NASA Technical Memorandum 89425

Aviation Technology Applicable to Developing Regions

John Zuk
Larry R. Alton, Ames Research Center, Moffett Field, California

September 1988

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035

TABLE OF CONTENTS

SUMMARY

An analysis of aviation technologies which would be useful for formulation of aviation or development plans to the year 2000 for the emerging countries of the world has been completed. The Caribbean Basin was used as a specific application. Aviation technology was organized in the following categories: current technology in the region, applicable technology used in other regions, significant trends in technology, and technology issues regarding developing regions. The categories covered under the significant trends in technology section were: next generation CTOL aircraft, general aviation aircraft, rotorcraft applications, rotorcraft technology, lighter than air, used aircraft upgrading, and computer/satellite advances.

The rapid growth of aviation technology and passenger and cargo traffic that has occurred in the past is projected as likely to occur in the future as well. These aviation technologies, if planned for and utilized properly in the Caribbean as well as other developing regions, offer the possibility of "leap frogging" current technology to arrive in the 21st century without many of the major costs involved in present technology such as extensive air traffic control ground infrastructure, new and extended airports, and road, rail, port, and communication systems in remote areas.

The next generation transport aircraft, with improved infrastructure and management methods, will provide lower cost air transportation to these regions from the United States and the rest of the world. The new short haul air transportation capability, if looked at from an overall systems and intermodal viewpoint, can offer many unique economic development opportunities. Satellite technology will enable rapid, economical capabilities in many areas such as navigation, communications, weather forecasting, training, and maintenance assistance.

I. BACKGROUND

This paper is an analysis of aviation technologies useful for formulation of development plans to the year 2000 for the emerging countries. The Caribbean Basin was used as a specific application. If we look at the context of this paper forward to the year 2000, about 15 yr from now, we are on a continuous technology explosion which will make it difficult to predict the technologies which will be impacting the developing regions such as the Caribbean Basin during those 15 yr in a comprehensive way. Technology moves so rapidly (table 1) that there will undoubtedly be technology developments which cannot be predicted at this time which will have an impact in the developing regions by the year 2000.

We must also be able to look forward to the changes in the regions themselves. For instance, air cargo and air passenger traffic will grow by about 300% in the Caribbean Basin during that time (figs. 1, 2), along with significant population and economic growth. Major changes in air traffic control (ATC) systems, fleet size, maintenance capability, etc., will be required to accommodate this growth.

As part of their national strategy, many countries are using aviation as a potential catalyst for national technology capability development. By getting the regions involved in aviation--particularly if they can address the supporting activities, maintenance, etc., and integrate that into their overall transportation system--their overall technology capability will be enhanced, which can mean an influx of industry and help for these areas.

Air transportation should be recognized as a significant tool for rapid economic development in the developing regions through efficient transportation and technology resource growth.

II. THE CURRENT AVIATION TECHNOLOGY IN THE CARIBBEAN BASIN REGION

The size of the Caribbean Basin Region is extensive, covering areas greater than those in the contiguous 48 states of the United States. There is a wide range of flight distances in the region, from long haul, to medium range, to very short hops (fig. 3), which shows the need for the wide spectrum of aircraft which exists in the region. The scheduled international air traffic in the region focuses on several major hubs such as San Juan, Puerto Rico; Nassau, Bahamas; and Mexico City, Mexico.

Both passenger and freight traffic in these hubs is comparable to some of the major cities in the U.S. and the rest of the world (tables 2 and 3). Figure 4 shows the statistics on airport runway lengths in the region as reported in the Scheduled Airline Guide for scheduled service with over 56% being less than 7500 ft in length.

An inventory of aircraft in the region for international passenger carriers, regional passenger carriers, air cargo carriers, and helicopter services, with spread sheets of the associated data are shown in tables 4 through 11. Data are shown by country, airline, manufacturer, and aircraft model. Data on the privately owned, not-for-hire aircraft in the region are not shown (estimated to be about 5000 aircraft). There is a wide variety of aircraft sizes, manufacturers, ages, and propulsion systems represented in the basin. The fleet percentages of jet, turboprop, and piston aircraft are shown graphically in figure 5; air cargo amounts shipped in and out of the region are shown in table 12; types of air cargo shipped to and from the United States and the Caribbean are shown in table 13; and passenger volume to and from the region is shown in table 14.

The region is actively purchasing aircraft; some of the purchases made during a recent time period are shown in table 15. It is very difficult for manufacturers

with conventional financing methods to compete with soft financing available through development loans from some countries. The Canadian government, for instance, sold Twin Otters to Indonesia with a 40-yr loan at a 2% interest rate.

Aviation can impact economic development opportunities in tourism and business, the transport of agricultural products, emergency services, mineral development, law enforcement, fishing, and cargo. Industry perceives the high cost of transportation to, and lack of security in, outlying areas with low-cost labor as barriers to expansion in these locations. Factors which favor the use of aviation transportation in the developing countries are increased productivity in the transport of high value and time sensitive payloads; flexibility to adapt to supply and demand; and lower investment and carrying costs based on existing geographic barriers and the availability of open space for airstrips. Many people may not realize in the Caribbean for instance, once you have met the capital costs of $15-20,000 for a used airplane it is cheaper to operate a 10-yr-old Cherokee 180 than a 16-ft boat with two 40-hp engines. As long as the aircraft remains in U.S. Registry it does not pay import duties, whereas a car does, and sometimes a boat also does. Therefore, the capital investment in an aircraft works out to be significantly cheaper than either a boat or a car in this region.

In general, some of the special technology needs for aviation in remote areas are low power, low maintenance, durable inexpensive equipment with access to accurate weather information, navigation and guidance aids, minimal ground equipment, and aircraft rough field operation.

By comparing the applicability of aviation in the Caribbean with other parts of the world, we can see there are other major island regions in the Pacific and Southeast Asia similar to the Caribbean Basin. The population of the Caribbean Basin is estimated at 168 million as of January 1, 1982. Indonesia and the Philippines alone had a population of about 203 million in 1982. The islands of the Southwest Pacific Ocean have relatively small populations. (Solomon Islands 245,000, New Caledonia 144,000, and French Polynesia 152,000, all in 1982.)

The potential for expansion of aviation in these developing regions is very large when compared with the more developed countries such as the U.S. These islands have strategic importance to the U.S. and the rest of the free world. There are many islands in these areas; Japan alone is comprised of over 700 islands. Many of these islands are also mountainous, providing further incentives for aviation. The translation of this analyses of the Caribbean to these other island regions and other developing nations appears to have a high probability of successful application. Preliminary assessment of the Caribbean Basin aviation opportunities and benefits are; (1) an opportunity for use of the entire spectrum of current future aircraft (short/long haul, small/large aircraft, VTOL, STOVL, STOL, and CTOL); (2) a catalyst for accelerating new technology developments in the region; (3) similar benefits appear to apply other regions of the world.

III. EXISTING TECHNOLOGY USED ELSEWHERE

Convertible Interior Configurations

One of the technologies used elsewhere that is not used as much in the Caribbean is the convertible interior configurations, that is, being able to modularize the interior for cargo and flexible seating. This technology is being used effectively in Alaska where they are able to rapidly change the proportions of the cabin used for cargo and passenger seating and even accommodate emergency medical patients very rapidly.

Aircraft Runway Modifications

In Micronesia, on some of the small islands that are really coral reefs, the aircraft operating there have had problems with short engine life. When aircraft were operating on these unpaved coral runways, the ground vortex from the engine thrust would ingest coral, which is very abrasive, causing very short engine life. A simple fix was discovered in putting on a vortex spoiler in the form of a wand which blew bleed air onto the core of the vortex and dissipated it, greatly reducing the ingestion of coral. Also, where unimproved runways exist, there are special tires that are used. With greater aviation activity in the region, more frequent cooperative efforts between aircraft operators in the region and manufacturers that address the special problems each region has can result in more cost-effective operations.

Unique Aircraft Characteristics

There are unique aircraft model characteristics which may solve the difficulties which are encountered in a particular location. The De Havilland Twin Otter (fig. 6) is one of the workhorses in developing countries worldwide. The De Havilland has a strong history of activity in areas that are inaccessible or remote. Many lessons can be learned from De Havilland experience in the use of this aircraft. The British Aerospace 146 offered a unique solution at Dutch Harbor, Alaska; high value fish caught in the area can be flown directly to Anchorage and return, whereas the turboprops used previously did not have the range to do this. The Alaskan government investigated extending the runway 1000 ft to enable longer-range jets to land at Dutch Harbor. The proposal was for $90-100 million to extend the runway, so the use of the four-engined BAe 146 at about $15 million per aircraft was an effective solution to the range problem. Turboprop aircraft are used extensively in developing regions by operators such as Transamerica and Evergreen. The McDonnell Douglas DC-3 is very economical, durable, and reliable, and is much used in the developing regions.

The Lockheed Hercules turboprop is in use in 92 countries; much of it is military. The unique aspects of the Hercules are the adjustable height ramp for loading, the large aft cargo bay opening, and the large square 10-ft by 9-ft interior

cargo hold which matches most of the usual cargo loads the complete length of the aircraft. The Hercules also has an optional removable rail-roller system that can be installed on the floor for easy loading of palletized cargo (fig. 7*). The landing gear design is also unique for landing and taking off on soft-earth runways. Applications have included transporting equipment to remote sites to construct or install a development project, copper bars out of a remote Zambia mine, development equipment to a Canadian mine, produce to Greenland, hay overboard to starving cattle stranded by a blizzard, flame retardant to fight a forest fire, supplies for earthquake disaster relief, wildlife to remote sites, iceberg and fishing patrol personnel, airborne hospital to disaster scene, etc. The auxiliary power unit enables operation into remote areas since it makes the Hercules independent of ground-support equipment for engine starting and air conditioning.

Navigation and Ground Aids

Runway lights using the radioactive element tritium, which is a by-product of nuclear reactors with a half-life of 3-6 yr, are now being evaluated in Alaska. These lights are useful for both fixed-wing aircraft and helicopters in remote sites without a power source, and in areas where there is low ambient light. The simple construction of the tritium unit itself can be seen in the daylight photograph in figure 8. A scene of what a pilot would see using these lights is shown in figure 9. This concept has been successfully evaluated under flight conditions.

A simple battery-powered remote beacon that has been experimented with at Ames Research Center is shown in figure 10. This unit uses nickel cadmium rechargeable batteries, and is particularly useful for temporary helicopter landing sites while developing a project. The beacon is portable and has drawn military interest.

An inexpensive air-to-ground communications system from commercial aircraft called Air Fone has become operational and is representative of many rapidly expanding telecommunications applications that can have significant impacts for air-to-air and air-to-ground communication.

There are many advances occurring in computer software enabling analysis of large amounts of aviation data such as computer weather forecasting and flight planning. These services include information such as best routing and profile, latest weather, alternate routing, average wind factor, equal time point, etc., for greater safety and efficiency.

Loran C is excellent, where available, for line-of-sight aircraft tracking; but it is mostly inadequate for complete coverage in the Caribbean because the antenna locations in the U.S. do not provide assured navigation accuracy. Additional sites in the Caribbean are required to obtain full benefits of this technology's accuracy of one-quarter mile to 50 ft.

---

*Courtesy of Lockheed-Georgia Company.

Microwave landing systems (MLSs) are beginning to be implemented in the U.S. The New York Port Authority has been evaluating MLS at the Battery Park heliport for helicopter approaches and it has been very impressive. At Valdez in Alaska, where there is a difficult approach with mountains in the area and the weather is often bad, it is proving to be very effective. The use of MLSs is especially important in high traffic density areas. One of the greatest advantages of the MLS is the ability to install it in difficult areas at low cost. Microwave landing systems do not require a lot of antenna site preparation work which is especially important on runways bordering the sea where putting in a conventional ILS is difficult if not impossible because of the tidal changes.

Sarsat is a satellite in Polar orbit operated by NOAA which, along with another corresponding Soviet satellite called COSPAS, is programmed such that it can pick up emergency signals from either aircraft or ships and relay the signal to a ground receiving station; the signal is then sent to a mission control center. In the U.S. the mission control center is Scott Air Force Base, where the appropriate search and rescue force (Coast Guard or the Air Force) is then alerted to respond to the emergency. Over 300 lives have been saved because of this capability; however, there is not a receiver yet in the Caribbean (fig. 11) although one has been targeted for San Juan. It is possible the Coast Guard budget may be severely cut and therefore the Coast Guard may not be available for rescue. This satellite capability could be crucial and the receiver in San Juan should be recommended for activation.

These are just a few examples of existing technology used outside the Caribbean Basin that could be used in the region. There are many others, and the reader's ideas and contributions are requested.

