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Air Transport for Emerging Countries

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Introduction

TODAY passengers, investors, and operators evaluate air transport in many complex ways. Cargo airline systems have equally well-defined measures of adequate performance. These measures of performance may not be the proper clues to the creation of new air transport systems for emerging nations.

Transportation services may be the most important and most visible element of advanced communities that new nations will attempt to assimilate. To varying degrees, each of these nations consists of a primitive countryside with rivers. Few of them have level ground, some have impenetrable jungles, and many have resources that they and the rest of the world need. These nations should have a chance to use their resources, and to move into the 20th century as fast as they can and want to. It is difficult to realize, but almost 90% of the people in this world have never flown—approximately 3.6 billion potential new passengers.

We who live in the "developed" world must realize that the emerging countries live in an environment we have never experienced and, perhaps, do not understand as well as we should. They can see the complete new world, and it is working reasonably well. Should they experiment with canals, railroads, carve roads through jungles, mountains and deserts, when it is obvious that they can fly? This is a logical, importunate question and its answer is a challenge to us all.

We can help these nations write their requirements, we can estimate what a more remote tomorrow may imply for them, and we can help them to recognize how mature systems, i.e., roads, railroads, and airlines, might fit their future needs.

This paper proposes to discuss the political and economic environment within which a transportation need exists, how it may affect any approach to fulfill the need, and to share some conjectures concerning programs that might be initiated by the aerospace community of the developed nations.

Broad Look at the Economic World

Figures 1-6 show the results of a worldwide economic study with alternate prognostications for the future.[1] Note that the "Industrial" category is in the middle of each scale, topped by the "Mass Consumption" and "Post-Industrial" groupings.[2] Thus, the Industrial category separates the fully developed nations, which we recognize today, from the emerging nations. It is obvious from looking at the patterns for various geographical divisions of the world that the U.S., the Soviets, the Japanese, and many European nations have moved into and beyond the Industrial economic zone.

Figures 1-6 illustrate the broad expanse of the economic difference among the several economic groups of nations. In this environment, there are two obvious pressures that drive a new nation's transportation policy: 1) a desire to compete with other nations in the international arena; and 2) the necessity to acquire internationally acceptable income in order to purchase what the emerging nation needs, or feels it needs, from the outside world. Thus, we see the creation of extensive international airports and facilities and the purchase of advanced air transports. These "instant" airlines are then made useful by infusion of imported talent until those who are inclined can be trained to take over the complex operations of an international airline. This process has happened worldwide and, thanks to the knowledge of those who were imported for the task, we have a proliferation of international airlines. These airlines, except when local political barriers are raised, serve communities worldwide in competition with more mature operators, and they do it successfully. Table 1

Willis M. Hawkins, senior advisor to the Lockheed Corporation, fills this role after retiring as senior vice president-aircraft and director of the corporation. During his long Lockheed career, Hawkins has played a major role in design and development of airplanes, missile systems, and space vehicles and has had the managerial responsibility for extensive space and aircraft programs. Hired in 1937 as a junior detail engineering draftsman in Lockheed's engineering department in Burbank, California, Hawkins advanced through a number of key engineering positions, becoming engineering department manager in 1944 and chief preliminary design engineer in 1949. From 1953 to 1957 he was director of engineering at Lockheed Missiles & Space Division, and in 1959 was appointed assistant general manager of that division. He was elected a vice president of Lockheed Corporation in 1960. In 1961 Hawkins received the U.S. Navy Distinguished Public Service Medal for his contributions to the Polaris missile program. Before assuming duties as the corporation's vice president-science and engineering in 1962, he served for more than a year as vice president and general manager of the Lockheed Missiles & Space Company's Space Systems Division. Hawkins served as Assistant Secretary of the Army for Research and Development for nearly three years beginning in 1963. He received Distinguished Civilian Service Awards in 1965 and 1966 for his contributions to the Army's research and development programs in his direction of the U.S.-German main battle tank development. He returned to Lockheed in July 1966 to resume his duties as vice president-science and engineering. Hawkins was advanced to senior vice president-science and engineering of Lockheed Corporation in 1969, a position he held until 1974. He is a member of many professional societies, including Tau Beta Pi (honorary engineering society) and the National Academy of Engineering, and is a Fellow of both the American Institute of Aeronautics and Astronautics and the Royal Aeronautical Society.

