may be made to an earlier observation that experience with the third level airline operations over the last five years has shown a phenomenal annual growth in traffic. If now within this framework is also encompassed the fourth level airline service such as airtaxi, group charter, executive and VIP travel, as well as the newly perceived community aerial service, the volume and the heterogeneity of the business that such an airline will have to cope with in the future would be too great a burden for a single agency. For this reason it is better if the Vayudoot is identified more with the genuine third level airline network. It would also seem logical to strengthen the Vayudoot by extending its operations step by step to medium haul air transportation (divesting the Indian Airlines of this somewhat nonlucrative business; its overheads being excessive for such operations). This could be achieved through the use of a 30-50 seat capacity cruise-efficient commuter airliner.

Assuming that this course of action would be acceptable to the Government of India, the question still remains as to whether the fourth level airline service and the community aerial service could be combined and run by one agency. Do the two have anything common between them as one is clearly dominated by profitability and convenience for some, and the other is need-dominated, serving many but perhaps under grants and subsidies from the Centre, State, Welfare Institutions, Charitable Trusts and Endowments etc?

In spite of the above facts, there is a case why a serious attempt should be made to run the two together. For instance, the two services could operate the same aircraft (though fitted differently), management of which by a single overall agency would be more economical and easier than two separate organisations. The aircraft utilisation would be higher and periodic slack of one could be compensated by the pull of the other. The Agency could have East, West, North, South and Central Zone operators who would be called upon to serve a group of States forming a contiguous harmonious block. Each zonal operator could have two constituents, one handling the fourth level airline network and the other the community aerial service. The aircraft assets could be held in a common pool but accounting could be separated. Even some of the overheads in running the community aerial service could be absorbed by the profit-making fourth level airline service which, it is expected, would be worked at high load factors and could draw upon the aircraft pool when there was less demand by the community service. The fact that the fleet is pooled could result in some reduction in number of aircraft and spares held on the inventory. Maintenance and ground services would also cost less and service schedules could be suitably planned, and aircraft so rotated that time on ground was minimised and operational utilisation optimised.

It is fully appreciated that aircraft holdings would vary from zone to zone depending upon the territorial coverage and the extent of service rendered to the community at large. But for planning purposes, 12 aircraft for each zone could be taken as the starting point (4 helicopters additionally for each zone could provide service where fixed wing aircraft are unable to operate).

At present many States, private and public institutions are known to operate their own aircraft. Once the fourth level ai service comes into operation, it would be advisable t standardise on one aircraft countrywide. It should be mad mandatory for all these users to indent for their air travel onl on the zonal operators of the new Airline Agency. It is almos certain that if each institution operated its own aircraft i would be spending much more than if it were served by a wel structured professionally manned airline network which could do this with greater flexibility and with lesser staff. Executive and VIP travel would also be much smoother and timely as service could be rendered through better aircraft holdings and minimum grounding of aircraft.

It is estimated that each zonal operator would require approximately 24 aircraft to serve the network, assuming that the methodology suggested would be acceptable to the States and all the other agencies. This way, a fleet of 36 aircraft held by each zonal operator could mean a total strength of 180 aircraft. Making allowance for maintenance spares, premature withdrawals and other contingencies, an overall requirement for about 250 aircraft could be assumed for planning purposes. This is a significant number and provides the necessary rationale for establishing an industrial base for civil aviation. It also provides sufficient motivation for developing a single aircraft to cover the two requirements. The aircraft could have the same airframe, powerplant (engines could be derated to suit the performance requirements), and standard flying instruments, but dedicated aircraft could be fitted with equipment and services suitable for the assigned role. The zonal operators could be responsible to a duly constituted Airlines Board which would administer the two services together. It would be desirable if the community service wing of the airline had at its head a person well versed in social welfare matters, had access to State Health Services, rural welfare departments, forests and agricultural departments, voluntary and charitable organisations, police and border security agencies etc, for coordinating user requirements with the operating staff. A feedback system in the set up should be useful for providing practical information on operations in the field. An organisational structure for this Agency is suggested in Figure 5. The beneficiaries of Fourth Level Airline and Community Aerial Service are shown in Figure 6. It would be desirable to have this Agency also in the joint sector. The Agency could then be steered by men and women experienced in both the sectors. Spirit of service and motivation to achieve something worthwhile in an uncharted field could be crucial to the success of the enterprise.

An alternative to the above was also considered. Would it not be more economical and effective if the Operating Agency were to be the front-end organisation of the industry itself? The industry would design, manufacture and operate its own aircraft. It would also maintain them from its manufacturing base, avoiding expense on separate storage and supporting staff etc. This proposition had certain attractions but it was felt that it would distract the industry from its primary goal of developing and manufacturing the aircraft, a complex business in itself. It is also believed that running an airline has its own work ethics and service efficiency should not be compromised through diffused management.

11 MANUFACTURING BASE AND ASSOCIATED ECONOMICS

Earlier on it was stated that the three programmes could be attempted in three separate ways. Firstly, the 30-50 seat medium haul airliner could be developed and manufactured by HAL in collaboration with an international partner. The aircraft in this category could cost between 5m-7m US dollars depending upon the seat capacity, performance and systems specification. On the basis of broad estimates it can be stated that investment of about Rs.30-40 crores would be required if development and manufacture of this aircraft is undertaken in collaboration with a foreign partner. As mentioned earlier, HAL Kanpur could be the agency for development and manufacture of this aircraft. A strong design and development base would need to be structured for it. Alternatively, development activity could be retained with the Design Complex, Bangalore, by establishing a Civil Aircraft Design Bureau there. Here again, a substantial induction of design personnel would be necessary as perhaps only a few experienced designers could be spared from the combat aircraft and other programmes. Investments made at Kanpur and Bangalore would eventually enable this public company to develop aircraft in this category by itself should it decide in future to go alone.

Experience elsewhere shows that international collaboration in civil aviation programmes has much to recommend for itself. Not only can the development cost be shared but mustering of capable designers and development engineers (becoming more difficult day to day because of conflicting priorities on other programmes) can also be accomplished more easily and effectively through partnership. And of course market potential is also enhanced through collaboration. It may however be appreciated that international collaboration will be profitable only if a strong technological and manufacturing base existed in the company. It is very important therefore to start building a strong design and development organisation at HAL and establishing prototype development facilities suited to the future generation civil airliners.

Another factor in favour of international collaboration in civil aviation is the absence of secrecy which invariably surrounds the military programmes and makes collaboration virtually a conduit for discarded technology and a source of additional revenue to the more aeronautically advanced partner. In the civil aviation field, the dominant factor would be market accessibility and profitability, motivations unlikely to run counter to India's own interests provided due care was taken by the Indian aircraft industry of its own ambitions in this regard.

Secondly, the ab initio trainer can be developed by NAL in association with a small scale entrepreneur who would be willing to interface with NAL at the prototype development stage and later on productionise and market the aircraft. Expenditure on prototype development (assuming that the existing infrastructure and technology will be utilised by NAL at minimal cost to the project) is estimated at around Rs.50 lakhs. The above would cover the cost of two flying prototypes and various test components. It is also assumed that the fatigue life of the aircraft would be determined theoretically taking recourse to experiments only on some vulnerable items. Investment by the entrepreneur for productionising this aircraft can be around Rs.30-40 lakhs. Some additional expenditure on technical staff will also have to be incurred. This staff would carry out modifications and develop variants of the basic model besides coordinating with DGCA on airworthiness matters. It is assumed that access to existing runway would be available for flight testing the prototypes and subsequently for production testing from the airport owners at a nominal fee. The whole programme is estimated to cost just over Rs.1 crore. The selling price of the basic aircraft is targetted at Rs.2.5-3 lakhs.