IV. TECHNOLOGY ALREADY IMPACTING THE REGION

Regional Radar

The Air Force Caribbean Basin Radar Network is depicted in figures 12 through 15 prepared by Westinghouse (a major contractor in the system). It is sponsored out of the Air Force Logistics Command Office in Sacramento. The concept is based on a joint operations center located in Panama; other nations in the region can be members of the network and utilize the system. The main use of the system as far as the Air Force is concerned is security; however, the system can also be used for civilian ATC by other nations. The system is planned as a two-phase approach; initially there will be national radar sensors for three-dimensional radar located in the nations that desire to be a part of the network. The information gathered will be fed to the joint operations center in Panama. The early capability will be a manual plotting system; later on, it will be a completely automated system. A satellite communication system will obtain the data from the national sensors for high-altitude data, and low-level data will be gathered from airships tethered either to land or ships. In the early phase, high-frequency radios that already exist or meteor bursts would be used.

The ground radar system should be under way in 1986, and in 1988-89 the satellite system should be operational. Since the satellite system will be used for military purposes it will be a very secure system. This system has the potential of greatly improving the ATC in the region. There was some concern that this system could not provide complete coverage because the tethered airships would have to come down in bad weather and satellite coverage would not be accurate enough for the aircraft transition from terminal to landing. The information on this system should be made available as soon as possible since it could permit doing away with some small towers. The Air Force is very interested in having the Caribbean countries involved and therefore is interested in providing information on the systems to these countries.

Remote Sensing

Landsat has been in operation since 1972 and has provided excellent infrared photos of the Earth which we are still learning how to analyze. There have been some discoveries from this photography; for instance, discovering areas in the ocean where shrimp are plentiful, identifying diseased forest areas, outlining areas of high potential for mineral development, performing resource inventories, and discovering archaeological sites. At Ames Research Center we have high-altitude aircraft (a U-2 and an ER-2) that operate at 60-70,000 ft and give a higher resolution. There is a great opportunity for the countries of the region to utilize this type of mapping capability for these applications.

Existing Aircraft--New Applications Potential

Considering multimission uses of the vehicle is very important. If only one application is considered, an aircraft may not be practical; if the same aircraft is used for several missions it can become very cost effective. Regional specialist teams can be organized to provide expertise to operators lacking resources of their own for evaluating aviation applications and operations.

V. SIGNIFICANT TRENDS IN TECHNOLOGY

New-generation transport aircraft will be characterized by efforts to keep both acquisition and operating costs down. This means that the potential for long-haul tourism is significantly greater than today's market, considering that population and incomes will grow. A number of next-generation, short-haul aircraft that are on the drawing boards or under development offer high-performance potential. However, product-liability insurance cost for both manufacturers and operators are a very significant cost factor which could potentially offset any productivity improvements obtained through incorporating new technology. Success in addressing this liability cost problem is necessary if aviation is going to continue to be available or grow in the future. Manufacturers in countries outside the U.S. currently have an

advantage because their liability insurance costs are lower; however, the European Economic Community (EEC) recently adopted changes that will move them toward the U.S. tort system over the next 7 yr.

The electronic microminiaturization revolution will continue into the year 2000 with enormous advances because of the high density, power, and low cost of chips. Figure 16 shows some of the technology forecasts for the year 2000 by the National Academy of Engineering in their "Aeronautics Technology Possibilities for 2000" study.

Intel's 512K EPROM chip, the size of a small fingernail, is an example of today's technology. Figure 17 indicates the rapid growth in performance that has occurred over a relatively short period of time in a family of Intel chips.

The worldwide consumption of EPROM capability is shown to double every year (fig. 18). Computing system technologies will be characterized by dramatic reductions in cost and size; software will improve less rapidly, but the use of knowledge-based expert systems will help in this area. Some of the technology application opportunities include full resolution remotely piloted vehicles, airborne video conferences, near-zero unscheduled maintenance, combustion models, turbulence simulation, computational fluid dynamics, structures, and non-linear, multi-variable optimization.

Symbolic processing and artificial intelligence are becoming more viable and will result in major improvements in aviation systems. Areas where man-machine interfaces will be impacted are the ability to support effective total situation comprehension by pilots, to assist and support the pilot's decision process, and to exploit the computation-rich airborne environment. These have major military implications but spinoffs to the civil sector will, hopefully, result in much safer flying, particularly in high pilot workload or adverse weather conditions.

Advances in telecommunications and fiber optics for high-speed, digital data transmission will be very significant. The military is investing large amounts of money in command-control communications intelligence and remote sensing; this will create a great deal of improvement in the civilian marketplace.

Transportation into space with the Space Shuttle, repairing satellites in space, and new satellite technology will expand satellite opportunities even more. New areas such as flexible manufacturing techniques will have a favorable economic impact. These significant trends in technology are summarized below.

Significant Aircraft Technologies

There are a number of aircraft technologies projected to be significant in the year 2000. Engines that are 20-40% more fuel efficient will be possible, such as the General Electric unducted fan, ultra-high bypass ratio concept (fig. 19). In addition, a higher thrust-to-weight ratio, lower cost, longer engine life, and a shorter, more responsive engine development cycle are possible. More extensive

aircraft and engine-condition monitoring systems will result in longer times between overhauls, safer, more reliable flights, and lower skill levels required to operate and maintain the aircraft.

Advanced composites will be replacing aluminum as the primary material in aircraft. Metal matrix and carbon-based composites will be used for high-temperature capability, high quality, low cost, and customized qualities. The Williams aircraft utilizing composite forward swept wings and canards is shown in figure 20.

Fly-by-wire and fly-by-light control systems will likely be used for reduced crew loads and optimum aircraft performance. Semi-automated cockpits with improved displays and automated flight and mission management will be possible. Night vision with forward-looking infrared radar (FLIR) can sense temperature differences of less than 2°F. This capability can enhance the night-flying capabilities of helicopters and to aid in the detection of criminals, lost children, etc.

Next-Generation Aircraft

The next-generation CTOL aircraft is projected to be available about 1992. This vehicle will likely have a 100-150 passenger capacity and low acquisition and operating costs. Manufacturing costs will be 20% lower and extensively revised with more automation, computer-aided engineering (CAE), computer-aided design (CAD), computer-aided manufacturing (CAM), and robotics involved.

New structural materials will be used, including advanced composite materials that are much lighter, with better fatigue resistance, and greater corrosion resistance (which is very important for ocean environments). Aluminum-lithium alloys which are lighter than aluminum are being developed. With composites, large assembles are possible, resulting in a smoother skin and 1/100th-1/1000th fewer fasteners.

In flight control systems, microelectronics, fiber optics, and flat panel displays will be much lighter and more reliable. Electronic controls and integrated circuitry can be integrated with the global positioning satellites and the MLS automatically, which should greatly enhance the safety and efficiency of operations. Automatic icing control will be available. Greater propulsion efficiencies will be incorporated in these aircraft, such as the ultra-high bypass ratio engines. Research on these engines has been positive so far; however, the ultimate decision on its use will be based on the in-flight testing because the passengers must not be exposed to excessive vibration or noise levels.

Improved aerodynamic efficiency will be possible through computational fluid dynamics techniques which will make wind tunnel testing much more efficient. Obtaining natural laminar flow using high-aspect-ratio wings will result in a drag reduction of over one third. Effective use of canards will make aircraft capable of landing and take-off from short runways. Rapid interior modifications will be possible, including the use of nonmechanical connectors.

General Aviation Aircraft

There has been a movement toward improving the safety of general aviation aircraft with better crashworthiness and stall/spin characteristics utilizing canards, etc., and this trend will continue. Overall efficiency improvements are also being addressed. There is the idea that general aviation is for recreational flying, but only a very small percentage of general aviation is actually for that purpose. Primary uses include training, commuter traffic, agriculture, and business. Figure 21 depicts a commuter configuration from a NASA study which looked at technology requirements for commuter and general aviation aircraft. Figure 22 shows some of the commuter aircraft recently developed.

Flying boats can be advantageous around bodies of water and islands; Shin Miwa of Japan is thinking of developing a new aircraft of this type.

One of the new STOL developments is the upper-surface blowing NASA research aircraft called the QSRA. By blowing the exhaust gases over a wing of proper design (fig. 23), twice as much lift can be obtained. A Japanese consortium recently successfully flew a Phase I version of this concept at Mach 0.57 and they plan to develop a Mach 0.7 version. This technology should impact the developing country market for aircraft using short or unimproved runways. This concept can also be used for flying boats; for instance, the QSRA can take off and land at very low speeds because it has a stall speed of 45 knots.

Rotorcraft Applications

Some of the potential applications of rotorcraft in the Caribbean are agriculture (fig. 24), medevac (fig. 25), construction, search and rescue (fig. 26), fire fighting (fig. 27), police work, air taxi, and air transport (figure 28 shows the largest helicopter currently available, the Boeing Vertol 234 Chinook, which carries up to 44 passengers).

Rotorcraft Technology

Future rotorcraft technology with many potential applications for the Caribbean includes the XV-15 Tilt Rotor aircraft (fig. 29), which takes off and lands like a helicopter, but also rotates its rotors and engines and flies like a fixed-wing turboprop at twice the normal speed and range of a helicopter. This concept potentially could have a revolutionary impact on short-haul transportation. The V-22 Osprey version of the tiltrotor is currently under development for the military services (fig. 30). The Marine Corps will use it as their main troop transport for assault missions of up to 200 miles away. The Air Force will use it for special operations; the Navy will use the JVX for search and rescue as shown in figure 31.

The civil version of the V-22 Tilt Rotor could potentially carry 40 passengers (fig. 32). A range of vehicle sizes is being studied by NASA, FAA, and DOD to see

what implications this concept has for the civil market. Short-haul city center to city center travel as well as remote area markets are being evaluated.

A combined DARPA/NASA program with Sikorsky is evaluating a stopped-rotor concept using advanced technology. This aircraft (fig. 33) will take off like a helicopter and then in forward flight at about 200 knots the rotors will stop in the orientation shown and the wide-chord rotors will act as fixed wings. Much longer and faster trips will be possible with helicopters in the 21st century as a result of the development of this technology.

Lighter than Air (LTA) Vehicles

The Macon, a 1933 rigid technology airship, and the hangar in which it was housed (which still exists, near Ames Research Center) is shown in figure 34. Today there are new technological developments under way; the British Aerospace Industries 500 (fig. 35) and 600 models are using modern concepts in LTA vehicles about the same size as the Goodyear blimp. Because of the modern technology used, they can carry about twice the payload of the Goodyear blimp in the same-sized vehicle. They also require less ground handling and have more precision control because they have tiltable propellers as shown in figure 36. Goodyear is designing and building a new version of their blimp, again using a ducted prop for better control. The Navy has undertaken a major LTA feasibility study program; if this program is successful, they will begin a significant new LTA surveillance program. This LTA technology is also of interest to the Coast Guard.

Figure 37 shows a tethered aerostat used by the Coast Guard in the Caribbean which is deployable in half a day. Their payload is easily changed and they are also deployable from ships. One of these Coast Guard vehicles is located off the Florida keys at about 15,000-ft altitude. As mentioned earlier, the Air Force is planning to use tethered airships in their Caribbean radar network for the low-level radar coverage.

Figure 38 shows another application that is being actively developed: the use of an LTA vehicle to lift heavy payloads acting as an aerial crane. Today's best helicopter lift capability is under 20 tons but there are many containers and construction equipment that weigh much more. This has provoked the interest of entrepreneur's developments; one of these, the Cyclocrane (fig. 39), was developed in Oregon and funded by Canadian forest interests, the U.S. Forest Service, and DARPA. This concept operates similar to a tip-driven helicopter rotor, is very controllable, and shows a great deal of promise for operating as an aerial crane. Other LTA concepts that may become viable with time are the Van Dausen and the Helitruck.

Another significant growth area (because of the military interests in advancing the technology) will be civil versions of remotely piloted vehicles (RPVs). The advantages for using RPVs include remote operation from the ground, low cost (some use chain saw motors), small, sensor-carrying platforms, etc. The Department of Agriculture sees a great use of RPVs because water is becoming scarce and we can no

longer be inefficient in watering fields as we have been in the past. Sensors have been developed that can measure the plants' need for water.

Other applications for RPVs on the horizon include surveillance of fishing activities, very high-altitude, solar-powered RPVs that operate up to 90,000 ft (low-cost satellite-type missions), etc.

Used Aircraft Upgrading

Used aircraft technology upgrading is applicable to the developing regions. Modern conversions include interiors, avionics, engines which meet lower noise requirements, and piston-to-turboprop conversions which result in speed increases and higher productivity. Lines between military, commercial, and other government service are much broader in many foreign countries than in the U. S. Therefore, it is possible to certify an aircraft as a "public use aircraft," in which case it does not have to meet the FAA civilian air regulations.