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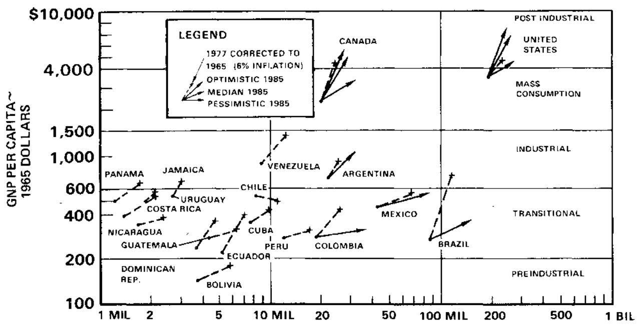

Fig. 1 GNP/capita vs population—Western Hemisphere (1965-1985).

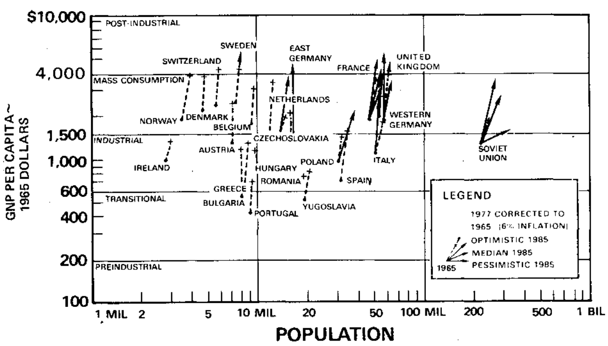

Fig. 2 GNP/capita vs population—Europe (1965-1985).

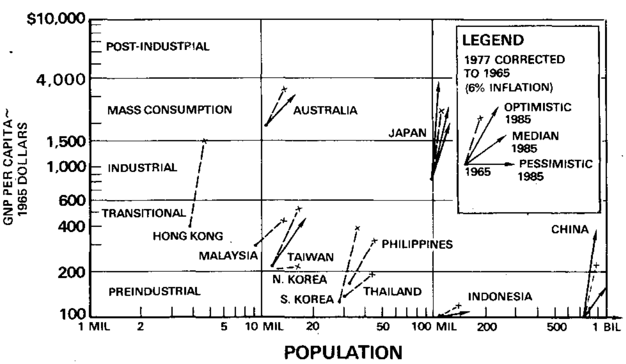

Fig. 3 GNP/capita vs population—Pacific Area (1965-1985).

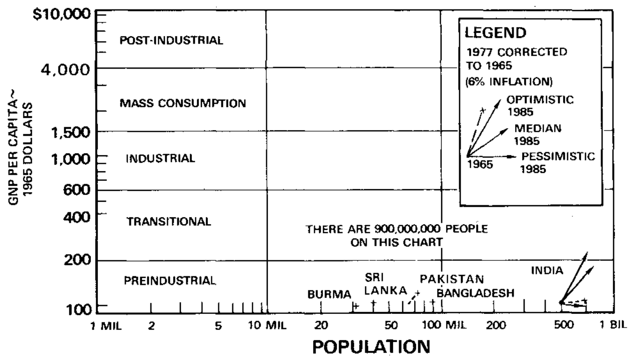

Fig. 4 GNP/capita vs population—South Asia (1965-1985).

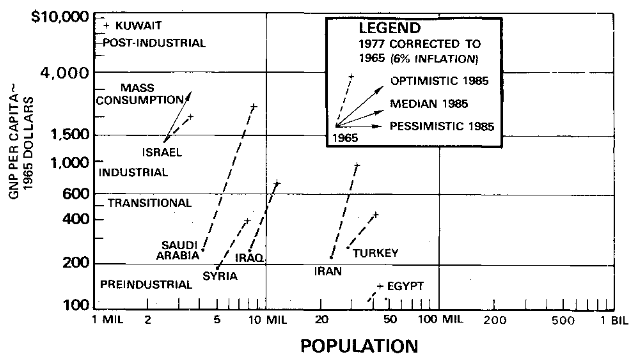

Fig. 5 GNP/capita vs population—Middle East (1965-1985).

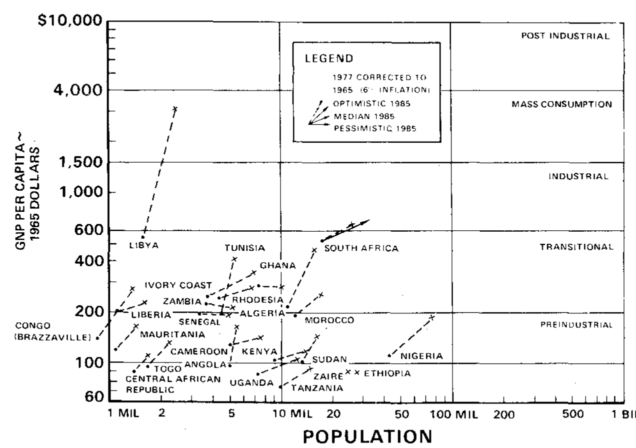

Fig. 6 GNP/capita vs population—Africa (1965-1985).

summarizes why these nations reach beyond their borders first. Expanding the domestic air network is a problem with different economic limits and uncertain growth patterns. Thus, ready financing is not available.