Thirdly, the development and manufacture of 8-10 seat mixed role aircraft is proposed to be taken up by a company in the joint sector. As pointed out earlier, this was considered more appropriate as the level of investment required to cover indigenous development of a future generation aircraft in parallel with the manufacture of a foreign aircraft under licence may well inhibit a private company from establishing an industrial base at which indigenous designs could be developed. A private industrialist would be inclined to pursue licence-based manufacture indefinitely as it would be safer for him to do so. In the longer term it would be detrimental to the growth of the company as no new project would emerge. In this context it is also necessary to formulate economic policies such that the industrialist is forced to take advantage of indigenous manufacture.

A company in the joint sector, having participation from R&D laboratories and Government-backed institutions, will have a much better chance to develop and build its own aircraft. Since the ultimate objective is to quicken the pace of national development programmes, the company ought to build up its infrastructure in collaboration with agencies already in the field so that duplication of expensive test and development facilities is avoided and maximum use is made of the national facilities which have been installed over the years. For example, the NAL facility which is modern and extensive, would be very useful for the purpose. Similarly, availability of HAL facilities for the development programmes at this joint sector company could help reduce overall investment. However, enquiries will have to be made at the appropriate time whether HAL could spare its capacity from other defence programmes. In the beginning the company, adopting the classical model, could set out to develop expertise in assembling the aircraft from major assemblies and sub-assemblies bought out in various kit forms. The manufacturing agency will make use of interchangeability media for assembling fuselage, horizontal and vertical stabilisers, control surfaces etc.

The powerplant will be installed using proper jigs and fixtures and similarly the other components related to various aircraft systems. During this phase, the manufacturing agency will need to develop skills mainly in assembling the airframe parts and components and to integrate aircraft systems. Quality control and inspection practices associated with aircraft manufacture would need to be introduced right in the beginning by taking on qualified staff in the respective fields. Progressively as the trained manpower begins to master the details of assembly work, the company could carry out source survey and explore the possibility of getting parts made if such manufacturing facility was available elsewhere. A general survey made in the beginning will show whether engine, propeller, landing gear, avionic equipment and other accessories could be used from any of the other projects handled in the country. It is more than likely that many of these will have to be imported. However, a parallel exercise can be carried out whether some of these can even be developed/manufactured by HAL since it has licence arrangements with various international equipment manufacturers and may be in a position to broad base its product line.

It is estimated that manufacture of the 8-10 seat passenger aircraft will require an organisation of about 250-300 personnel supported by 20-30 design development and test engineering staff. This will need further augmentation when part manufacture is also taken up. It is felt that this organisation will also be capable of developing variants of the basic model for other roles that may be required by different customers. However, some additional 15-20 designers will be required to interface with various other institutions when development of indigenous design is taken up.

12 AIRCRAFT CHOICES AND PROJECT COST

In determining the economics of the project, a survey was carried out of the aircraft available in the international market, their prices and associated financial data /14, 15/. Examination of the published data indicates that Piper Cheyenne IA, II, Conquest I, Conquest II, Aero Commander and Beech 90 of the older generation and Beach Super King 200-300, Piper IIIA, Piper 400 LS, Cessna Citation II, Citation III of a later generation are some of the better known aircraft available in this category. Examination of the published data on aircraft prices given by Interavia from time to time indicated that the first cost of the later generation twin turboprop 8-10 seater pressurised aircraft ranged anywhere between $ 1.8-2.8m in th international market depending upon the seating capacity standard of equipment and performance. The turbofan powere Citation II and Citation III ranged from $ 3m to $ 5.5m. Th older generation aircraft such as the Cheyenne IA, Cheyenne II Conquest I, Conquest II, Aero Commander and the Beech 90 were al in the low price bracket costing between $ 1m-1.5m. Some of thes models offer seating capacity of about 6 passengers only.

The newer generation aircraft suchd as the Beech Starshi and Piaggio Avanti which have yet to come off the production lin and which have been designed using advanced concepts i aerodynamics, structures, propulsion, and are built fro composites in varying proportions, are reported to cost anywher between $3.7m-4.2m.

Taking a manufacturing licence for the older generation aircraft will not be desirable because of age, low technology, limited seating capacity and low performance. The new generation aircraft such as the Starship and Avanti are unlikely to be on offer for licence manufacture as these aircraft have yet to be entered into service and may take some time before they establish themselves. Also, it may not be profitable for the parent company to allow its manufacture under licence elsewhere in the world unless and until the company had acquired sufficient foothold in the market for the aircraft from its own production line.

Avtek 400A, which is also a new generation aircraft and is reported to carry 6-9 passengers, was priced at $ 1.7m (1985 price). By now this would have risen to $ 2.25-2.5m. The exact status of this aircraft is not known, presumably it has yet to reach production stage.

A business jet announced by Swearingen in late 1987 is yet another aircraft in this category. The company is quoted to be intent on setting a firm price under $ 2m equipped and claims it to be cheaper, faster and more economical than all existing jets and nearly all the turboprops, but it has yet to develop this aircraft. In contrast with other new generation aircraft, this aircraft is reported to be designed for maximum cruise speed of 450 knot and supposed to offer fuel economy comparable to the turboprops through the use of a high bypass ratio, light-weight turbofan engine under development at William International in USA. It is not known if this aircraft could accommodate more than six passengers as it is basically addressed to executives.

A broad assessment of some of these aircraft has shown that the project cost covering all stages of assembly could vary between Rs.10-15 crores depending upon such factors as the annual rate of production, scale of tooling, jigs and fixtures, land cost, and investments on buildings, plant and machinery. To a degree it is also dependent upon royalty and licence fee associated with the transfer of technology. Additional investments will be required to construct the aircraft from raw material, economic viability for which will depend upon the number of aircraft being built. It is estimated that a minimum of 150 aircraft will need to be built to justify an additional investment of about Rs.5-6 crores. The price of the aircraft built indigenously will further depend upon excise and other duties that may have to be paid to Government agencies. There will also be transhipment and insurance charges on imported materials, equipment, assemblies, kits of parts etc. It would be prudent to add approximately 25-30% to other costs when determining the sale price.

Even though Indian man-hour rate in the precision manufacturing industry is still 1/4th to 1/5th of that prevailing for similar industries in Europe and USA, much of the lower labour cost advantage gets eroded because of lower productivity in the Indian industry. This must be avoided at all costs when a new aircraft industry is being set up, otherwise such in-built inefficiencies could be pernicious.

In a licence-run programme the primary aim usually is to increase the indigenous content and reduce the outgo of foreign exchange. But, in doing so, care also has to be taken to maintain overall economic viability of the project. There are multiple costs in the project of this nature, each affecting the overall cost differently. A complex financial exercise is necessary to strike a reasonable balance between some of the conflicting considerations and to undertake such an exercise, fairly detailed information would be required from the licensor.