Examples of Computer/Satellite Advances

One of the examples of computer and satellite advances impacting future aviation in the Caribbean Basin is the Global Positioning Satellite (GPS) concept. Eighteen satellites will be placed in orbit by the DOD and will enable a revolution in navigation techniques. With signals from any four of these satellites being accessible to an aircraft, very precise three-dimensional positioning is possible. Using advanced electronics, navigation routes can be programmed over time using this information. Utilizing a fixed, ground-reference transceiver, the civilian equipment could obtain accuracies of ±5 m. Therefore, accurate navigation will be available anywhere and the developing countries will not have to incur heavy expenses for ground infrastructure in order to establish an accurate navigation capability.

In communications, secure tracking and identification of aircraft will be possible and low-cost portable equipment will be available. Automated information systems blending and displaying navigation, terrain, traffic, and aircraft status data in order to generate trajectories or mission options are projected. Significantly better communications between aircraft and between aircraft and ground systems will be possible.

In complex maintenance problems, satellite linkages will be used to provide expert opinion to remote areas very economically. Knowledge-based expert computer systems can assist in providing information on how to maintain high-technology equipment. Computers will enable the rapid recovery from failures or errors by hypothesizing causes and recommending diagnoses to the flight personnel. In-flight plans for postflight maintenance, flight-line checkout, and in-flight monitoring of performance can be performed using computers. There will be large advances in visual aids assisting in maintenance and training. Natural language translators and user friendly computers will help solve some of the language-barrier problems.

Training will be greatly assisted by the growth of low-cost simulators for both pilots and support services personnel. Pilots will be able to be trained and flight-qualified without flying the aircraft. However, the potential negative impact of regulation in this area and others must be considered. Recent regulations obsoleted some older simulators which were being used for older aircraft.

Weather forecasting by computer is growing rapidly and it will enable en route forecasting and flightpath modification considering terrain and air traffic for optimum effectiveness.

Remote sensing will dramatically improve using spin-offs from military technology for effective crop, land, and resource management, etc.

Impact of Significant Trends in Technology

The major impacts of these technology trends on aviation in the developing regions will, if planned for and utilized properly in the region, offer the possibility of leap-frogging current technology to arrive in the 21st century without many of the major costs involved in present technology. The next-generation transport aircraft with improved infrastructure and management methods will provide lower-cost air transportation to the region from the U. S. and the rest of the world. The new short-haul air transportation capability, if looked at from an overall systems and intermodal viewpoint, can offer many unique economic development opportunities. Satellite technology will enable rapid, economical capabilities in many areas such as navigation, communications, weather forecasting, training, maintenance assistance, etc.

VI. ISSUES

1. The trade-off between the cost of using new technology versus using old or upgraded old technology.

2. The conflict between the desire to keep employment high versus reducing costs through ground infrastructure, including automation and fewer employees.

3. The tourism needs (modern equipment) versus the industrial development needs (workhorse vehicle).

4. Can costly new regulations (perfectly good old simulators for older aircraft cannot be used because of new regulations) be avoided?

5. Can the expense of product liability costs be reduced?

6. What can be done to facilitate appropriate military aviation related technology flowing to commercial interests in the region?

7. Will the major economic development agencies recognize aviation as a development tool?

8. Is the influence of soft financing and other incentives distorting the aircraft marketplace undesirably?

VII. BIBLIOGRAPHY

1. Boeing Commercial Airplane Co.: Civil Tiltrotor Missions and Applications: A Research Study. NASA Contract Report 177452, July 1987.

2. Christensen, J. V.; and Williams, L. J.: Future Rotorcraft and Short-Haul Airplane Transportation Opportunities. Conference on Planning for Rotorcraft and Commuter Air Transportation, Monterey, CA, Sept. 1981.

3. Cartaino, T. F.: Technological Aspects of Contemporary and Future Civil Aircraft for the World's Less-Developed Areas. Rand Corporation, RM-3060-RC, 1962.

4. Center for Strategic and International Studies: On the Wings of Development: Aviation and the Caribbean Basin. Washington, D.C. 1988.

5. De Neufville, R.; Ayala, U.; Acevedo, J.; and Mira, L.: Role of Air Transportation in Sparsely Developed Areas. Massachusetts Institute of Technology, NTIS N73-27880, 1973.

6. De Neufville, R.; Hoffmeister, J.; and Shpilberg, D.: Investment Strategies for Developing Areas: Models of Transport. Massachusetts Institute of Technology, 1973.

7. Department of Transportation: Special Transportation Problems of the American Pacific Islands. Report to Congress, 1985.

8. Gobetz, F. W.; Assarabowski, R. J.; and Leshane, A. A.: Applications of Advanced Transport Aircraft in Developing Countries. NASA Langley Research Center. May 1978 (2 volumes).

9. Jacabo, C. M.; and Ziman, D. B.: Lighter Than Air Vehicles an Attractive Alternative. Conference on Lighter Than Air Vehicles, Fifth Bi-Annual Conference, July 1983.

10. Maddalon, D. V.: Potential Applications of Advanced Aircraft in Developing Countries. Ninth International Forum for Air Cargo, Vancouver B.C., Canada, Sept. 1978.

11. McDonnell Douglas: The Airlines of Oceania: Micronesia, Melanesia, and Polynesia. Airline Market Planning Report C1-804-6944, 1982.

12. National Research Council: Aeronautics Technology Possibilities for 2000: Report of a Workshop. Aeronautics and Space Engineering Board, Washington, D.C., 1984.

13. Stockwell, W. L.: Proceedings on the Monterey Conference on Planning for Rotorcraft and Commuter Air Transportation. NASA Contractor Report 166440, 1983.

14. Sutter, J. F.: Risks and Rewards in Air Transportation Development. Annual DGLR Meeting, Hamburg, Germany, Oct. 1984.

TABLE 1.- AVIATION TECHNOLOGY HISTORY

1899	Wright Brothers build their first aircraft
1915	NACA established
1919	Nonstop crossing of the Atlantic
1920	First autogyro
1923	Nonstop transcontinental crossing of the U.S.
1927	Solo crossing of the Atlantic (33.5 hr)
1930	Coast to coast air service in U.S.
1936	Trans-Pacific air passenger service
1939	Turbojet flight
1947	Supersonic flight
1948	First turboprop airliner
1950	Nonstop jet transatlantic flight
1952	Transatlantic helicopter flight
1958	Jet passenger service across the Atlantic
1959	Nonstop flight between Moscow and New York
1960	Apollo project announced
1961	Manned orbital flight
1965	First "Space Walk"
1968	Manned flight to the moon (orbital)
1969	Prototype of supersonic transport
1970	First flights of 747 and DC-10
1972	American manned Space Station
1976	Supersonic transport service (1000 mph, 3.5 hr transatlantic)
1981	Prototype of the 767
1981	Reusable winged spaceship demonstration
1983	Flight of 757-200

TABLE 2.- CARIBBEAN AIRPORTS WITH MAJOR INTERNATIONAL PASSENGER TRAFFIC AND COMPARISONS

Country	City	International passenger traffic 1983, k
Bahamas	Nassau	137[a]
Barbados	Bridgetown	989
Dominican Rep.	Santo Domingo	1179
Bermuda	Hamilton	1015[b]
Puerto Rico	San Juan	1016[b]
Venezuela	Caracas	2360[b]
Mexico	Mexico City	3989[b]
United States	Honolulu	2181
	Los Angeles	4736[c]
	New York (Kennedy)	13637[c]
	Miami	7081

[a]Estimated 1981
[b]1981
[c]1982

TABLE 3.- MAJOR CARIBBEAN INTERNATIONAL FREIGHT TRAFFIC AIRPORTS - 1981

Airport	Air freight, ton
Bogota	107,000
Caracas	100,000 (est)
Mexico City	62,000
Panama	52,000
Santo Domingo	35,000
Port au Prince	28,000
Honolulu	206,000[a]

[a]1982

TABLE 4.- INTERNATIONAL PASSENGER AIR CARRIERS OF THE CARIBBEAN BASIN COUNTRIES

Source: World Aviation Directory (Summer 1985)

Country	Airline	Equipment	Location
Anguilla	---	---	---
Antigua and Barbuda	Lait Ltd.	6 Britten-Norman Islanders; 4 BAE HS-748; 4 DHC-6 Twin Otter (on lease); 1 Embraer Bandeirante	Coolidge Airport St. Johns Antigua, West Indies Tel: 046-20700
	Subsidiaries		
	Four Island Airways	3 Britten-Norman Islanders;	c/o Liat
	Inter Island Air Service	3 Britten-Norman Islanders; 1 Britten-Norman Trislander (leased)	c/o Liat
Bahamas	Bahamasair Holdings Ltd.	2 BAC 1-11-400; 3 B-737; 4 Hawker-Siddeley HS 748	Box N4881 Nassau - Bahamas Tel: 809 327-8451
Barbados	Caribbean Airways	1 DC-10	Low Bay St. Bridgetown, Barbados Tel: 42 69900
Belize	Maya Airways	4 Britten-Norman BN-2A; 3 Cessna 206	Box 458, 6 Fort St. Belize City, Belize Tel: 02 7215/2312

TABLE 4.- CONTINUED

Country	Airline	Equipment	Location
British Virgin Islands	Air BVI	3 Britten-Norman Islanders; 5 DC-3; 1 HS-748	Box 85 Road Town Tortola, British Virgin Islands Tel: 809 495-2346
Cayman Islands	Cayman Airways Ltd.	2 8-727-200; 1 Britten-Norman BN-2A; 1 Hawker-Siddeley HS 748-105	Box 1101 Owen Roberts Airport Flds - Grand Cayman Cayman Islands, BWI
Columbia	Aerolineas Centrales De Colombia	1 B-727; 1 Fokker F-28; 1 6 DHC-6-300 Twin Otters	Box 6503 Carrera 45, #54-63 Medellin, Columbia Tel: 2-314111
	Intercontinental De Aviacion	1 Vickers Viscount 700; 1 C-46	Carrera SA #18-85 Bogota, D.E. Columbia Tel: 833015
	Aerotal	2 B-707; 5 B-727-100	Ave Eldorado E-Z Bogota, D.E. Columbia Tel: 267-9200

TABLE 4.- CONTINUED

Country	Airline	Equipment	Location
	Avianca	1 B-747; 2 B-747M; 7 B-707; 7 B-7275; 11 B-727; On order: 3 B-767	Av. 26, #93-30 Bogota, D.E. Columbia Tel: 263-9511
	Sam (Subsidiary of Avianca)	5 B-727-100; 1 B-720B	Calle 52 #52-11 Nedellin, Columbia Tel: 315277
	Satena	4 Hawker-Siddeley HS 748; 2 DC-4; 7 DC-3	Box 11163 Carrera 14, #24-83 Bogota, D.E. Columbia Tel: 427190
	Tavina S.A.	2 De Havilland Twin Otter; 2 Embraer Bandeirantes	Calle 7 #31-10 P15010 Aparatado Aero 23563 Bogota, D.E. Columbia Tel: 232-6580
Costa Rica	LACSA	4 B-727-200; 2 DC-8-51F; On order: 2 B-757	Box 1531 1000 San Jose Costa Rica Tel: 323555

TABLE 4.- CONTINUED

Country	Airline	Equipment	Location
Cuba	Cubana Airlines	10 Llyushin IL-62M; 5 Tupolev TU-154; 8 Yaklovlev Yak-40; 4 Antonov AN-24; 2 Llyushin IL-18; 2 Llyushin 12-14; 3 AN-2	Calle 23 #64 La Rampa, Vedado, Cuba
Dominica	---	---	---
Dominican Republic	Dominicana De Aviacion c Por A	3 B-727; 2 DC-6; 1 B-707	Calle El Donde 83 Santo Dominigo, Dominican Republic Tel: 809 687-7111
El Salvador	Taca Int'l Airlines	2 B-737-200; 2 BAC 1-11; 1 Lockheed L-88 Electra	Altos Edificio Caribe San Salvador - El Salvador Tel: 232244
Guadeloupe	Air Guadeloupe Sub. Airfrance	4 DHC-6-300; 2 F-27J; 1 BN-2	Raizet Airport 97.110 Abymes Guadeloupe Tel: 832759/822161
Guatemala	Aviateca	2 B-727; 1 DC3	Avenida Hincapie Zone 13 Guatemala City, Guatemala Tel: 318222
Grenada	---	---	---