To stay healthy and alive, these nations need products to sell to the world as they seek to bring their populations closer to economic parity. To move into the future requires exploitation of their resources, the education and organization of the population, and the development of trade with their neighbors. This, to a large extent, has not yet happened, and is a major opportunity and an important responsibility for those of us in the economic driver's seat.

Cost of New Transportation Systems

Emerging nations have a choice of three basic concepts of transportation systems, all with fully developed technologies and a substantial history of economic performance. These nations, in general, have few existing systems and can choose the optimum balance among systems to serve them. Some broad comparisons may be useful.

To help illustrate the relative costs of the choices available, a typical 800-statute-mile, main terminal-to-main terminal system was assumed. Three mid-terminals were assumed to obtain the time en route. These systems were put into operation with enough rolling stock or aircraft to produce 640,000 seat miles in a 24-h period. The initial comparative outlay is shown in Tables 2-4.

This kind of comparison ignores many costs-sidetracks, intermediate terminals, rights of way, terrain modification, and the amortization of the infrastructure to make any of the systems work, but it does show that the airplane system starts off with an advantage. It costs about one-third of the other systems. Not apparent is the fact that the airplane system, being dependent only on terminals, can be expanded by many factors with the addition of terminals scaled to the expected use. As the range of airline systems and the addition of stops is increased, the investment advantage grows. Finally, as expansion takes place, the speed with which capacity and new routes can be added is dependent only on airplane-order lead time and terminal construction. These are much shorter time consumers than railroad or highway construction, particularly over new and rugged terrain.

Table 1 Comparison of development: international vs domestic air system

	International system	Domestic system
Airports	One	Many
Airplanes	Few	Many
World prestige (Show flag)	High	Low
Infrastructure costs (support, hotels, navaids, etc.)	Low	High
Development costs	Low	High
Operating costs	Low	High
Financing available	Yes	No

Table 2 Cost of highway system

Highway at $400,000/mile and 800 miles	$320,000,000
Buses: 16 (50-passenger) plus 2 spares at $125,000/each	2,250,000
Total investment (No right of way, terminal, or bridge costs included)	$322,250,000

Table 3 The railway system

Roadbed: $317,000/mile[a]	$253,600,000
Equipment: (2 pass. trains, 5 cars each)	
1) 2 locomotives plus 1 spare @650,000/ea.	1,950,000
2) 10 pass. cars (80 pass.) $400,000/ea.	4,000,000
Total	$259,550,000
(No right of way or terminal costs included)	

[a] In 1976, the Tazara Railroad from Dar Es Salaam through Tanzania and Zambia to Lusaka (1160 miles) cost $397,000/mile. (Time: Nov. 6, 1978).

Table 4 An airplane system

Airports:	2 @ $40,000,000 each	$80,000,000
Equipment:	(6 DHC-7 50-pass. transports)	31,500,000
		$111,500,000
[a] (No infrastructure costs included)		

When considering cost comparisons of this nature, it is worth reminding ourselves of the changes taking place in the air transport industry. Figure 7 combines two trends in one curve—first, the cost to purchase airplanes and second, the cost of operating them. The trends appear to be opposite, and there is good reason. The making of an airplane is still, with all our advances, a labor-intensive business and, even though economic escalation has been removed from the cost per seat of new airplanes, there is a further escalation in the costs of new skills and more demanding specifications for greater safety and reliability as well as more comfort and performance.

In the operating business, however, it is apparent that the productivity of new airplanes and new airlines is still producing economies which are not apparent in other modes of transport. A recent estimate of Amtrak service costs showed a cost per seat mile (available) nearly double that of

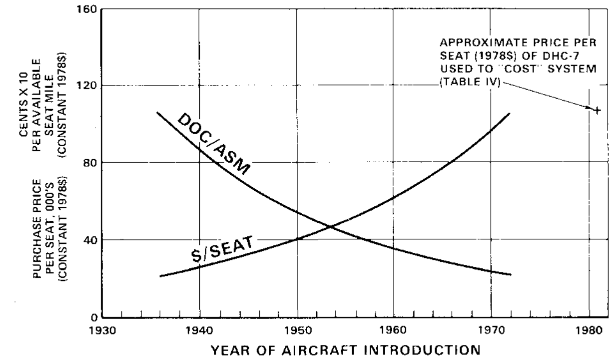

Fig. 7 Purchase price per seat and DOC per seat mile (1978 dollars, DOC's for 750-seat mile segment).