In the present circumstances, any company setting out to launch such a programme will be well advised to by and large restrict itself to airframe assembly, and powerplant and system integration work. Going into manufacture from raw materials will require a different set of tooling, machinery and equipment involving more money and time. Raw material manufacture is really justifiable when aircraft in large numbers are being manufactured so that additional costs can be amortised suitably. In the present case, there is a danger of obsolescence creeping in by the time the raw material manufacture is half-way. It would be better if additional investment required for this phase is saved and used in the development of next generation aircraft. As discussed earlier, in the long term a requirement of some 250 aircraft is visualised for this class of aircraft; by maintaining an annual rate of production of say 10 aircraft, the company could deliver 60 aircraft in the course of six years. Meanwhile, in parallel with the assembly and integration work, development activity on the next generation aircraft is started then with good planning, the new aircraft could receive service certification within five years from go-ahead. A new production line could then be established to construct the remaining 190 aircraft. The annual production rate could be stepped up to 2/3 aircraft per month to suit the operating agency's requirements.

Anticipating that the above suggestions would be acceptable and that the company would be willing to go ahead with the development of a future generation aircraft, a preliminary design concept is presented in Figure 7. The aircraft is powered by two contemporary 800-850 shp turboprob engines with 6-bladed counter-rotating propellers of 5-6 ft (1.5-1.6 m) diameter. (Both Pratt & Whitney and Garrett engines were considered) The aircraft is pressurised and air-conditioned. It has a maximum take-off weight of 11,000-12,000 lbs (5,000-5,500 kg). It is designed with a wing loading of 40 lbs per sq ft (200 kg per sq m) and power loading of 6.5 lbs/shp (2.23 kg/kw).

A detailed study of many existing aerodromes (Figure 8) was carried out before deciding on the take-off and landing distance of 2000 ft (610 m) /15/. With braking propellers the landing distance could be reduced to about 1200 ft (~364 m). The study revealed that there are some places like Baripada in Orissa, Buxar in Bihar, Behrampur in West Bengal, Bakshiwala in Punjab, Falna in Rajasthan, where there are aerodromes of runway length varying between 1500-1700 ft (460-520 m). Operations from such shorter length runways would have to be carried out at reduced take-off weight.

The power loading was optimised for high ambient conditions and hilly terrains, but most engines on offer have facility for flat rating and derating; the final rating could therefore be arrived at later when more detailed design evaluation is made.

Right from the start the design concept makes use of natural laminarisation flow. Therefore, design and manufacture of the airframe have to go hand in hand for achieving this objective. Use of composite materials and adoption of large seamless panels is a built-in design feature which would help achieve this objective besides producing lighter structure. The above is based on the assumption that the aeronautical institutions in the country would have mastered the technology of composite material structures through other national programmes by the time this aircraft is launched. Through this technology, many design aims can be met more easily and at lesser cost.

Metal structure, on the other hand, though more familiar has the drawback of greater capital and tooling cost, and also employment of more labour. For instance, to achieve smoothness of contours on metallic structure, one would have to adopt super plastic forming and integral skin milling etc. In the latter case, there is a higher material waste.

The design concept embodies cruise efficient wing profile and high lift devices to help reduce DOC and enhance STOL capability. The fuselage is shaped to minimise drag.

The pusher propeller configuration and powerplant location is chosen so as not to affect the air flow over the wing, and also to keep the noise and vibration away from the cabin. The powerplant is located at the middle of the rear fuselage to provide good ground clearance and to reduce hits from debris. Care is also taken to minimise possible interference between the fuselage and propeller air flows.

The "T" tail is chosen to give good aircraft handling over the complete flight regime but particularly near stalling conditions. Horizontal tail position as sited on the fin is also expected to cause less sound reflection.

The aircraft is sized to provide optimum cabin dimensions for the combined passenger and cargo roles. High standard of passenger comfort is achieved by adopting cabin width and height of 6 ft (1.82 m) which is usually associated with a medium haul airliner. As the new aircraft is likely to find many operational uses, care is also taken at the conceptual stage itself to build in a reasonable stretch potential. The two baggage sections one in front and one in the rear of the fuselage are located within the pressurised zone. The cabin height is maintained almost constant along the greater length of the fuselage. The rear baggage section could be suitably modified to accommodate more seats, if required. In a denser layout of the stretched version, the aircraft would be able to carry 14-15 passengers. In the normal airtaxi layout, ten passengers can be accommodated with comfort, higher than that offered by any contemporary aircraft in this class. A luxurious 6-passenger layout is offered in the executive role version. The cabin length of 7 m provides excellent accommodation for health personnel besides patients on stretchers etc. There is sufficient room in the cabin for installing consoles, cameras, and special equipment for various air missions.

The aerodynamic configuration conceived when coupled with two 800-850 shp engines is capable of achieving maximum cruise speed of about 700 km/hr which is considered competitive with aircraft in this class being developed elsewhere in the world. Since lower cruise speeds would be acceptable for the community aerial service aircraft, the engines could be derated to suit the actual requirements. The aircraft can operage over stage lengths up to 1000 km cruising between 25,000-36,000 ft (7.6-11.0 km) height band, though design cruising height is taken to be 25,000 ft (7.6 km) over shorter stage lengths. The Community Aerial Service could operate the aircraft even at lower altitudes when the stage length was between 150-300 km. A somewhat higher fuel consumption at lower cruising altitudes can easily be offset by operating at lower speeds with negligible effect on block time. The aircraft is conceived for easy manufacture and maintenance in the field.

Insofar as prototype development is concerned, the work could be undertaken using many off-the-shelf items. For example, the landing gear, the hydraulic components, the flight instrument panel, wheels and brakes etc used on the aircraft that might be assembled by the company initially could be adapted to the prototype aircraft. Even an engine of lower power rating such as Garrett 331-5 used on the Do-228 and under manufacture at HAL could be tried on one of the prototypes for proving the airframe and for evaluating handling and stability characteristics of the aircraft. Barring the final performance, most of the other design parameters could be determined with reasonable confidence following this approach.

The propeller configuration being unorthodox, it would be necessary to study right at the beginning various options available by inviting proposals from the propeller companies.

Based on past experience on other development programmes and using extrapolations, it is estimated that a team of about 100 designers and technicians, and an equal number in the prototype shops could complete the development work in about 4-1/2 to 5 years. Two flying prototypes and one full-scale test specimen would be required to obtain type certification. Mock-up study would be conducted mainly for cabin layouts. A budget of Rs.20 crores would be necessary during the development phase. Cost of productionising would be separate. This could be estimated after deciding on the quantum of production that the company would carry out in its plant and what could be subcontracted out to other manufacturing agencies in the country. Even then, basic manufacturing infrastructure particularly for airframe manufacture, integration of the powerplant and the aircraft systems and for final production flights will have to be established at the company's premises. This would require an outlay of about Rs.10-15 crores. Such infrastructure should be adequate later on for developing variants of the basic model.

Even though establishment of some prototype development facilities is inescapable, several development test facilities already in existence at other national institutions are not to be reproduced. This would be one of the many benefits that are to accrue from setting up a company in the joint sector.

To summarise, it is estimated that the company may need an investment of Rs.10-15 crores for establishing an assembly line another Rs.20 crores to develop a new generation aircraft followed by a production investment of about Rs.10-15 crores, totalling Rs.40-50 crores. A sound base could be laid through this level of investment. Several variants of the basic model and its successor aircraft could then be developed from this base for the domestic and international civil aircraft market.