TABLE 4.- CONTINUED

Country	Airline	Equipment	Location
Guyana	Guyana Airways Corp.	2 B-707; 2 Hawker-Siddeley HS 748; 2 De Havilland Twin Otters; 1 DC-6F	Box 10223 32 Main St. Georgetown, Guyana Tel: 02 594-9015
Haiti	Air Haiti, S.A.	2 Curtiss C-46; 1 DC-8-55F	Francois Duvalier Airport - Port au Prince - Haiti, West Indies Tel: 62722/3
Honduras	Lansa	3 DC-3	Box 35 Laceiba, Honduras Tel: 42-235
	Sahsa	5 DC-3; 2 Electra L-1B8; 1 B 737-200	Box 129 Tegucigalpa, DC Honduras Tel: 331134
	Tan Airlines	1 B-737-200; 1 B-727-100; 2 Lockheed Electras	Edificia Tan Teguicigalpa, DC Tel: 331134
Jamaica	Air Jamaica Ltd.	4 B-727-200; 2 A300-B4-200	72-76 Harbour St. Kingston, Jamaica Tel: 922-3460

TABLE 4.- CONTINUED

Country	Airline	Equipment	Location
Martinique Islands	Air Martinique C.A.A.A.	1 DHC-6-200; 2 BN-2A; 1 Beech 99; 1 Piper Aztec	Aeroport de Fort de France 97232 Lamentin Martinique Tel: 790809
Mexico	Aeromexico	17 DC-9-30; 5 DC-8-51; 3 DC-10-30; 2 DC-10-15; 5 MD-80; DC-10-15	Paseo de la Forma #445 Mexico City 5, D.F. Mexico Tel: 05 286-4422
	Mexican Airlines	30 B-727-264A; 5 DC-10-15	Xola Ave. 535 03100 Mexico City D.F. Mexico Tel: 905 687-9722
Netherlands Antilles	Alm-Antillean Airlines	2 DC-9-30; 2 DC-9-80	Alm Building Aeropuerto Hato Curacao Netherlands Antilles Tel: 81322
Nicaragua	Aeronica	1 B-720; 1 B-727	APDO. 3688 Contiguo Aeropuerto International Managua-Nicaragua Tel: 02 40940

TABLE 4.- CONTINUED

Country	Airline	Equipment	Location
Panama	Air Panama International	2 B-727-100; On lease: 1 DC10-40	Apartado 8610 Panama City 5 Panama Tel: 272000
	Compania Panamena De Aviacion (Copa)	1 Lockheed L188A Electra; 1 B-737-112	Box 1572 Ave. Justo Aerosemena Panama City 1, Panama Tel: 274551
St. Christopher Nevis	---	---	---
St. Lucia	St. Lucia Airways	2 Britten-Norman BN-2A; 1 B-707-351-C; 1 Piper Navajo; 1 De Havilland Twin Otter; 1 Lockheed Hercules	Box 253 Castries St. Lucia Tel: 045-22686
St. Vincent	---	---	---
Suriname	Suriname Airways	2 De Havilland DHC-300; Twin Otters	Box 2029 Jodenbreestraat 65 Paramaribo, Suriname Tel: 73939

TABLE 4.- CONCLUDED

Country	Airline	Equipment	Location
Trinidad & Tobago	BW1A International Airline	4 DC-9-50; 1 DC-9-340F; 4 L1011-500; 5 Avro HS-748	Adminstration Building Piarco----- Trinidad, West Indies Tel: 809 664-4871/3
Turks & Caicos Islands	Turks & Caicos National Airlines	4 Britten-Norman BN2A; 2 Britten-Norman BN2A III; 1 Piper Aztec	P.M.B 12, Grand Turk Turk & Caicos Islands, BWI Tel: 809 946-2082
U.S. Virgin Islands	---	---	---
Venezuela	Aerovias Venezolanas	7 Convair CV-580; 3 DC-9-32; 4 B-727-200; 4 B-727-100	Box 943 Caralas, Venezuela Tel: 562-3022
	Linea Aeropostal Venez Olana	3 DC-9-31, 6 DC-9-51; 6 DHC Twin Otters	Centro Capriles P.H.
	Savar	3 B-737	Viatur, Edif. Parsa Plaza La Castallena Caracus, Venezuela Tel: 073-22668
	Viasa	5 DC-10-30; 1 DC-8-63; On lease: 1 DC-8-53F	Viasa Towers, Svr 25 Norelos Plaza Los Caobos, Caracus, Venezuela Tel: 572-9522

TABLE 5.- INTERNATIONAL AIR CARRIER EQUIPMENT INVENTORY BY MODEL.

AIRLINE	COUNTRY	JETS													TURBO PROP.											PISTON						TOTALS
		B707	B720	B727	B737	B747	A308	L1011	BAC11	F28	MD-88	USSR	DC-8	DC-9	DC-10	USSR	MG748	DHC-6	VCNT	EMB	L-100	F-27	BEECH	PIPER	HERC	CV500	C-286	BN-24	DC-3	DC-4	DC-6	C-46	
ACES	CO			1						1								16														18
AEROMEXICO	MX										5		5	17	6																	33
AERONICA	NI		1	1																												2
AEROTAL	CO	2		5																								3	5			7
AIR BVI	BVI																1											1				9
AIR GUADELOUPE	GD																	4				2									2	7
AIR HAITI	HA												1																			3
AIR JAMAICA	JA			4			2											1					1	1				2				6
AIR MARTINIQUE	MA														1																	5
AIR PANAMA INTL'	PA			2										4												7						3
ALM	NA													3																		18
AVENSA	VZ			8																								1				28
AVIANCA	CO	7		18		3																										3
AVIATECA	GT			2					2								4															9
BAHAMAS AIR	BH				3			4						5			5															14
BVIA	TR														1													1				1
CARIBBEAN AIRWAYS	BR																1															4
CAYMAN AIRWAYS	CI			2																	1											2
COPA	PA				1							23				11																34
CUBANA	CU																														2	6
DOMINICANA	DR	1		3																								3				3
FOUR ISLAND AIR	AT																2	2												1		7
GUYANA AIRWAYS	GY	2																										4				4
INTER ISLAND AIR	AT																		1											1		2
INTERCON AVIACION	CO												2																			6
LACSA	CR			4																								6				3
LANSA	HO																4	4		1									3			15
LIAT	AT													9				6									3	4					15
LINEA AEROPOSTAL	VZ																															7
MAYA AIRWAYS	BZ														5																	35
MEXICANA	MX			30																	2								5			8
SAHSA	HO				1																								7	2		6
SAM	CO		1	5													4															13
SATENA	CO																							1	1			2				3
SAVAR	VZ				3													1														6
ST. LUCIA AIRWAYS	SL	1																2														2
SURINAM AIRWAYS	SR																				1											5
TACA	ES				2				2												2											4
TAN	HO			1	1													2		2												4
TAVINA	CO																							1				6				7
TURKS & CAICOS AIR	TK												2		5																	7
VIASA	VZ																															
	TOTALS	13	2	86	11	3	2	4	4	1	5	23	10	38	18	11	21	38	1	3	6	2	1	3	1	7	3	32	21	2	3	3	270

TABLE 6.- REGIONAL PASSENGER AIR CARRIERS OF THE CARIBBEAN BASIN COUNTRIES

Source: World Aviation Directory (Summer 1985)

Country	Airline	Equipment	Location
Colombia	Aires	5 Embraer Bandeirates	Aptdo. Aero 44120 Carrera 13, No. 35-43 Bogota, Colombia Tel: 287-4414
	Tagua	7 Cessna Station Air 671; 3 Cessna Skyhawks; 1 Piper Turbo Lance II; 2 Piper Turbo Saratoga SP; 2 Cessna 404 Titans	Calle 40, No. 31-15 Villavicencio, Tel: 6537
	Transamazonica Ltd.	3 DC-3; 2 Britten-Norman Islanders; 4 Britten-Norman Trislander	Calle 38, No. 30A44 Villavicencio, Colombia Tel: 2345
Costa Rica	Sansa	2 Casa-212; 1 DC-3; 1 DC-8-55F; 3 Cessna 206	Apdo. 999 Centro San Jose, Costa Rica Tel: 237429
Dominican Republic	Aerolineas Domincanas	1 DC-3; 1 Martin 404; 1 Convair	Apdo. 202 Calle El Sol No. 62 Santiago, Dominican Republic Tel: 809-583-3410

TABLE 6.- CONTINUED

Country	Airline	Equipment	Location
	Alas Del Caribe C. Pora.	3 Britten-Norman BN2A; 1 DC-3	Aeropuerto Herrera Av. Luperon Santo Domingo, Dominican Republic Tel: 566-2141
Haiti	Haiti Air Inter	2 DC-3; 1 Britten-Norman BN Islander; 1 De Havilland DHC-6-200 Twin Otters	Box 985 Port Au Prince Haiti, West Indies Tel: 2-4797
Honduras	Aero Servicios	3 Piper Aztecs; 4 Cessna Skywagons; 1 Piper Apache	P.O. Box 543 Tocontin Intl Airport Tegucigalpa, Honduras Tel: 331-287
Jamaica	Express Air Ltd.		P.O. Box 14 Tinson Pen Aerodrome Marcus Garvey Dr. Kingston 10, Jamaica Tel: 809-923-6693
	Trans-Jamaican Airlines Ltd.	2 Britten-Norman Islanders; 1 Cessna Ad2C; 2 Cessna 206; 1 Cessna 182	Box 218 Montego Bay, Jamaica Tel: 809-952-0198

TABLE 6.- CONTINUED

Country	Airline	Equipment	Location
Mexico	Aero California	1 DC-9-15; 3 DC-3; 1 Convair 340; 1 Cessna 185 Skywagon; 1 Aerocommander 560	Centro Commercial Plaza Rio Tijuana, Baja California Norte Mexico
	Aero Caribe	1 Embraer Bandeirante; 1 Convair 440; 1 Convair 340	Local 10Y 11 Ave. Tulum Y Uxmal Cancun, I.R. Mexico Tel: 30394
	Aero Taxco	2 Britten-Norman BN-2B-27 Islanders	Aeropuerto De Taxco Taxco de Alarcon, Guerrero, Mexico
Netherlands Antilles	Windward Island Airways	2 De Havilland DHC-300 Twin Otters; 1 Britten-Norman	Box 288 Philipsburg, St. Maarten Netherlands Antilles Tel: 4210
Panama	Aeroperias	3 De Havilland DHC-6-300; 1 Convair 580; On Lease: 1 DHC-6-300	Aeropuerto de Paitilla Aptdo. 6-3596 Estafeta el Dorado, Panama City, Panama Tel: 69-4555

TABLE 6.- CONTINUED

Country	Airline	Equipment	Location
	Aerovias Darientas	5 Britten-Norman Islanders; 1 Britten-Norman Trislander; 1 Cessna 337; 1 Cessna Titan	Aptdo 7773 Paitilla Intl Airport Panama City 9, Panama Tel: 641531
	Alas Chiricanas	1 DC-3; 2 Embraer EMB-110	Paitilla Airport Panama City, Panama
	Compania Chitreana De Aviacion	2 DC-3	Aeropuerto de Paitilla Panama City, Panama Tel: 263-069
Puerto Rico	Flamenco Airways Inc.	4 Britten-Norman	Box 224 Culcebra, PR 00645 Tel: 809-725-7707
	Crown Air/Dorado Wings	2 Piper Navajos; 2 Beech Bonanzas; 1 Beech Airliner; 1 Beech Baron	Box 50 Dorado Beach Hotel Dorado, PR 00646 Tel: 809-796-1448
	Oceanaire Flight Services, Inc.	2 F-27; 1 Beech Queen Air; 2 Casa 212	International Airport Isla Verde, PR 00913 Tel: 809-728-6340

TABLE 6.- CONTINUED

Country	Airline	Equipment	Location
	Prinair	27 DH Heron 114; 4 Convair 580; 13 Casa 212; Recent Purchases: 4 Casa 212-200; 5 (option) Casa-Nurtanio CN 235	Intl. Airport Isla Verde, PR 00913
	Viesques Air Link Inc.	3 Britten-Norman BN-2A; 2 Piper Cherokee Six	Box 487 Viesques, PR 00765 Tel: 809-741-3991
Suriname	Gonini Air Service	1 Cessna 337; 2 Cessna U-206; Recent Purchase: 1 Hushkitted DC-8-63	Zorg en Hoop Airport Paramaribo, Suriname Tel: 99098
U.S. Virgin Islands	Aero Virgin Islands Corp.	5 DC-3	Box 546 Harry S. Truman Airport St. Thomas, V.I. 00801 Tel: 809-776-7725
	Coastal Air Transport	1 Beech D-55; 1 Britten-Norman BN-2A	P.O. Box 3985 Christiansted St. Croix, V.I. 00820 Tel: 809 778-1122

TABLE 6.- CONTINUED

Country	Airline	Equipment	Location
	Sunaire	1 Cessna 207; 1 Piper PA34 Seneca; 1 Piper PA31 Chieftan; 1 De Havilland DHC-6 Twin Otters; 1 Lear 35	P.O. Box 1686 Alexander Hamilton Airport Kingshill, St. Croix, V.I. 00850 Tel: 809 778-9200
	Virgin Air Inc.	3 Beech D-18; 1 Piper Apache; 3 Piper Aztecs; 2 DC-3; 1 Cessna 402B	Box 2788 St. Thomas, VI 00801 Tel: 809-776-2722
	Virgin Islands Seaplane Shuttle	4 Grumman G-73 Mallards; 2 Grumman G-73T Mallards; Recent Purchase: 5 Grumman Mallards with Upgraded Pratt and Whitney Turbo PT6-34 Engines	Seaplane Ramp Christiansted St. Croix, V.I. 00820 Tel: 809-773-3590
Venezuela	Aeronaves Del Centro	2 Short 330	Edif, Tecoteca, Terazza PH Ave. Fco. De Miranda, Los Palos Grandes 1062 Caracas, Venezuela Tel: 02-284-9542

TABLE 6.- CONCLUDED

Country	Airline	Equipment	Location
	Rutas Aeras Campania Anonima	1 Convair CV-440; 1 Convair CV-340; 4 DC-35; 1 Cessna 206; 1 Cessna 185; 1 Cessna Agwagon; 1 Hiller UH-12	Edificio Taller Mares Aeropuerto Ciudad Edo Bolivar, Venezuela

TABLE 7.- REGIONAL PASSENGER AIR CARRIER EQUIPMENT INVENTORY BY MODEL.