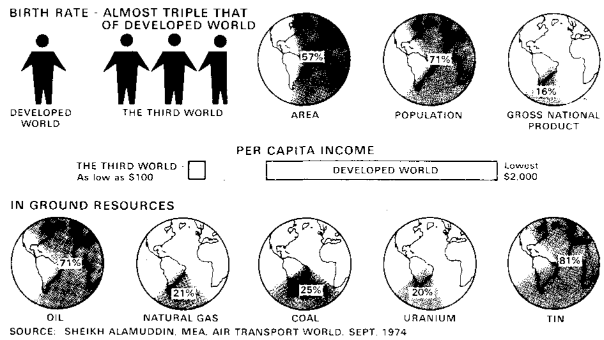

Fig. 8 The Third World...what it has (percent of world total).

the domestic U.S. airlines. This comparison might not be pertinent in a comparison of pioneering systems, but the experience of China, Tanzania, and Zambia with the new Tazara Railroad suggests that the comparison might be even more adverse to the railroad system.

Creating cargo systems has a different series of factors, most of which are dependent on the density and quantity of cargo to be carried and the promise of future expansion. As one reviews the type of potential cargo for developing nations, however, one sees great promise in the export of native handiwork unique agricultural or animal products. In all these fields, the cargo airplane has proven itself to be competitive and, in some cases, uniquely capable as in the transport of flowers, fresh fish, meats, and other perishables. Furthermore, when major new mineral or energy fields are to be developed in virgin country, the cargo airplane is nearly the only method of bringing the gear and the people into the area of development. The Alaskan pipeline is one of the most recent and dramatic examples of how valuable aircraft can be in exploiting natural resources.

What is the Character of this New Market?

To develop this Third World Market, there are many special problems that must be faced. For a clear description of the character of this part of our world, Fig. 8[3] is shown. The dramatic facts of 1974 are true for these same nations today, but today they are closer to, and more impatient for, emergence. Imagine, for instance, that the per capita income of this world suddenly equalled that of the "developed" world. This would mean that the world GNP would be tripled. This is dramatic enough, but it completely ignores the multiplying effect it would have on the GNP for developed nations if such economic health were to be experienced. It seems obvious that anything we can do to help this process would be good for us all.

Both the United Nations, through the International Civil Aviation Organization (ICAO), and the International Air Transport Association (IATA) have made extensive studies

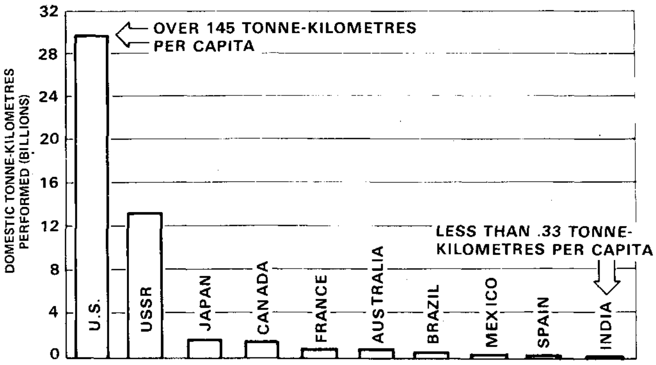

Fig. 9 Domestic traffic—top ten countries in world (ICAO 1977 data).

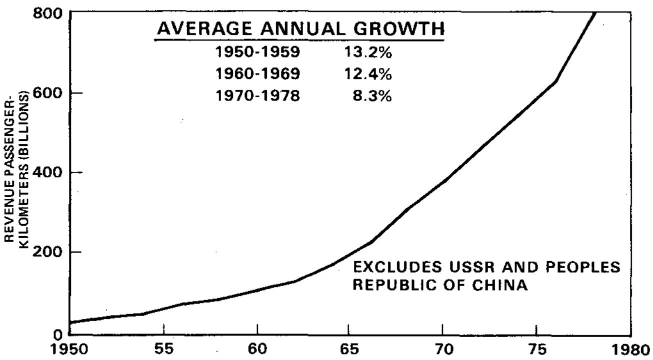

Fig. 10 World airline traffic (ICAO scheduled services).