Concerning the economics of the indigendous programme, a year ago the price of the top of the line Starship and Avanti was quoted at $ 3.7m and $ 3.4m respectively. These prices were subject to revision. In all probability these have now risen to $ 4m and $ 3.7m. In a $ 4m priced aircraft the cost of powerplant standard equipment, accessories, raw materials etc would be around $ 2.5m. Approximately $ 0.5m would account for the manufacturer's profit, agent's commission, distributorship fee marketing expenses etc leaving $ 1m towards labour cost. It is estimated that the aircraft made out of composites may require around 20,000 stabilised man-hours and an aircraft of all-metal construction 25,000 hours. This establishes man-hour rate of about $ 50. In India, the man-hour rate could vary from between $ 10-15. Manufacture in India could therefore result in a cost advantage of about $ 0.75m. Allowing for some increase i stabilised man-hours in Indian condition, the net advantage could be $ 0.7m. It is imperative that this advantage is not allowed to be wiped out by increased material cost by way of excise duty, transhipment and insurance charges etc. Any net cost advantage must be fully exploited in securing export of this aircraft and to earn foreign exchange for offsetting some of the F.E. outgo for buying materials and components from abroad.

As Government of India is adopting a liberal policy towards export of engineering goods, it might be worthwhile to approach the Government for special incentives (other than duty drawback) that could promote export of Indian designed and developed aircraft and make it more competitive in the international market (appointments of agents abroad, product support infrastructure abroad, commissions to be paid in foreign exchange etc).

13 PROGRAMME INVESTMENT

Investment in the civil aviation sector till the turn of the century, according to some planners, is likely to be Rs.20,000, (in the present prices perhaps 25,000 crores) /4,7/. This planned estimate is to cover the cost of 45-50 aircraft for Air India, 155 aircraft of mixed classification for Indian Airlines, the cost towards land acquisition for airports and their construction, expenditure on navigation, communication and other ground facilities for existing and projected airports. Bulk of this will no doubt be spent on aircraft and equipment acquisition for Air India and Indian Airlines. One-eighth of this may be spent on the airport facilities. If a meagre 5% investment of about Rs.1250 crores is earmarked for Third Level, Fourth Level, Community Aerial Service and the Trainer aircraft, this could provide for the acquisition of about 75 aircraft for Vayudoot (at Rs.6 crores per aircraft) about 190 for Fourth Level and Community Aerial Service (at Rs.3.5 crores per aircraft) and 150-200 Trainers (at Rs.3 lakhs per aircraft), as well as cover the development and production launching cost (Rs.130 crores) on the abovementioned aircraft. Such an investment will not only generate revenue in excess of Rs.1,000 crores over a period of ten years but will also provide direct employment to about 800 people besides creating indirect employment for several thousands for running the airlines, community aerial services, Flying Clubs, tourist agencies, hotel industry, travel and other linked agencies.

14 CIVIL AVIATION PROGRAMME POLICY

The air transportation system is expected to grow enormously if it has to keep pace with the economic growth of the country. Present indications as projected in the Eighth Five Year Plan are that the country may aim at achieving at least 5.5% annual growth rate and this may even be stepped up to 7% if higher national savings could be generated. With this type of economic growth, industrial and trading activity will grow. Domestic and international traffic will also grow, requiring a well coordinated civil aviation policy. A chart is made as to how the civil aviation programmes could be organised so as to create a healthy indigenous base for civil aeronautics. This is presented in Figure 9. It may be seen that even though a large number of civil aircraft are planned to be imported, nevertheless a sizeable number are to be developed and produced indigenously and an equally large number through joint production and co-production with international partner(s). The development and production may take place in the Public/Private Sector by receiving the necessary technical inputs from aeronautical institutions already in existence in the country.

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Fig 1: STOL Transport Aircraft for Civil and Military use.

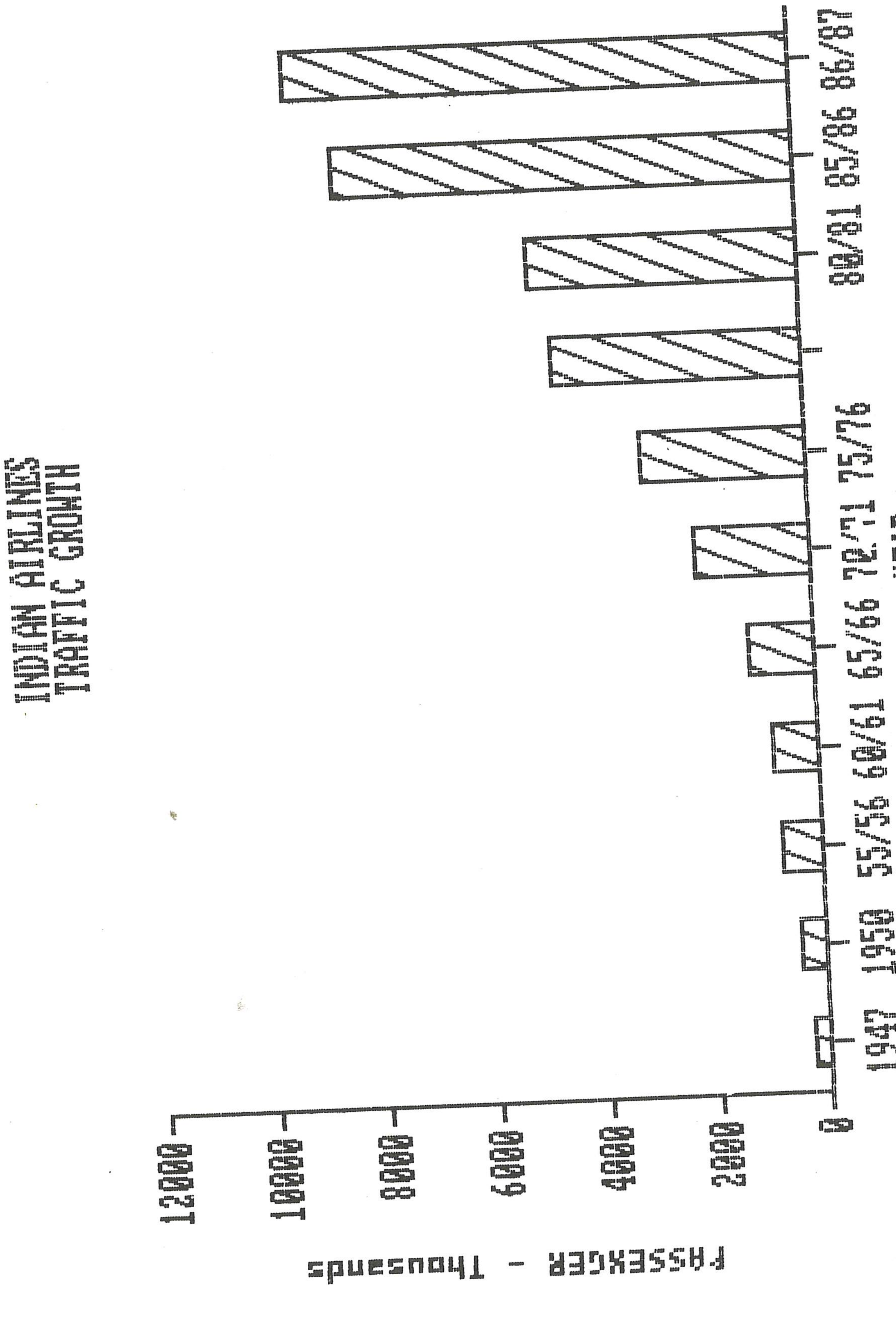


Fig 2: Indian Airlines - Traffic Growth.