AIRLINE	COUNTRY	JETS			TURBO PROP.									PISTON										TOTAL
		DC8	DC9	LEAR 35	EMB	BM	CASA	CESSNA	DHC	F-27	CONVAIR	G-371	330	CESSNA	PIPER	DC3	MARTIN	CONVAIR	AEROCOM.	DH-114	BEECH	G-73	UM-12	
AERO CALIFORNIA	MX		1											1		3		1		1				7
AEROCARIBE	MX				1													2						3
AERO SERVICIOS	HO													4	4									8
AERO TAXCO	MX					2																		2
AERO VIRGIN ISLAND	USVI															5								5
AEROLINEAS	DR															1	1	1						3
AERONAVES	VZ												2											2
AEROPERIAS	PA								3			1												4
AEROVIAS DARIENTAS	PA					6								2										8
AIRES	CO				5																			5
ALAS CHIRICANAS	PA				2											1								3
ALAS DEL CARIBE	DR					3										1					1			4
COASTAL AIR	USVI					1										1								2
COMPANIA CHITREANA	PA															2					4			2
CROWN AIR	PR														2									6
EXPRESS AIR LTD.	JA																							4
FLAMENCO AIRWAYS	PR					4																		4
GONINI AIR SERVICE	SR	1												3										4
HAITI AIR INTL'	HA					1			1							2					1			5
OCEANAIRE	PR						2			2														53
PRIMAIR	PR						22				4									27			1	10
RUTAS AERAS CO.	VZ													3		4		2						7
SANSA	CR	1					2	3								1								5
SUNAIRE	USVI			1					1					1	2									15
TAGUA	CO													12	3									9
TRANSAMAZONICA	CO					6										3								6
TRANSJAMAICAN	JA					2								4										5
VIESQUES AIR LINK	PR					3									2						3			10
VIRGIN AIR	USVI												7	1	4	2						4		11
VIRGIN ISL' SEAPLANE	USVI									2														3
WINDWARD ISL' AIR	NA				1																		1	215
TOTAL		2	1	1	8	29	26	3	7	2	5	7	2	31	17	25	1	6	1	27	9	4	1	

TABLE 8.- AIR CARGO CARRIERS OF THE CARIBBEAN BASIN COUNTRIES

Source: World Aviation Directory (Summer 1985)

Country	Airline	Equipment	Location
Antigua & Barbuda	Avia Aero Services (Antigua) Ltd.	On Lease: 2 Jet Freighters	P.O. Box 1266 St. John's Antigua, W. Indies Tel: 24984
Barbados	Caribbean Air Cargo Co. Ltd.	2 B-707-351C	Grantley Adams Int'l Airport Christ Church Barbados Tel: 2417
Columbia	Aerolineas	3 DC-4	Aeropeurto Las Playas Medellin, Columbia Tel: 459728
	Aeronorte	3 Curtiss C-46; 1 DC-4	Aeropuerto Camilo Daza Cucuta, Colombia
	Aerosucre	2 Dart Herald 401; 1 Caravelle IOR; 1 Caravelle 11R	Apartado A23 Barranquilla, Colombia
	Arca Columbia	2 DC-8-43F; 1 DC-6B; 1 DC-3	Calle 19, No. 8-81, Officina 303 Bogota, Colombia

TABLE 8.-CONTINUED

Country	Airline	Equipment	Location
	Lineas Aereas Del Caribe	2 DC-8-54F; 2 DC-6	Calle 39, No. 41-31 Barranquilla, Colombia Tel: 319794
	Tampa Airlines S.A.	2 B-707-320C	Box 494 Aeropuerto Olaya Herrera Medellin, Colombia Tel: 558577
Costa Rica	Serca Costa Rica	1 DC-8-30; 1 Convair CV-880	Caixa Posta 6855 San Jose, Costa Rica
Dominican Republic	Aeronar, C. Por A.	2 DC-8F-54; 2 DC-8-33; 2 B-720-022	Aeropuerto Int'l Santo Domingo Dominican Republic Tel: 687-0281
	Aerotours Dominicano	2 Lockheed L-1049 Super Constellations	Aeropuerto Las Santo Domingo Dominican Republic
	Hispaniola	1 B-707-120; 1 B-720	Esquian 30 De Narzo Ave. 27 De Ferrero Santo Domingo Dominican Republic

TABLE 8.- CONTINUED

Country	Airline	Equipment	Location
El Salvador	AESA	2 DC-6A/B	P.O. Box 1830 Paseo General Escalon, Plaza Beethoven San Salvador El Salvador
Mexico	Aeroleon S.A.	1 DC-8-21	Puerta No. 9, Hangar 4 Mexico 9, DF - Mexico Tel: 905-763-4841
Netherlands Antilles	Caraibische	2 DC-6	Kaminda Michigan #3, Zeelandia Curacao Netherlands Antilles Tel: 37311
Panama	Transpana Airlines	1 DC-8-21F	P.O. Box 6895 Edif, Balmoral, Via Argentina 82-3 Panama City 5- Panama
Puerto Rico	Borin Quen Air	2 Cargo DC-3	Calle 4, DO No. 109 Extension Villamar Isla Verde, PR 00913 Tel: 809-791-5060

TABLE 8.- CONCLUDED

Country	Airline	Equipment	Location
	Caribbean Air Services	3 Curtis C-64; 3 Curtis C-47	San Juan International Airport San Juan, PR 00913 Tel: 809-791-1334
	San Juan Cargo	1 Douglas DC-3; 1 Beechcraft D-18	1174 Calle 30 S.E. Caparra Terrace Rio Piedras, PR 00921 Tel: 809-763-4898
Venezuela	Interamericana Cargo Venezuela	1 DC-8-30F	Aeropuerto Maiquetia Caracas, Venezuela

TABLE 9.- REGIONAL AIR CARGO CARRIER EQUIPMENT INVENTORY BY MODEL.

AIRLINE	COUNTRY	JETS					TURBO PROP			PISTON						TOTALS
		B-707	B-720	DC-8	CV-880	CARAVELLE	DART	401	L-1049	DC-3	DC-4	DC-6	C-46	C-47	BEECH D18	
AEROLEON S.A.	MX			1												1
AEROLINEAS	CO										3					3
AERONAR	DR		2	4												6
AERONORTE	CO										1		3			4
AEROSUCRE	CO					2	2									4
AERROTOURS	DR								2							2
AESA	ES											2				2
ARCA COLUMBIA	CO			2						1		1				4
AVIA AERO	AG			2												2
BORINQUEN AIR	PR									2						2
CARIBISCHE	NA											2				2
CARIBBEAN AIR CARGO	BR	2														2
CARIBBEAN AIR SERVICE	PR												3	3		6
HISPANIOLA	DR	1	1													2
INTERAMERICANA	VZ			1												1
LINEAS AEREAS	CO			2								2				4
SAN JUAN CARGO	PR									1					1	2
SERCA COSTA RICA	CR			1	1											2
TAMPA AIRLINES	CO	2														2
TRANSPANAMA AIR	PA			1												1
	TOTAL	5	3	14	1	2	2		2	4	4	7	6	3	1	54

TABLE 10.- HELICOPTER NON-SCHEDULED AND SPECIALTY AIR SERVICES

Source: World Aviation Directory (Summer 1985)

Country	Airline	Equipment	Type of service	Location
Columbia	Aeroexpreso	7 Hughes 500D	Air Taxi/Charter	Apdo. Aereo 6781 Bogota, Columbia Tel: 248-1761
	Helicopteros Del Valle Ltd. (Helivalle)	5 Bell 47G-A 5 Bell 206 1 Bell 212 2 Bell 206L	Air Taxi/Charter; Air Ambulance; Domestic Cargo Services and Air Freight Forwarding; Forestry; Offshore Oil Support	Office 202 Carrera 11 #86-60 Bogota-Colombia Tel: 257-4265
	Helicopteros Nacionales De Colombia S.A. (Helicol)	2 Bell 206 Jetrangers 3 Bell 205 3 Bell 204 2 Westwinds 5 De Havilland Twin Otters	Air Taxi/Charter; Maint.	Avienda Eldorado No. 93-30 Bogota-Colombia Tel: 263-7504
	Helicopteros Territoriales de Colombia (Helitec)	4 Bell 47-GA 2 Bell 47-J2A 1 Enstrom F28C2 1 Bell 204 B 1 Cessna 182	Air Taxi/Charter Geographical Survey; Offshore; Agriculture	Box 19415 Antiguo Airport Techo Bogota-Colombia Tel: 273-2449

TABLE 10.- CONCLUDED

Country	Airline	Equipment	Type of service	Location
Guatemala	Helicopteros De Guatemala	1 Aerospatiale AS-350B 1 Bell 205 1 Bell 47G 3 Bell 206 1 Texas WASP	Oil Industry Support	Zona 13, Aeropeurto LA Aurora Ave. Hincapie 23-30 Guatemala City-Guatemala Tel: 318282
Mexico	Aeropycsa	1 Bell 412	Air Taxi/Charter	Bosque Des Bosque De Lomas 11700 Mexico City, DF-Mexico Tel: 596-0955
	El Espacio	3 Hiller UH12E3 3 Bell 206B III	Air Taxi/Charter	AVDA Insurgentes Sur 568 03100 Mexico Tel: 5 543-6915
Venezuela	Aerotecnica	1 Soloy/Bell 47G-4A	Mountain Work; Rescue	Apdo. 60107 106 Caracas - Venezuela Tel: 303 587-4454

TABLE 11.- REGIONAL HELICOPTER NONSCHEDULED AND SPECIALTY AIR SERVICES EQUIPMENT INVENTORY BY MODEL.