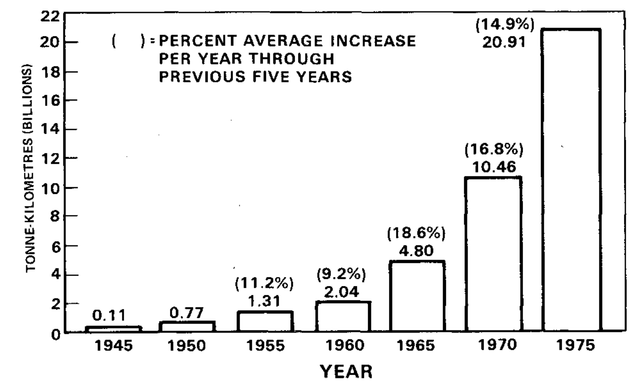

Fig. 11 World air freight traffic, 1945-1975 (ICAO data, excludes USSR and PRC).

	T.O. GROSS WEIGHT (LBS)	MAX PAYLOAD PASS. NO. OR CARGO LBS	CRUISE SPEED KNOTS	TAKEOFF FIELD LGTH AT MAX PAYLOAD
L-100 (101 PASS.)	155,000	101/43,900	320	6000'
CL-400 (70 PASS)	84,000	70/25,100	250	4900'
DHC-7 (50 PASS)	43,000	50/11,640	234	2430'
HS-146 (NEW 4 ENG, 71 PASS)	73,850	71/18,000	426	5100'
SHORTS (30 PASS)	22,400	30/7,500	191	3700'
DHC-TWIN (20 PASS)	12,500	20/3,800	175	2000'
DH-BUFFALO (40 PASS)	49,200	40/10,600	225	2100'

Fig. 12 Short-range aircraft characteristics.

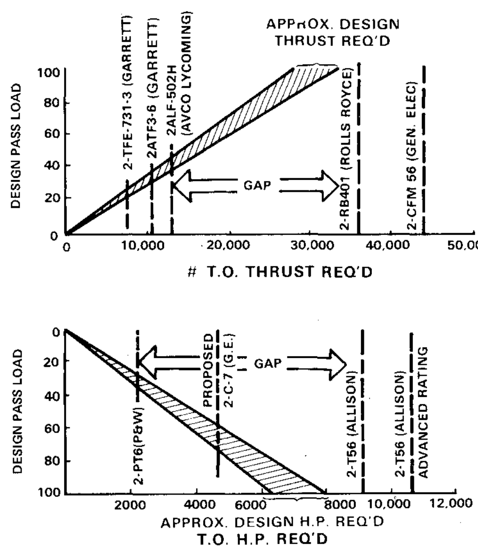

Fig. 13 Thrust of H.P. available and required for new bimotor passenger transports.

searching for ways to accelerate the growth of the world's disadvantaged countries.[4,5] Before exploring the problems uncovered in these studies, it is worth remarking that the ICAO and IATA statistical efforts and the clarity with which they are presented are a great help to anyone pursuing the trends and problems of air travel. An illustration of this is depicted in Fig. 9 showing 1977 ICAO data concerning domestic air traffic. Ton-kilometer performance comparison between India and the U.S. is one illustration of the tremendous potential for growth in domestic systems.[6]

The prime obstacles to the economic emergence of many of these nations are the following: 1) the lack of foundation and skill to analyze national potential; 2) the impatience of many of these nations to be counted as a member of the developed world; 3) the lack of skills throughout the population to build a national economic system using the resources available; 4) the lack of effective internal transportation or communication system; and 5) the lack of, or diffuse sources of, financial aid to those nations with emerging economies.

What "Hardware" is Needed?

When compared to United States airline history, we see a major difference with new nations. The United States carried passengers beginning with as few as two to four per trip. The pioneer airlines sold "time-saving" as a commodity because fully developed transportation systems, rail or road, already existed. Today, new nations need transport for everything, and we would be remiss if we did not start with the assumption that what we offered must be a good cargo airplane first, a reasonable passenger airplane next and, for the most part, an airplane that served a mixture of passengers and cargo for most of its life. Commodious accommodations, which are rapidly disappearing in developed airlines, will not be a demand for the pioneering airlines in this new world.

In oblique support of the importance of cargo is a comparison of Figs. 10 and 11, which shows how worldwide air cargo has expanded in the last few years compared to passenger traffic.[7] Some of this expansion represents first shipments from these new nations to the developed world. These shipments have been spasmodic and have been restrained by the lack of modern means to feed the international terminal from the internal sources of the nation. The market appears to be there for a substantial new expansion if such cargo can be consistently gathered in the countryside.