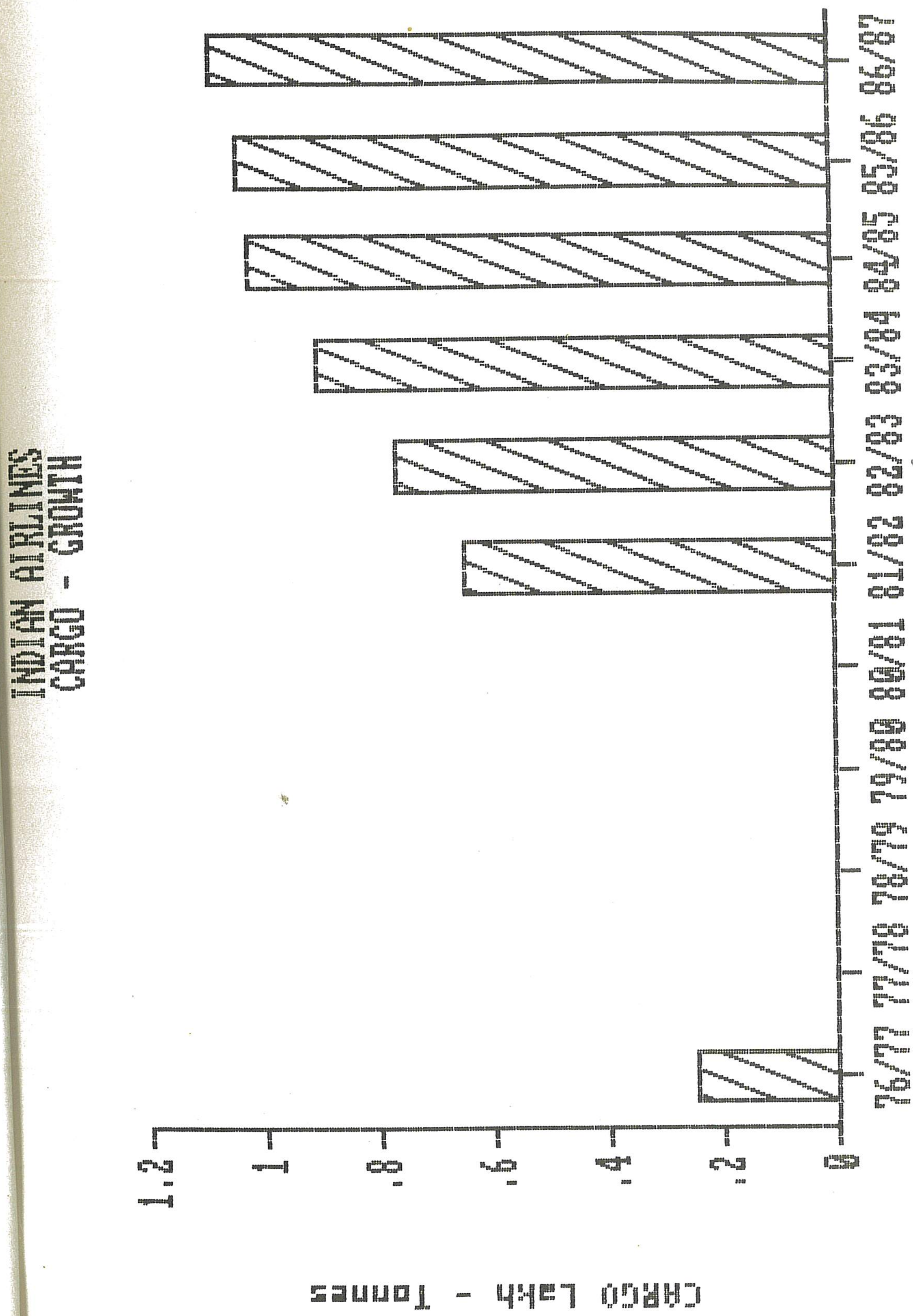


Fig 3: Indian Airlines - Cargo Growth.

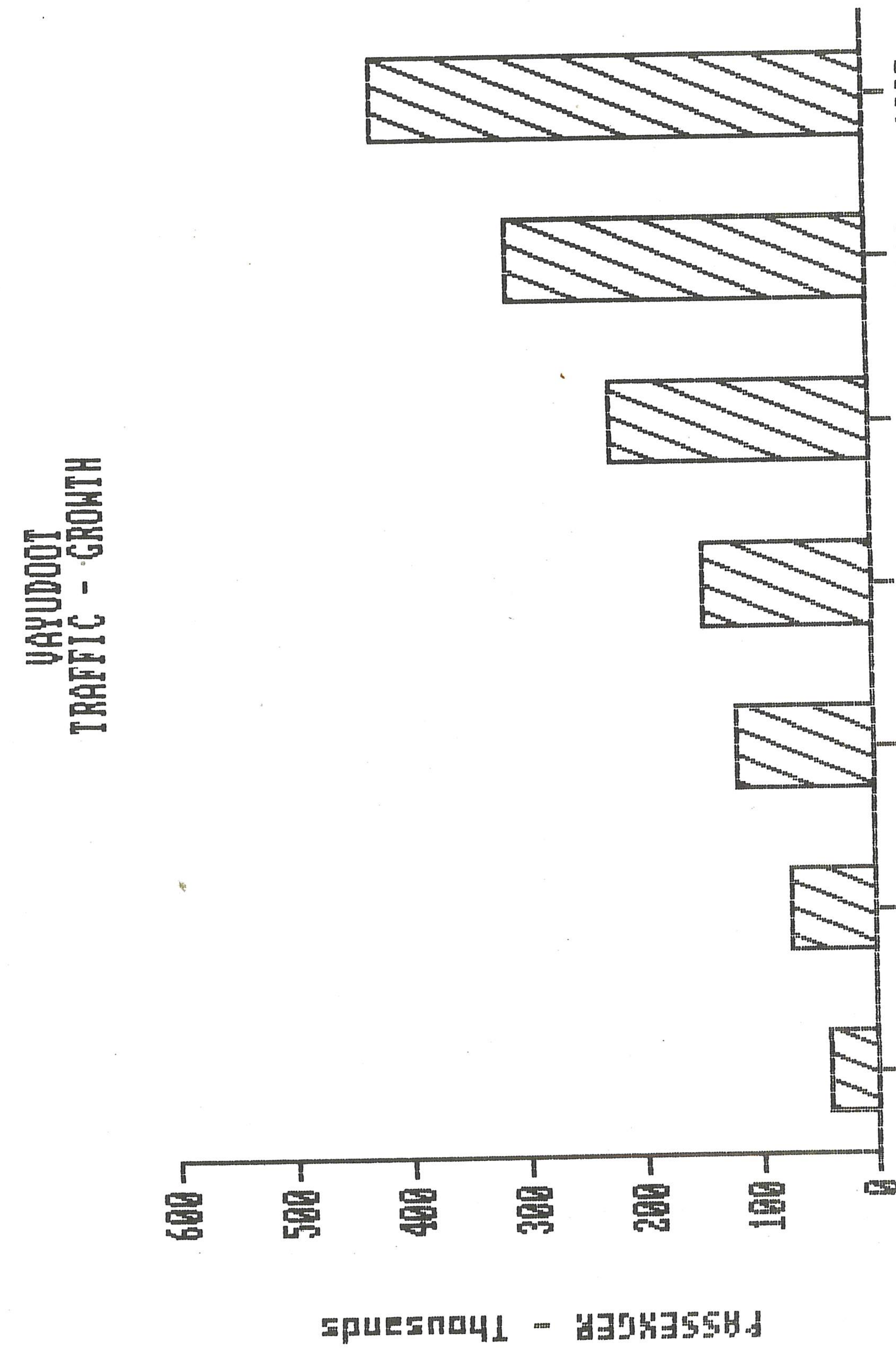


Fig 4: Vayudoot - Traffic Growth.