AIRLINE	COUNTRY	HELICOPTERS															TOTAL
		AS-350B	BELL 47G	BELL 47J2A	BELL 204	BELL 205	BELL 206	BELL 212	BELL 412	CESS. 182	DHC	ENS. F28C2	HIL. UH12E3	TEXAS WASP	HU. 500D	WESTWIND	
AEROEXPRESO	CO														7		7
AEROPYCSA	MX								1								1
AEROTECNICA	VZ		1										3				6
EL ESPACIO	MX						3				5			1		2	15
HELICOL	CO				3	3	2										7
HELICOP. DE GUATE.	GT	1	1			1	3			1		1					9
HELITEC	CO		4	2	1												13
HELIVALLE	CO		5				7	1									59
	TOTAL	1	11	2	4	4	15	1	1	1	5	1	3	1	7	2	

TABLE 12.- AIR FREIGHT BETWEEN STATION PAIR

Source: Traffic by Flight Stage - 1982 ICAO Digest of Statistics

Country	Station pair	Distance, km	Airline	Freight, ton
Costa Rica	San Jose - Miami	1807	LACSA	4000
	San Jose - San Andres, Co.	397	LACSA	175
Dominican Republic	Santo Domingo - San Juan	376	American	2282
Guatemala	Guatemala City - Miami	1642	Aviateca	726
	Guatemala City - Miami	1642	Pan Am	2219
Haiti	Port Au Prince - San Juan	653	American	2655
Panama	Panama City - Lima	2357	Faucett	193
	Panama City - Los Angeles	4840	Varig	764
	Panama/Balboa-Manaus	2400	Varig	1712
	Panama/Balboa-Santiago	4819	Fast Air	1332
Puerto Rico	San Juan - Bogota	1766	Iberia	611
	San Juan - Madrid	6377	Iberia	582
	San Juan - Port Au Prince	653	American	1373
	San Juan - Santo Domingo	376	American	2245
Trinidad & Tobago	Port of Spain - Miami	2610	Pan Am	229
Venezuela	Caracas - Buenos Aires	5127	Pan Am	2251
	Caracas - Miami	2190	Pan Am	1301
	Caracas - New York	3403	Pan Am	5256
	Caracas - Quito	1744	Lufthansa	176
	Caracas - Sao Paulo	4400	Pan Am	617
	Maracaibo - Miami	1918	Pan Am	667

TABLE 13.- GENERAL IMPORTS/EXPORTS BY AIR TO THE U.S., 1984

Commodity		Value ($)	Weight (1000 lb)
Costa Rica			
U.S. imports			
Misc manufactured articles		57,407,122	6,388
Wear app and articles made of fur		54,922,880	6,068
Machinery and transport equip		23,472,487	362
Electric machinery, nspf and pts		22,261,353	337
Undergarments, knit		21,670,117	1,859
Electrical equip current carry		18,492,310	228
Fixed and variable resistors and pts		17,289,724	193
Outwear app, cot wool, mmf		16,134,091	1,774
Gar for rainwear		12,339,657	1,382
Crude materials, inedible		9,297,114	6,259
Animal and vegetable mtrl crude		9,007,041	6,258
Vegetable materials, nspf, crude		9,003,681	6,256
Food and live animals		7,774,161	7,450
Fish (include shellfish) and preps		7,292,125	4,022
	Total	286,363,863	48,836
U.S. exports			
Machinery and transport equip		43,169,501	3,346
Misc manufactured articles		42,797,602	6,845
Apparel articles and accessories		36,198,950	6,147
Electric equip nspf and parts		17,207,947	1,262
Mfrd goods by chief material		11,028,468	1,828
Electrical appar current carry		9,861,044	421
Yarn, fabric, and textiles		8,802,447	1,347
Resistors, fixed and variable; pts		7,806,450	137
Office machines and data proc		6,861,546	210
Coats, suits, knit (women)		6,738,114	1,220
Specialized industrial machinery		5,543,176	573
Robes, wm slacs, text not knit		4,933,346	1,108
	Total	200,948,591	24,444

TABLE 13.- CONTINUED

Commodity		Value ($)	Weight (1000 lb)
Dominican Republic			
U.S. imports			
Articles not provided for elsewhere		150,284,075	9,729
Gold, nonmonetary ex ores and concts		146,091,317	29
Misc manufactured artcls		103,907,989	10,733
Wear app and acces made of fur		81,211,022	9,549
Undergarments, knit		26,542,417	2,792
Machinery and transport equip		25,210,280	857
Outwear app, cot, wool, mmf		22,183,366	2,967
Misc manufactured articles		19,673,240	565
Electrical machinery		18,181,303	780
Jewelry and related articles		16,605,066	16
Manufactured goods by chief mtrls		15,557,854	2,632
Food and live animals		7,097,327	31,166
Vegetables and fruits		4,664,019	29,184
Fresh veg; dried legum veg		3,896,211	21,162
Vegetables, nspf, frsh, chill, frzn		3,673,307	19,628
	Total	644,778,793	141,789
U.S. exports			
Misc manufactured articles		47,412,940	8,048
Machinery and transport equipment		44,245,657	3,572
Apparel articles and acces		36,822,814	6,256
Manufactured goods by chief mtrl		21,564,740	5,350
Electric equip and electric parts		17,485,503	1,356
Undergarments		17,450,516	2,196
Yarn, fabric, and articles, textiles		11,997,826	3,228
Office machines and auto data equip		10,537,656	293
Coats, suits, etc., nonknit, women's		8,782,615	1,825
Electrical machinery and apparatus		8,636,518	584
Parts of ADP and calc office mchns		8,458,437	151
Ferrites, elec mach and equip		8,232,770	521
Elect appar, current carry; resist		7,720,020	639
Elect current carrying wiring devices		7,591,225	635
	Total	256,939,237	34,654

TABLE 13.- CONTINUED

Commodity	Value ($)	Weight (1000 lb)
Guatemala		
U.S. imports		
Crude mtrls, inedible/not fuel	11,804,087	3,979
Manufactured goods by chief mtrl	6,795,668	385
Metalliferous ores and scrap	6,222,869	86
Prec mtls, ores, cncntrts, swpgs	6,222,869	86
Metals, nonferrous	5,972,408	63
Silvr, plat, plat gp	5,972,408	63
Silvr, unwr and ref sil bln	5,972,408	63
Animal and vegetable materials	5,570,319	3,882
Vegetable materials, crude	5,559,719	3,880
Misc manufactured articles	4,411,831	660
Wear app and acces made of fur	3,959,653	506
Vegetables and fruits	2,164,339	5,541
Veg, frsh, etc.; dried legum veg	2,070,141	5,260
Vegetables, frsh, chill, frzn	2,061,973	5,215
Total	74,760,692	29,669
U.S. exports		
Machinery and transport equipment	23,849,687	2,171
Misc manufactured articles	10,554,103	1,829
Chemicals and related products	8,547,099	569
Specialized industrial machinery	6,367,892	703
Medicinal and pharmaceutical products	5,768,229	159
Office machines and auto data proc equip	4,462,070	183
Comm and trans not specified elsewhere	3,825,535	1,124
Apparel articles and accessories	3,516,807	1,016
Manufactured goods by chief mtrl	3,044,091	841
Antibiotics, in bulk	2,955,927	36
Misc manufactured articles	2,899,333	508
Civil engineer and contractors equip	2,847,088	349
Power generating machinery and equip	2,842,475	211
Parts of construction and mining machy	2,813,390	346
Industrial machinery, nspf; and mach pts	2,801,754	291
Total	87,095,480	10,336

TABLE 13.- CONTINUED

Commodity		Value ($)	Weight (1000 lb)
Haiti			
U.S. imports			
Machinery and transport equipment		77,839,515	8,041
Electrical machinery, nspf and pts		73,710,727	7,771
Misc manufactured articles		73,695,048	13,111
Wear app and acces and fur articles		48,077,100	6,335
Elect current carry, resist, etc.		34,463,146	3,345
Elect current carry wiring dev and pts		22,824,272	2,778
Manufactured goods by chief material		22,439,493	3,590
Misc manufactured articles		18,709,670	4,851
Non-rotating elect power equip and pts		16,950,474	1,711
Undergarments, knit		15,318,073	1,890
Leather, lea mfrs, and drssd furskin		14,647,572	2,650
Leather manufactures		14,028,728	2,555
Food and live animals		5,387,454	19,022
Vegetables and fruits		3,558,164	18,495
Fruits and nuts, prepared		3,512,664	18,146
Fruit, fresh or dried		3,428,942	17,768
	Total	448,591,042	132,059
U.S. exports			
Machinery and transport equipment		74,452,477	7,888
Elect equipment and parts		52,506,105	4,982
Misc manufactured articles		28,368,773	6,299
Elect apparatus, current carry; resist		20,326,820	1,470
Manufactured goods by chief material		18,276,528	4,726
Elect current carry wiring dev and pts		17,678,118	1,401
Apparel articles and accessories		16,608,559	3,746
Yarn, fabric, and articles, textiles		11,428,188	2,478
Electronic components and parts		10,952,568	896
Specialized industrial machinery		10,128,186	1,419
Misc manufactured articles		8,836,743	1,587
Specialized industrial machinery		7,931,831	934
Comm and trans not specified elsewhere		7,478,163	3,297
Electrical distributing equipment		7,315,894	743
	Total	292,288,953	41,866

TABLE 13.- CONTINUED

Commodity	Value ($)	Weight (1000 lb)
Panama		
U.S. imports	22,846,878	418
Articles not provided for elsewhere	13,796,158	3
Gold, nonmonetary, ex ores and concts	9,853,452	811
Misc manufactured articles	8,975,646	376
Special transactions	8,975,646	376
Special transactions	7,278,518	48
Manufactured goods by chief materials	5,776,359	649
Wear app and acces and fur articles	5,241,366	14
Nonmetalic mineral manufactures	5,228,823	10
Stones, prls, precious and semiprecious	4,384,542	1,607
Food and live animals	3,629,842	1,337
Fish (including shellfish) and preps	3,188,273	969
Shellfish, fresh, frozen, salted, dry	412,356	365
Fish, fresh, chilled, or frozen	131,980	246
Vegetables and fruits	131,980	246
Veg, frsh, etc.; dried legum veg		
Total	99,851,819	7,475
U.S. exports	56,786,117	3,364
Machinery and transport equipment	26,606,864	2,628
Misc manufactured articles	22,423,734	1,896
Comm and trans not classified elsewhere	17,528,915	932
Chemicals and related products	15,112,065	543
Medicinal and pharmaceutical prdcts	13,203,216	3
Nonmonetary gold, except ores etc.	12,660,551	426
Office machines and auto data proc	11,468,285	170
Transport equipment	11,049,720	108
Aircraft; spacecraft; and assoc equip	10,952,841	93
Parts of aircraft and spacecraft	9,400,976	920
Apparel articles and accessories	8,341,278	417
Telecom and sound reprod equipment	8,261,944	323
Medicinal etc. products, mixed or doses	7,854,087	361
Telecom equip, TV, radio pts		
Total	231,650,593	12,184

TABLE 13.- CONTINUED

Commodity	Value ($)	Weight (1000 lb)
Trinidad Tobago		
U.S. imports		
Articles not provided for elsewhere	5,642,879	172
Special transactions	5,576,576	160
Misc manufactured articles	2,489,695	121
Misc manufactured articles	2,450,181	118
Manufactured articles	2,270,253	90
Orthopedic articles, hearing aids, etc.	2,259,310	87
Food and live animals	833,124	215
Fish (including shellfish) and preps	673,564	161
Shellfish, fresh, frozen, salted, dry	605,720	131
Office machines and data proc equip	135,720	Not specified
Parts of office machines and adp machs	131,457	Not specified
Electrical machinery and parts	128,157	1
Elect eq current carry; resistors	127,273	Not specified
Printed circuit boards	127,273	Not specified
Total	23,451,182	1,256
U.S. exports		
Machinery and transport equipment	67,637,406	5,301
Misc manufactured articles	22,157,529	2,912
Specialized industrial machinery	21,903,429	1,939
Civil engineer and contractor's equipment	15,507,872	1,342
Parts of construction and mining machns	15,316,345	1,333
Office machines and data proc equip	9,066,086	350
Industrial machinery and machine parts	8,740,275	1,098
Comm and trans not specified elsewhere	8,604,497	2,124
Misc manufactured articles	8,583,018	1,979
Food and live animals	7,355,730	8,031
Manufactured goods by chief materials	7,211,027	21,126
Transport equipment	6,963,816	110
Aircraft; spacecraft; and assoc equip	6,873,835	103
Chemicals and related products	6,747,859	1,149
Bird's eggs... fresh, dried, preserved	5,492,958	5,406
Total	57,665,951	14,915

TABLE 13.- CONCLUDED

Commodity	Value ($)	Weight (1000 lb)
Venezuela		
U.S. imports		
Articles not provided for elsewhere	90,876,604	1,023
Gold, nonmonetary, ex ores and concts	54,504,061	14
Special transactions	36,052,297	774
Food and live animals	34,151,047	34,213
Fish (including shellfish) and preps	27,593,998	9,726
Shellfish, fresh, frozen, salted, dry	19,020,297	5,320
Misc manufactured articles	6,894,901	1,013
Chemicals and related products	6,480,120	217
Manufactured goods by chief matrls	6,366,483	948
Inorganic chemicals	6,072,805	90
Vegetables and fruits	5,143,792	24,377
Fruits and nuts, prepared or preserved	4,798,315	23,496
Nonmetallic nminerals manufactured	3,743,759	14
Stones, pearls, precious and semiprec	3,732,897	Not specified
Diamonds, ex indtrl, not set or strung	3,526,088	Not specified
Total	308,957,464	101,225
U.S. exports		
Machinery and transport equipment	365,975,521	20,071
Misc manufactured articles	100,884,609	4,913
Office mach and auto data proc equip	99,977,061	2,528
Auto data proc (adp) machines	67,923,646	1,717
Specialized industrial machinery	57,244,893	4,132
Power generating machinery and equip	54,439,590	2,531
Chemicals and related products	52,488,348	4,571
Prof, scientific and control instruments	46,176,193	1,325
Industrial machinery and parts	40,805,156	2,903
Electrical equipment and parts	40,032,500	2,595
Measuring, checking etc. instruments	38,656,911	1,056
Measuring, controlling instruments	37,134,007	957
Internal combust piston engines and pts	36,920,401	2,117
Civil engineer and contractor equipment	35,927,369	2,701
Parts of constr and mining machines	35,879,076	2,695
Total	1,110,465,281	56,812