Figure 12 illustrates some new or in-production airplanes that could be considered for a short-range pioneering airline or charter service. As one looks at this list, a curious fact is apparent in the 50-70 passenger category—two of the three aircraft are of the four-engine variety. New and modern as they may be, it seems unnecessarily complicated to use four engines for the kind of pioneering airlines which we are contemplating. This implies added maintenance costs and may cause consideration of extra crew members. In searching out why the designers used four engines, it soon became apparent that a very good reason was the unavailability of engines which were properly sized for such a transport.

This is shown in a simplistic way in Fig. 13 where the total thrust or horsepower (for turboprops) is plotted vs design passenger load. It is obvious that a large gap exists in power plants for bimotors with passenger capacity between 30-40 passengers and well over 100 passengers.

Another factor in deciding whether a new airplane is required is the availability of airports and the likelihood of their availability in the future. It is obvious that this concern is not only for their existence, but also for their length and their capacity to sustain reasonable growth if an airline system were established. A detailed survey was not found, but enough information was gathered to produce Fig. 14, which shows what is believed to be typical "coverage" of the countries by airports in terms of people per airport and square miles of the country per airport. This coverage was plotted vs GNP/person to determine whether a relationship existed. The only relationship apparent is that very many relatively poor nations respect the value of airports and have just as dense an airport per capita or area distribution as more prosperous nations. It should be pointed out that even the most prosperous nation in this family had a GNP/capita of \$3200 compared to the U.S. value of nearly \$7000, and there were only 5 of these 22 nations included with GNP/capita over \$1000. A similar distribution was attempted on how many of these airports were paved, but here again there was no trend. As noted in Fig. 14, however, there were only 2 nations of the 22 that had over 8.5% of their airports paved.

Although we mentioned the curious fact that the available airplanes close to 50 passengers were four-engine types, it is certainly far from clear that this passenger (or equivalent cargo) capacity fits all situations. In an attempt to explore the size that might be needed, a look was taken at the airline system that has developed in Africa below the Sahara. It should be recognized that many of these routes are truly international, but they have the characteristics of short-to-medium range domestic routes in the United States. Figure 15[7] is a map of this system illustrating one major problem confronting these pioneers. In order to maximize the economy per flight and probably to reduce the demand for additional equipment, very low-flight frequencies are scheduled. The dotted lines show those routes which have only one to four flights a week. This is certainly not a frequency designed to attract new customers, nor is it a frequency that offers aircraft speed advantages over anything but the most primitive ground transport system. To increase frequency probably implies smaller aircraft than those now used, which also implies an aircraft so small that even with full loads, economic viability would be doubtful. If this is the real case, then operating subsidies seem inevitable for such an airline to provide reasonable service. The question then becomes how best to use subsidy for maximum benefit. The question should be asked in a way that permits early, reasonably frequent operations

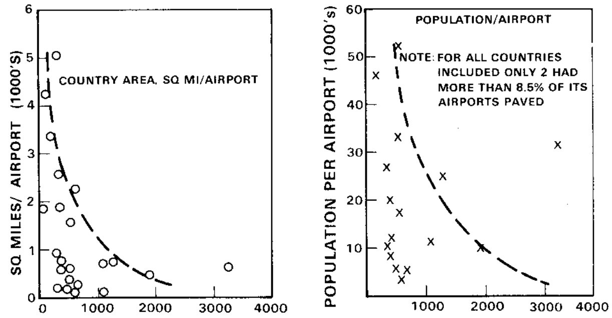

Fig. 14 Airport coverage vs GNP/capita (in 22 less developed countries).