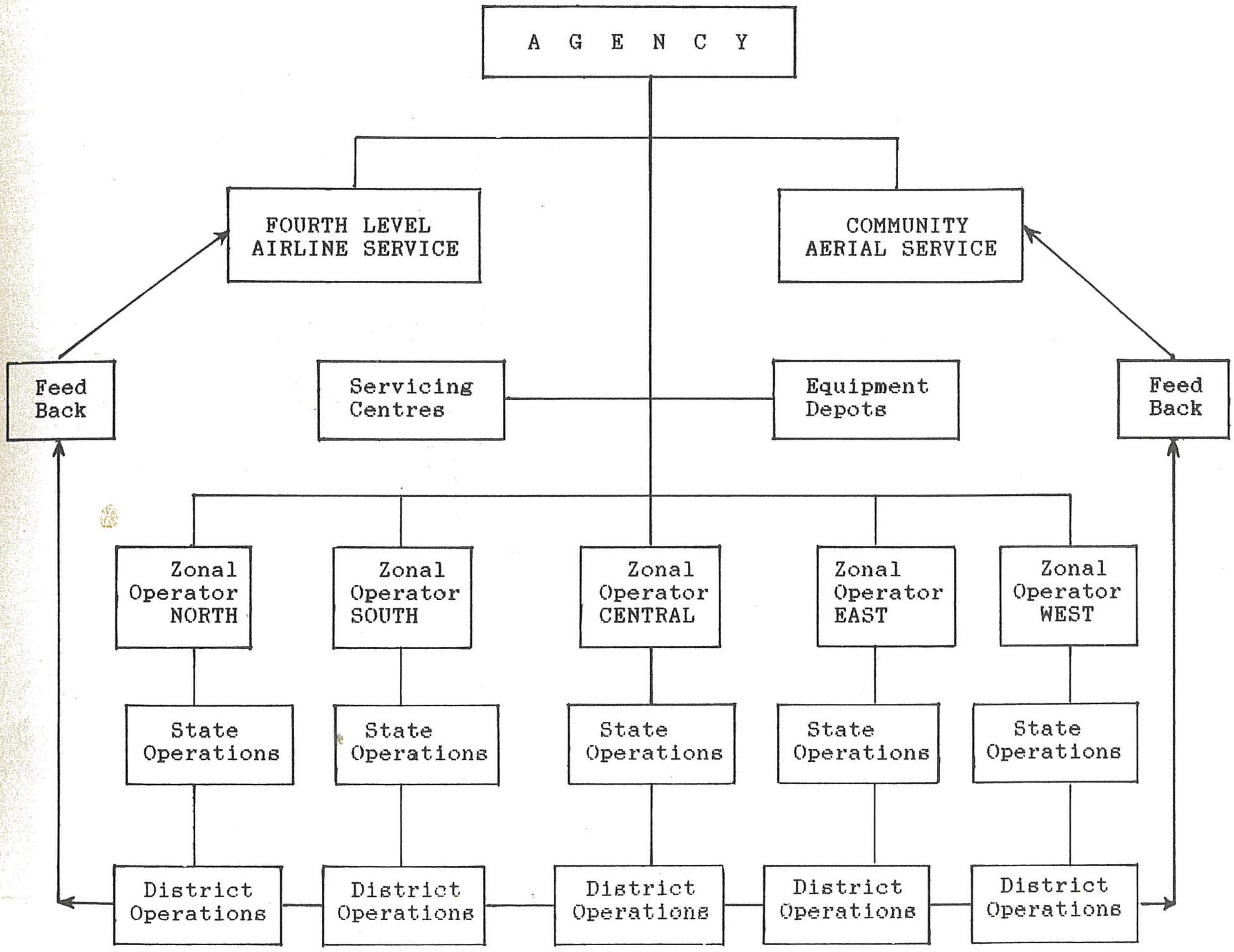


Fig 5: Suggested Organisation for Fourth Level Airlines and Community Aerial Service.

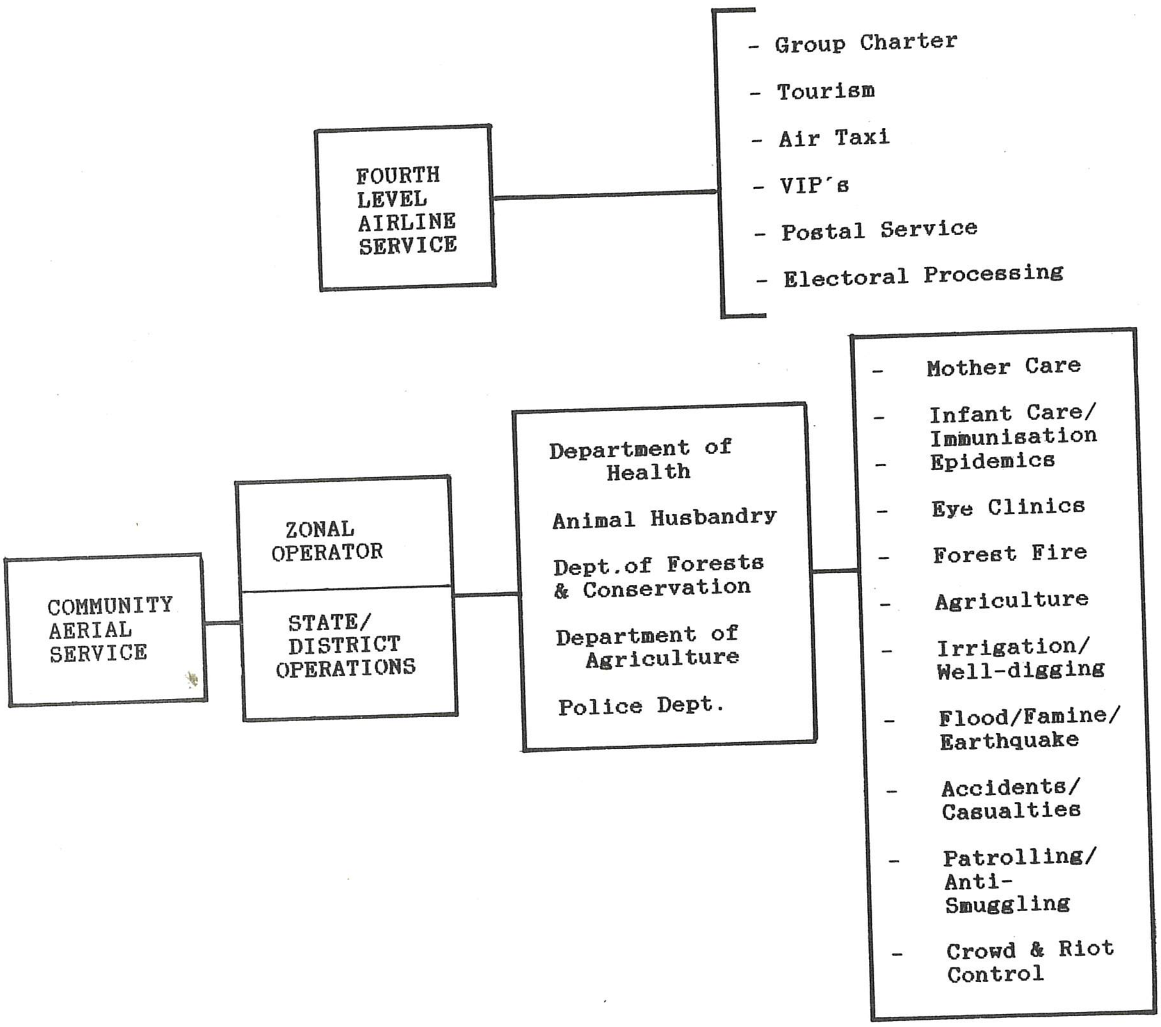
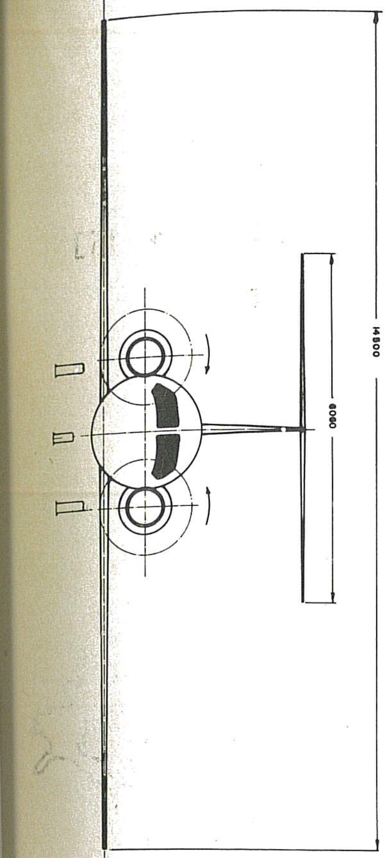