TABLE 14.- PASSENGER VOLUME TO AND FROM THE CARIBBEAN BASIN REGION

From	To	Passengers
Caribbean to U.S.A.		
Antigua		
Saint John	New York	58,779
	Miami	15,339
Bahamas		
Freeport	Miami	140,291
	Fort Lauderdale	25,923
	New York	10,184
	West Palm Beach	6,496
Nassau	Miami	200,398
	New York	72,732
	Atlanta	58,165
	Fort Lauderdale	29,511
	Dallas	8,022
Barbados		
Bridgetown	New York	58,608
	Miami	54,032
Belize		
Belize	Miami	25,648
Bermuda		
Bermuda	New York	171,551
	Boston	110,633
	Atlanta	56,199
	Baltimore	31,475
	Philadelphia	26,949
Colombia		
Barranquilla	Miami	18,980
Bogota	Miami	51,898
	Los Angeles	3,902
	New York	2,128
Cali	Miami	6,979
Nedellin	Miami	9,532
Costa Rica		
San Jose	Miami	71,064
Dominican Republic		
Santo Domingo	Miami	79,156
	New York	76,697
El Salvador		
San Salvador	Miami	4,895
Guadeloupe		
Point a Pitre	New York	22,164
Guatemala		
Guatemala City	Miami	72,795
	Houston	3,860
Guyana		
Georgetown	New York	13,428

TABLE 14.- CONTINUED

From	To	Passengers
Haiti		
Port au Prince	Miami	71,927
	New York	49,597
Honduras		
San Pedro Sula	Miami	19,643
Jamaica		
Kingston	Miami	84,258
	New York	53,761
Montego Bay	Miami	59,483
	Atlanta	7,966
Mexico		
Acapulco	Dallas	59,700
	Los Angeles	35,337
	Houston	22,984
	Chicago	11,844
Cancun	New Orleans	40,323
	Dallas	31,386
	Houston	14,344
	Chicago	11,445
	Atlanta	9,583
	New York	4,002
Cozumel	Houston	13,865
	Chicago	13,432
	Dallas	9,045
	New York	7,603
Guadalajara	Los Angeles	45,165
	Dallas	25,621
	Chicago	15,651
	McAllen, TX	7,604
	Houston	5,621
	El Paso	3,199
Mazatlan	Phoenix	13,107
	El Paso	8,019
Merida	New Orleans	17,730
	Houston	13,614
Mexico		
Mexico City	Houston	174,176
	Dallas	114,887
	Los Angeles	108,933
	Miami	99,123
	New York	54,752
	Atlanta	53,543
	McAllen, TX	33,425
	San Antonio	29,339
	New Orleans	26,786
	Chicago	25,785
	San Diego	24,743
	Tampa	22,068
Monterrey	Houston	30,758

TABLE 14.- CONTINUED

From	To	Passengers
Netherland Antilles		
Aruba	Miami	38,624
Curacao	New York	45,061
Saint Martin	Miami	28,392
Panama		
Panama/Balboa	Miami	148,521
	New York	15,120
	Los Angeles	9,417
	New Orleans	7,466
Trinidad and Tobago		
Port of Spain	Miami	5,137
Turks and Caicos		
Grand Turk	Miami	2,140
Venezuela		
Caracas	Miami	156,091
	New York	68,383
	Los Angeles	15,323
Maracaibo	Miami	30,690
	New Orleans	15,972
Caribbean to Canada		
Antigua		
Saint John	Toronto	7,934
Bahamas		
Freeport	Toronto	6,098
	Montreal	4,079
Nassau	Toronto	15,435
	Montreal	4,263
Barbados		
Bridgetown	Toronto	20,704
	Montreal	7,003
Bermuda		
Bermuda	Toronto	25,455
	Halifax	2,136
Cuba		
Havana	Toronto	8,025
Guadeloupe		
Point a Pitre	Montreal	3,123
Haiti		
Port au Prince	Montreal	12,163
Jamaica		
Kingston	Toronto	31,450
Montego Bay	Montreal	4,809
Martinique		
Fort de France	Montreal	16,708
Mexico		
Mexico City	Montreal	33,781
	Vancouver	18,326

TABLE 14.- CONTINUED

From	To	Passengers
Trinidad and Tobago Port of Spain	Toronto	20,845
	Caribbean to South America	
Colombia Bogota	Lima (Peru)	20,678
	Quito (Brazil)	18,865
	Guayaquil (Ecuador)	16,230
	Manaus (Brazil)	12,792
Cali	Guayaquil (Ecuador)	4,860
French Guiana Cayenne	Belem (Brazil)	3,660
Mexico Mexico City	Lima (Peru)	23,304
Netherland Antilles Aruba	Quito (Brazil)	2,884
Curacao	Guayaquil (Ecuador)	4,495
Panama Panama/Balboa	Lima (Peru)	25,869
	Guayaquil (Ecuador)	16,110
	Quito (Brazil)	9,767
	Rio de Janiero (Brazil)	12,348
Venezuela Caracas	Rio de Janiero (Brazil)	26,362
	Manaus (Braz)	12,991
	Buenos Aires (Argen)	10,900
	Quito (Brazil)	4,942
	Belem (Brazil)	4,428
	Guayaquil (Ecuador)	2,184
	Caribbean to Europe	
Antigua Saint John	London	32,355
Barbados Bridgetown	London	39,598
Bermuda Bermuda	London	44,166
Cuba Havana	Madrid	18,786
Dominican Republic Santo Domingo	Madrid	21,816
Mexico Mexico City	Madrid	20,360
Netherland Antilles Curacao	Amsterdam	14,501

TABLE 14.- CONTINUED

From	To	Passengers
Puerto Rico		
San Juan	Madrid	41,909
	Frankfurt	26,723
	London	18,686
Suriname		
Paramaribo	Amsterdam	11,626
Trinidad and Tobago		
Port of Spain	Amsterdam	13,386
Venezuela		
Caracas	Milan	26,209
	Zurich	19,924
	Frankfurt	13,658
	Amsterdam	13,086
	Rome	5,254
	In the Caribbean	
Antigua		
Saint John	Saint Martin (NA)	23,738
	Saint Kitts (SCN)	20,084
	Bridgetown (Barb)	19,399
	Point a Pitre (Guad)	15,940
Bahamas		
Nassau	Kingston (JA)	15,652
Barbados		
Bridgetown	Saint Lucia	42,182
	Saint Vincent	36,599
	Grenada	13,057
Belize		
Belize	Tegucigalpa (HO)	5,160
Bermuda		
Bermuda	Nassau (BA)	22,504
	Kingston (JA)	4,758
Colombia		
Barranquilla	Panama/Balboa	27,981
	Maracaibo (VZ)	26,024
Bogota	San Juan (PR)	55,014
	Panama/Balboa	47,746
	Mexico City	10,276
	Caracas (VZ)	3,916
Cali	Panama/Balboa	8,832
Cartagena	Panama/Balboa	6,020
Costa Rica		
San Jose	Panama/Balboa	31,126
	San Salvador	29,546
	Guatemala City	7,323
	San Juan	6,790
	Aruba	5,223
	Havana	4,886

TABLE 14.- CONTINUED

From	To	Passengers
Cuba		
Havana	Managua	6,932
	Panama/Balboa	4,588
Dominica		
Dominica	Point a Pitre (Guad)	14,396
	Fort de France (Mar)	8,712
Dominican Republic		
Santo Domingo	San Juan	64,936
	Port au Prince (HA)	25,831
	Panama/Balboa	13,909
El Salvador		
San Salvador	Mexico City	38,895
	San Jose (CR)	30,939
	San Pedro Sula (HA)	8,915
Grendad		
Grenada	Port of Spain (TR)	27,746
	Bridgetown (Bar)	16,592
	Saint Vincent	13,350
Guadeloupe		
Point a Pitre	Saint John (Ant)	15,530
	Dominica	12,251
	Saint Croix (USVI)	11,128
Guatemala		
Guatemala City	Mexico City	21,826
	Merida (Mex)	14,445
	Panama/Balboa	9,460
	San Jose (CR)	7,586
	San Salvador	7,275
	Cancun (Mex)	4,742
Haiti		
Port au Prince	Santo Domingo (DR)	31,073
Honduras		
San Pedro Sula	San Salvador	10,609
Tegucigalpa	Belize	10,894
Jamaica		
Kingston	Nassau	16,380
	Panama/Balboa	7,670
Martinique		
Fort de France	Saint Lucia	24,730
	Saint Croix (USVI)	15,006
	Dominica	12,305
Mexico		
Cancun	Guatemala City	4,531
Merida	Guatemala City	13,092
Mexico City	San Salvador	39,353
	Guatemala City	25,979
	Panama/Balboa	16,897
	Bogota (Col)	7,891

TABLE 14.- CONTINUED

From	To	Passengers
Netherland Antilles		
Aruba	Caracas (VZ)	7,697
	Panama/Balboa	5,716
	Port of Spain (TR)	5,183
Curacao	Caracas (VZ)	26,186
	Panama/Balboa	12,589
	San Jose (CR)	5,219
Saint Martin	Saint John (Ant)	79,475
	Saint Kitts (Scn)	13,825
	San Juan (PR)	12,628
	Saint Thomas (USVI)	6,873
Nicaragua		
Managua	San Jose (CR)	6,743
Panama		
Panama/Balboa	Bogota (CO)	49,800
	San Jose (CR)	34,658
	Barranquilla (CO)	24,968
	Cuaracao (NA)	18,486
	Mexico City	18,435
	Caracas (VZ)	13,662
	Santo Domingo (DR)	12,764
	Guatemala City	9,803
	Cali (CO)	9,726
	Kingston (JA)	7,519
	Caratagena (CO)	6,542
	Havana	3,411
Puerto Rico		
San Juan	Santo Domingo (DR)	64,589
	Bogota (CO)	50,961
	Caracas (VZ)	38,697
	Saint Martin (NA)	10,664
	Port of Spain (TR)	5,437
	San Salvador	4,939
St. Christopher		
Saint Kitts	Saint Martin (NA)	15,379
	Saint John (Ant)	14,584
Saint Lucia		
Saint Lucia	Bridgetown (Bar)	44,676
	Fort de France (Mar)	27,213
	Point a Pitre (Guad)	2,155
Saint Vincent		
St. Vincent	Bridgetown (Bar)	31,938
	Grenada	19,738
	Port of Spain (TR)	8,564

TABLE 14.- CONTINUED

From	To	Passengers
Trinidad and Tobago		
Port of Spain	Bridgetown (Bar)	77,143
	Grenada	26,722
	Curacao (NA)	17,875
	Saint Vincent	11,653
	San Juan	4,876
	Point a Pitre (Guad)	2,243
Turks and Caicos		
Grand Turk	Puerto Plata (DR)	14,101
U.S. Virgin Islands		
Saint Croix	Fort de France (Mar)	14,169
	Point a Pitre (Guad)	10,112
Saint Thomas	Saint Martin (NA)	6,441
Venezuela		
Caracas	San Juan (PR)	39,677
	Panama/Balboa	15,753
	Curacao (NA)	15,492
	Aruba (NA)	14,176
	Port of Spain (TR)	7,636
	Bogota (CO)	4,054
Maracaibo	Barranquilla (CO)	28,531
	Cartagena (CO)	9,626
South America to the Caribbean		
Bolivia		
Santa Cruz	Panama/Balboa	19,885
Brazil		
Belem	Caracas	5,061
Manaus	Bogota	13,926
	Caracas	13,024
	Panama/Balboa	4,368
Rio de Janiero	Caracas	26,081
	Panama/Balboa	10,440
Ecuador		
Guayaquil	Bogota	17,939
	Cali	2,249
	Curacao	5,041
	Panama/Balboa	17,514
Peru		
Lima	Bogota	21,644
	Mexico City	25,136
	Panama/Balboa	24,664