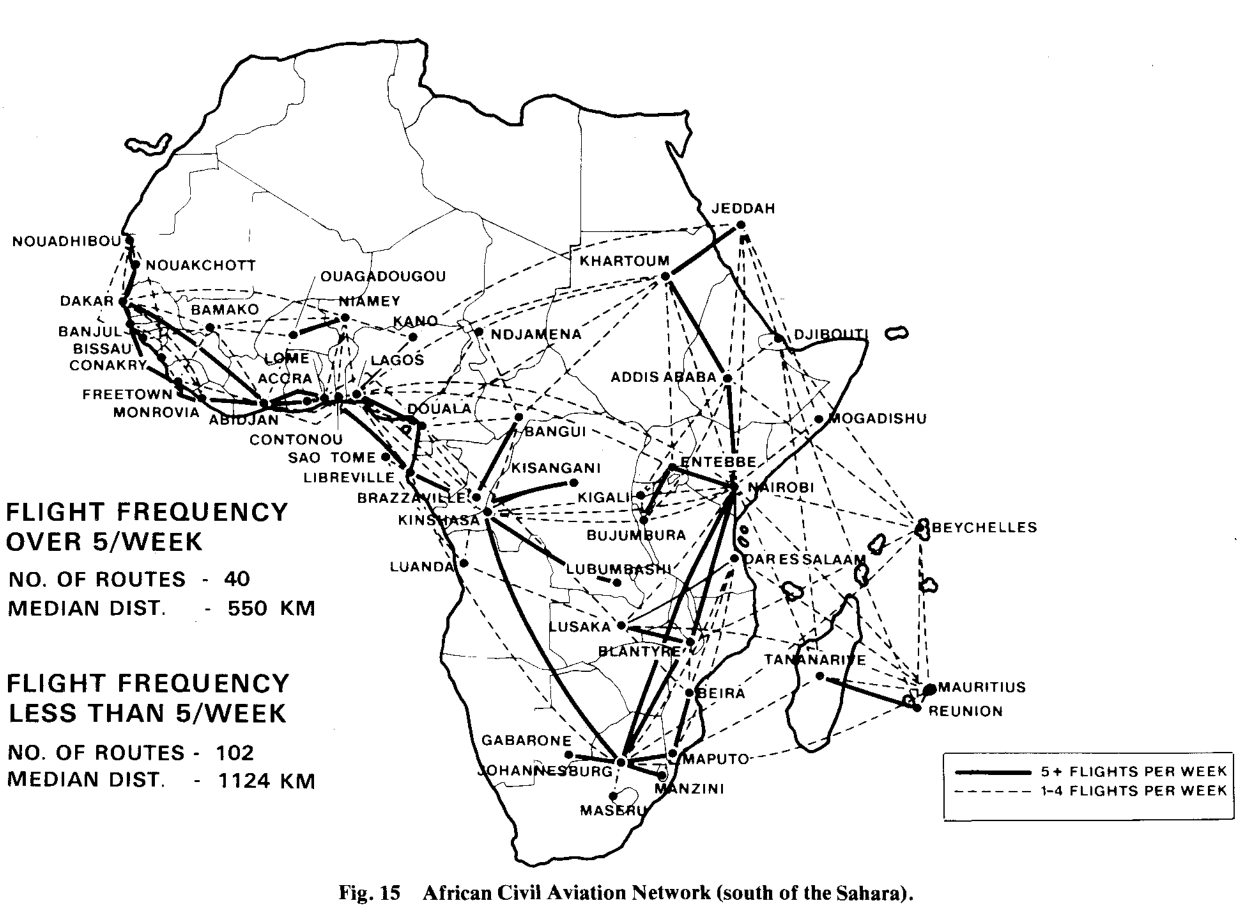

Fig. 15 African Civil Aviation Network (south of the Sahara).

for training, establishment of operating bases and maintenance procedures, with an airplane that had a reasonable chance of economic survival once the traffic had increased, and the frequency established that made sense for a healthy airline. This suggests that the airplane be reasonably close to, or larger than, the 50 passenger size previously mentioned.

In any discussion of new aircraft designed for this potential market, it must be recognized that other market needs may make available suitable aircraft or power plants. The current emerging commuter airlines in more developed countries have sparked many investigations including a concept development study initiated by NASA. It should also be recognized that earlier NASA contracts produced studies which summarized new technologies available for specific "emerging country" designs.[8] Finally, the serious potential shortage of aviation fuel can have a substantial impact on any new development and must be considered. It is the author's belief that the long-range market will be the first to convert to alternate fuels, and that these shorter-range systems may thus be provided with a reprieve from having to make use of different fuels before the airlines are reasonably well established.

How Does a Program to Help Get Started?

As one looks at efforts by many nations to assist others, it seems obvious than any agencies for helping should, if possible, be politically neutral and have the capability to collect the technical talent needed and handle the financial management. Two existing entities come to mind, the ICAO and the IATA.

In the ICAO, there is a substantial history of analysis and understanding of international air travel and, through interfaces with the U.N. aid organizations, a history of working with traditional aid programs.

The IATA is an entirely different combination of talents. It represents the collective international carriers who are members and helps them work together and with the various countries they serve. IATA can, and does, call on its members for talent to address its many responsibilities, and through this mechanism can bring to bear the total wealth of experience that operates the world airlines.