Fig 6: Beneficiaries of Fourth Level Airline and Community Aerial Service.



Overall length	:	48.00 ft (11.5 m)
Overall height	:	14.76 ft (4.5 m)
Fuselage length	:	42.00 ft (12.7 m)
Cabin Width	:	6.00 ft (1.82 m)
Cabin Height	:	6.00 ft (1.82 m)
Wing Span	:	48.00 ft (14.5 m)
Wing Aspect Ratio	:	8.50 ft (2.57 m)
Wing Area	:	275 ft^2 2.51 m^2
Wing Taper Ratio	:	0.30 ft

Horizontal Stabilier Area	:	60 ft^2	5.5 m^2
Horizontal Stabiliser Span	:	20 ft	6.0 m
Horizontal Stabiliser Chord	:	3 ft	0.91 m
Vertical Stabiliser Area	:	55 ft^2	5.05 m^2
Vertical Stabiliser Height	:	8.5 ft	2.75 m
Vertical Stabiliser Chord	:	6.04 ft	1.84 m

Propellors Counter Rotating	:	6 Bladed, 5-6 ft dia Props
Maximum take-off weight(Approx.)	:	5000-5500 kg (11000-12000 lbs)
Wing Loading	:	40 lb/ft^2
Power Loading	:	6.5 lb/SHP
Take-off and landing distance	:	2000 ft (610 m)
Landing distance with braking Propellers	:	1200 ft (363 m)
Cruise Altitudes	:	25000-36000 ft
Maximum Cruise Speed	:	700 km/hr

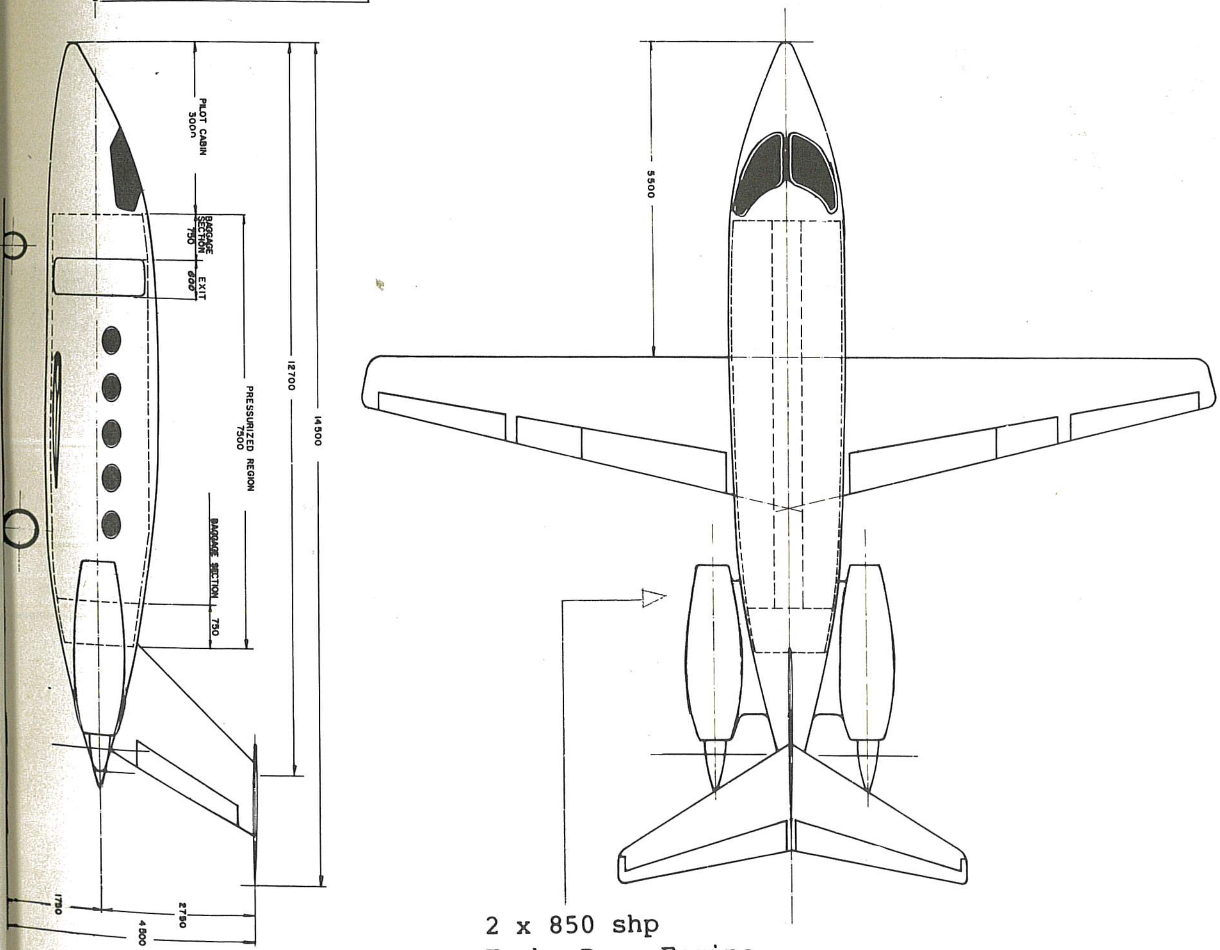


Fig 7: Aircraft concept for Fourth Level Airline and Community Aerial Service.