Some years ago the late William Magruder, then on the White House staff, attempted to seek a means for developing an airplane which would serve the nations which are addressed in this discussion. His concept of fulfilling the requirement by the adaptation of a carrier-based Navy transport was consistently thwarted by the difficult demands of "carrier-based" specifications. Inevitably, these so degraded the performance of the airplane as a land-based, simple transport that the program never gained momentum. Magruder's sensing of the need, his articulation of this need, and his estimates of cost all were valid then, and they are valid today. However, the experience of trying to combine a military requirement and a commercial one in a single development was once again demonstrated to be a difficult approach, usually leading to unacceptable compromises for both customers.

It appears that any new effort should be based on the following precepts:

1) The agency for helping to create air transport systems for emerging nations should, first and foremost, have available to it the technical talent to analyze airline needs, to create operational concepts, and to create essential specifications for the system elements. Equally important is the capability to analyze costs for the initiation and operation of such a system.

2) Financial aid should be made available from a source that contains a minimum of political bias and is sufficiently ample so that resources can be made available to a family of nations rather than just a few. Furthermore, once committed, these resources must be consistently applied until the system is operational in spite of political perturbations.

3) The applied, in-country help must be made available in such a form that its prime purpose is training indigenous people so that the system, once created, can be operated and perpetuated by indigenous talent.

It is suggested that a program like the following might have a chance of eventual success:

Step 1 IATA should create a substantial research program, sponsored by its members and assisted materially by the world's developers of aircraft, airport, and infrastructure hardware, to determine the worldwide need for small airline systems. This research should attempt to describe such systems, search for standardized elements, and analyze the cost of installation and operation at reasonable flight frequencies.

Step 2 ICAO, working with the IATA research program, should attempt to define the scope of a financial aid program whereby nations which professed the need for such a system could be made aware of the mechanism for seeking financial assistance. ICAO should assess whatever patterns for economic performance of the ultimate system would be expected by the sponsoring agencies including schedules for eventual payback of initial investments.

Step 3 If the research and the potential for finance were successful, then IATA should form a procurement agency calling upon its members for talented managers to be assigned for substantial periods of time. This agency would be available to sponsor in-country detail studies by indigenous or imported staffs to define needs and to design and estimate costs of the needed systems. If ICAO and IATA were satisfied that the need was valid, the system would then be procured using hardware elements that the IATA procurement agency had defined and developed based on its research. The financing would be provided by ICAO developed sources and enhanced by whatever wealth the receiving nation could muster.

In short, supported by the United Nations Development Program through ICAO, IATA would define, develop, and procure the elements of total "start up" airline systems so that emerging nations, with IATA support, could install and operate a pioneering airline system and find the expertise to train its people.

The author fully recognizes that, to many, this will appear to be a preposterous suggestion. A voluntary agency is rarely called upon to be a development and procuring agency as if it were a part of some government or international official body or a member of industry. It is, however, the body which could assemble the most knowledgable people to assess needs, define systems based on rational proposals, and help others to learn how to operate such technical systems economically. Putting any other "normal" agency in this creative loop could lead to ponderous bureaucratic and political costs and obstructions. The author points to the history of the U.S. Supersonic Transport to illustrate how difficult it was for men of good will to get a highly technical job done, and this involved only one government. The Concorde too, for all its magnificent achievements, was a difficult and costly management task.

The tentative steps we have already taken worldwide to sort out this opportunity are random at best. The airplanes needed are nearly small enough that the development costs might be financed. However, financially sound customers and provable markets do not exist. Furthermore, there is no mechanism to combine these markets sufficiently to justify a single economical approach rather than a costly multiple approach to the solution. Finally, the airplane, most visible of the system's elements, is hardly the most important. Standardization, definition, installation, and training for use of the whole infrastructure from runway to navigation, communication, and maintenance are equally demanding. This whole support base must be defined and economically installed before a viable start can be made.

How an IATA procuring agency would initiate development and production of elements, how contractors could be sorted out and rational proposals obtained, and how international jealousies and valid claims of expertise and economic performance could be evaluated will be a gargantuan task. If these tasks are addressed by the most experienced people the world has, we may have a chance for a rational outcome. The way we are approaching it today will not get us there for several generations. Even then, we may find that the outcome will be biased in the direction of who has the "quickest" resources to attract initial investment, a bias that may prevent rational definition of a universally usable "pioneering" concept. The author suggests that research (Step 1 and Step 2) is certainly worth a try and may uncover a better way to take Step 3. We have many nations looking for help to reach the 20th century and we should have the intelligence and motivation to provide that help—this is called leadership.

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