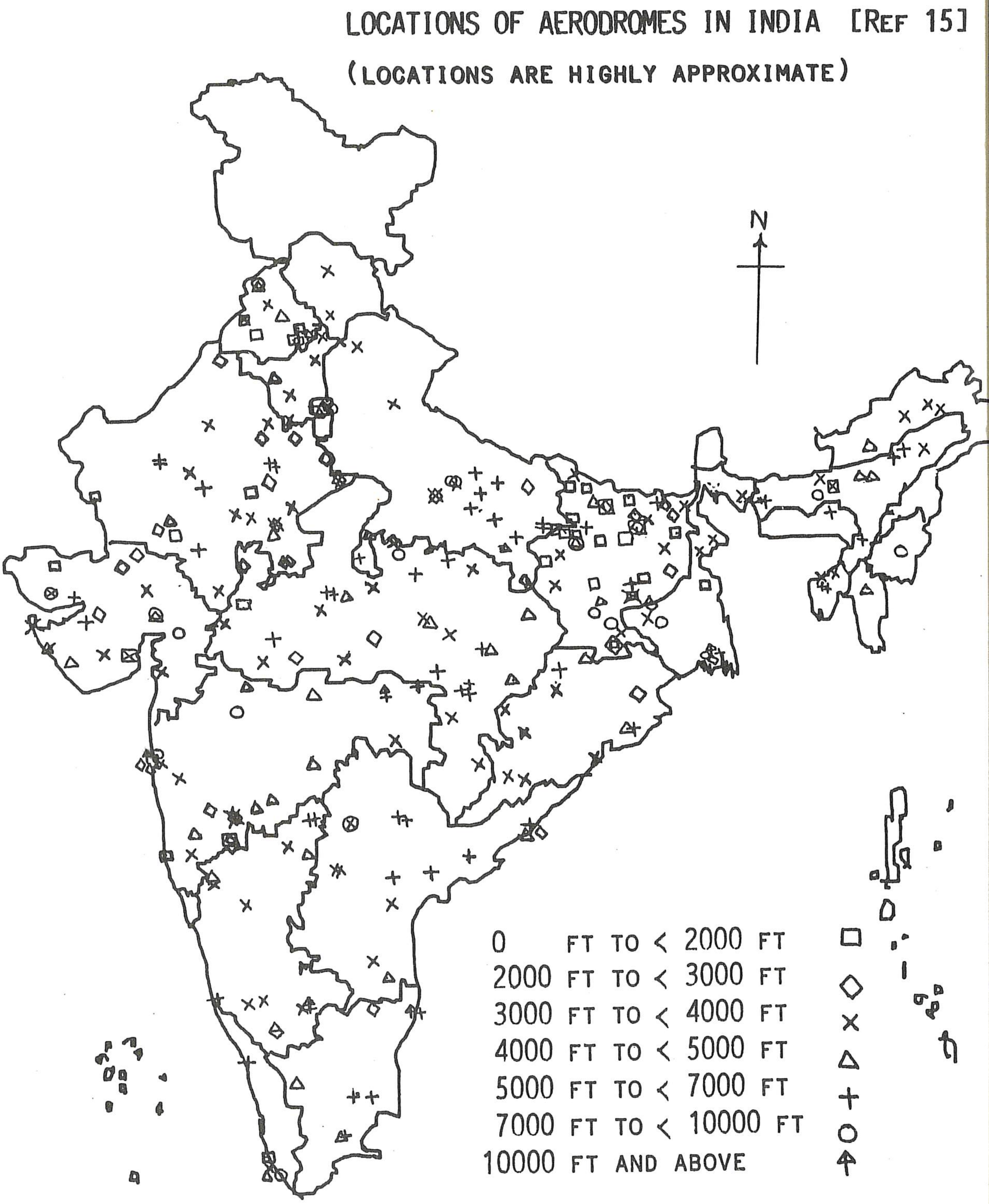


Fig 8: Aerodromes Map of India.

AIRCRAFT TYPE	Twin Seat Trainer/ Mission Oriented Light Aircraft	8/10 Seat Mixed Role Passenger Aircraft	Short to Medium Haul 30/50 Seat Airliner	100 Seat Commuter Aircraft	Wide-bodied 150/300 and 300/500 Seat Airliner
USER AGENCIES	Flying Clubs, NCC Air Wings	Fourth Level Airline Community Aerial Service	Third Level Airline- Vayudoot	Indian Airlines, Vayudoot	Indian Airlines, Air India
MODE OF ACQUISI-TION	Indigenous Design, Development & Production	Indigenous Design, Development & Production	Joint Development with Inter-national Collabora-tion Co-production domestic and abroad	Part Development Part Co-production in Collabo-ration with Inter-national Partner. Final Assembly Domestic and abroad	Mainly import. Small per cent of Parts, Components & Assemblies Selectively by Domestic Industrial under-taking for Global Market
WHERE TO DEVELOP & MANUFAC-TURE	NAL-Private Small Scale Entrepreneur	NAL-Private Large Industrial House.	HAL, NAL and Inter-national Collabora-tor. Manufacture at HAL/Large Private Industrial House	Inter-national Collabora-tor, HAL & NAL. Co-Produc-tion HAL, & Inter-national Collabora-tor. Final Assembly at HAL for Domestic/ Export	Production of Selected Components at HAL for Global Market.
SALE POTENTIAL	Domestic-200 Export-100	Domestic-200/250 Export-50/75	Domestic-100 Export-50	Domestic-50 Export-	Air India-50 Indian Airlines-170 Global Market: Components for 500/600 Aircraft

Fig 9: Civil Aviation Programme Policy.

Sheet classification :Unrestricted

National Aeronautical Laboratory	Documentation Sheet	Document Classification Unrestricted
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Abstract :

The paper gives a historical perspective of civil aviation in India and highlights the transport needs of third and fourth level airline services.

The paper projects the concept of a community aerial service to cover health service (including controlling epidemics and carrying out eye clinics, and immunisation campaigns), relief operations during floods, famines and other natural calamities, agricultural, forestry, animal husbandry, policing and patrolling functions, and transport of perishable and critical goods etc.

The paper suggests building an industrial base in India around three programmes; a 30-50 medium haul airliner, an 8-10 seat mixed role small passenger aircraft, and a twin seat ab initio trainer. Each aircraft programme is identified with a particular type of development and manufacturing agency to minimise financial and manpower investments.

Suggestion is made that requirements of fourth level airlines and community aerial service may be combined and a single basic aircraft model developed. A technical specification is drawn and the design concept of a single 8-10 seat aircraft combining the two requirements is offered for detailed feasibility study. It is proposed that this aircraft be operated by a new agency which will run an operational network on zonal basis, combining requirements of various States and Union territories in the country. The study excludes such issues as offsets for large aircraft, airport services, ground equipment etc.

Economics of the programmes are discussed and a broad estimate of investment is indicated. A fraction of the overall investment on civil aviation in the coming decade is shown to be adequate to launch programmes which would satisfy requirements of certain segments of civil aviation and also provide a sound base for the emergence of a civil aviation industry in India.