TABLE 14.- CONTINUED

From	To	Passengers
Europe and Canada to the Caribbean		
Netherlands		
Amsterdam	Aruba	412
	Caracas	724
	Curacao	3,470
	Paramaribo	6,259
Federal Republic of Germany		
Frankfurt	Caracas	13,758
	San Juan	24,247
England		
London	Bermuda	44,154
	Bridgetown	43,587
	Nassau	2,743
	Saint John (Ant)	32,342
	Saint Lucia	455
	San Juan (PR)	17,720
Spain		
Madrid	Caracas	33,238
	Havana	17,442
	Mexico City	21,047
	San Juan (PR)	43,499
	Santo Domingo	20,295
Portugal		
Lisbon	Aruba	952
	Caracas	60,121
	Curacao	4,695
	Port of Spain	15,958
Italy		
Milan	Caracas	25,823
Rome	Caracas	4,705
Switzerland		
Zurich	Caracas	133
	Curacao	127
Canada		
Halifax	Bermuda	2,062
Toronto	Bermuda	25,909
	Bridgetown	14,469
	Havana	7,530
	Kingston	1,516
	Nassau	12,835
	Saint John (Ant)	8,008
Montreal	Bridgetown	11,686
	Fort de France	3,023
	Mexico City	36,445
	Nassau	5,450
	Point a Pitre	16,899
	Port au Prince	10,069
Vancouver	Mexico City	17,148

TABLE 14.- CONTINUED

From	To	Passengers
U.S.A. to the Caribbean		
U.S.A.		
Atlanta, GA	Bermuda	56,113
	Cancun	7,667
	Mexico City	56,038
	Nassau	57,982
Baltimore	Bermuda	33,976
Chicago	Acapulco	9,998
	Guadalajara	8,356
	Mexico City	32,309
	Puerto Vallarta	6,029
Dallas	Acapulco (Mex)	49,560
	Cancun (Mex)	23,334
	Cozunel (Mex)	15,114
	Guadalajara (Mex)	26,474
	Mexico City	122,609
	Nassau	8,786
	Puerto Vallarta (Mex)	5,233
El Paso	Guadalajara (Mex)	4,215
	Mazatlan (Mex)	16,705
	Puerto Vallarta (Mex)	3,941
Fort Lauderdale	Nassau	29,884
Houston	Acapulco (Mex)	21,573
	Cancun (Mex)	25,392
	Cozumel (Mex)	11,042
	Guadalajara (Mex)	2,064
	Guatemala City	3,424
	Manzanillo (Mex)	2,596
	Merida (Mex)	2,515
	Mexico City	182,594
	Monterrey (Mex)	30,179
	Puerto Vallarta (Mex)	13,645
Los Angeles	Bogota	3,517
	Caracas	14,641
	Guadalajara	63,623
	Guatemala City	2,516
	Mexico City	130,955
	Panama/Balboa	10,131
	Puerto Vallarta	15,500
McAllen, TX	Guadalajara	8,293
	Mexico City	44,196
Miami	Aruba (Neth Ant)	35,641
	Barranquilla (Colom)	3,761
	Bogota	52,830
	Bridgetown	51,391
	Cali (Colom)	7,979
	Caracas	162,693

TABLE 14.- CONCLUDED

From	To	Passengers
Miami	Grand Turk (Turk and Caicos)	11,940
	Guatemala City	69,556
	Kingston (Jamaica)	57,939
	Maracaibo (Venez)	31,497
	Medellin (Colombia)	8,934
	Mexico City	104,554
	Nassau	185,505
	Panama/Balboa	155,882
	Port au Prince (Haiti)	74,124
	Port of Spain (Trinidad)	4,190
	Puerto Plata (Mex)	14,673
	Saint John (Ant)	14,154
	Saint Martin (Neth Ant)	25,280
	San Jose	70,064
	San Pedro Sula (Haiti)	18,151
	San Salvador	3,442
	Santo Domingo (Domin Rep)	75,026
	Tegucigalpa (Honduras)	12,496
New Orleans	Cancun (Mex)	19,515
	Maracaibo (VZ)	13,879
	Merida (Mex)	37,538
	Mexico City	23,965
	Panama/Balboa	6,293
New York	Aruba	46,898
	Bermuda	175,614
	Bogota	2,380
	Bridgetown	58,892
	Cancun	10,056
	Caracas	65,572
	Fort de France	19,637
	Georgetown (Guyana)	7,929
	Mexico City	67,003
	Montego Bay (JA)	50,556
	Nassau	75,042
	Panama/Balboa	12,528
	Point a Pitre (Guad)	2,709
	Port au Prince (Haiti)	43,005
	Puerto Plata (Dom Rep)	31,685
	Saint Martin	57,666
	Santo Domingo	72,406
Philadelphia	Bermuda	23,298
Phoenix	Mazatlan (Mex)	21,037
	Puerto Vallarta	4,928
San Antonio, TX	Mexico City	36,914
San Diego	Mexico City	28,554
Tampa	Mexico City	22,614

TABLE 15.- SOME RECENT AIRCRAFT PURCHASES IN THE CARIBBEAN

Country	Airline	Equipment
U.S. Virgin Islands	Virgin Island Seaplane Shuttle	5 Grumman Mallards with Upgraded Pratt and Whitney Turbo PT6-34 Engines 2 De Havilland Dash 6's
	Leeward Islands Air Transport	5 De Havilland Dash 8's 2 British Aerospace Advanced Turbo-Prop Airline (Options for 2 more) 4 British Aerospace Super 748's
Puerto Rico	Prinair (now bankrupt) (Puerto Rico)	10 Casa 212-200's 5 (option) CASA-Nurtanio CN-235 (underdevelopment)
Suriname	Suriname Airways	1 Hushkitted DC-8-63 (used)

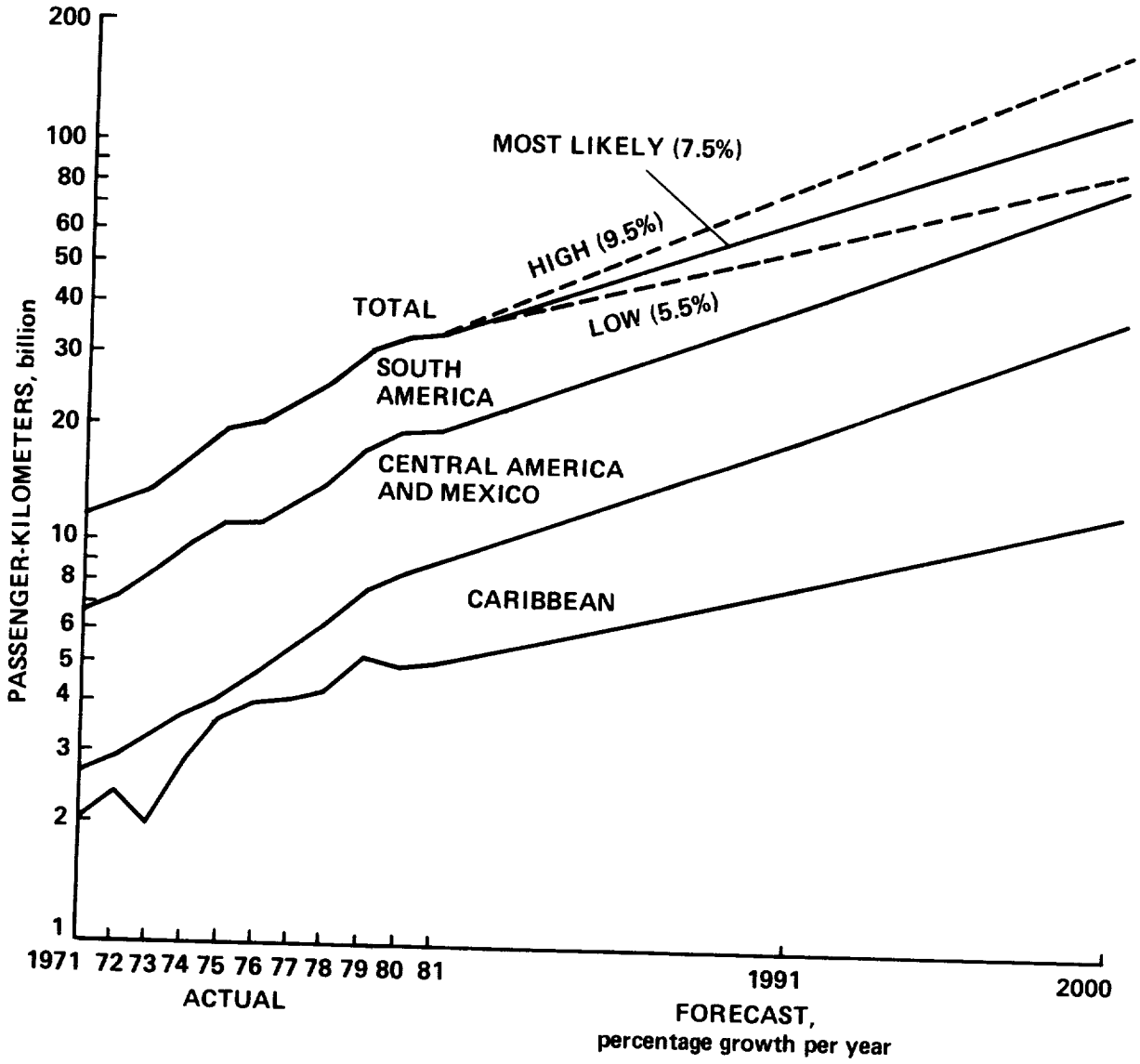


Figure 1.- Scheduled airline international passenger traffic forecast.

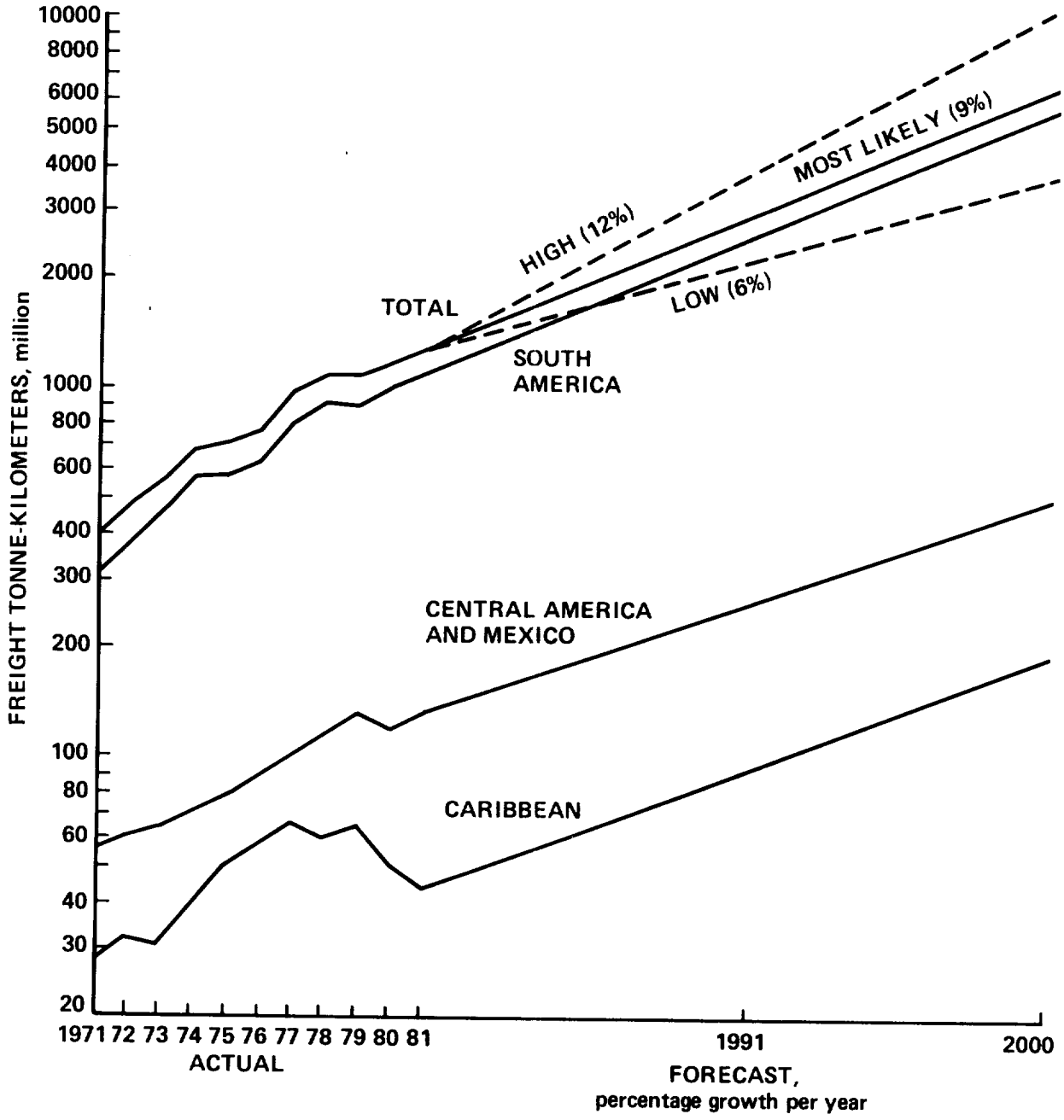


Figure 2.- Scheduled airline international freight traffic forecast.

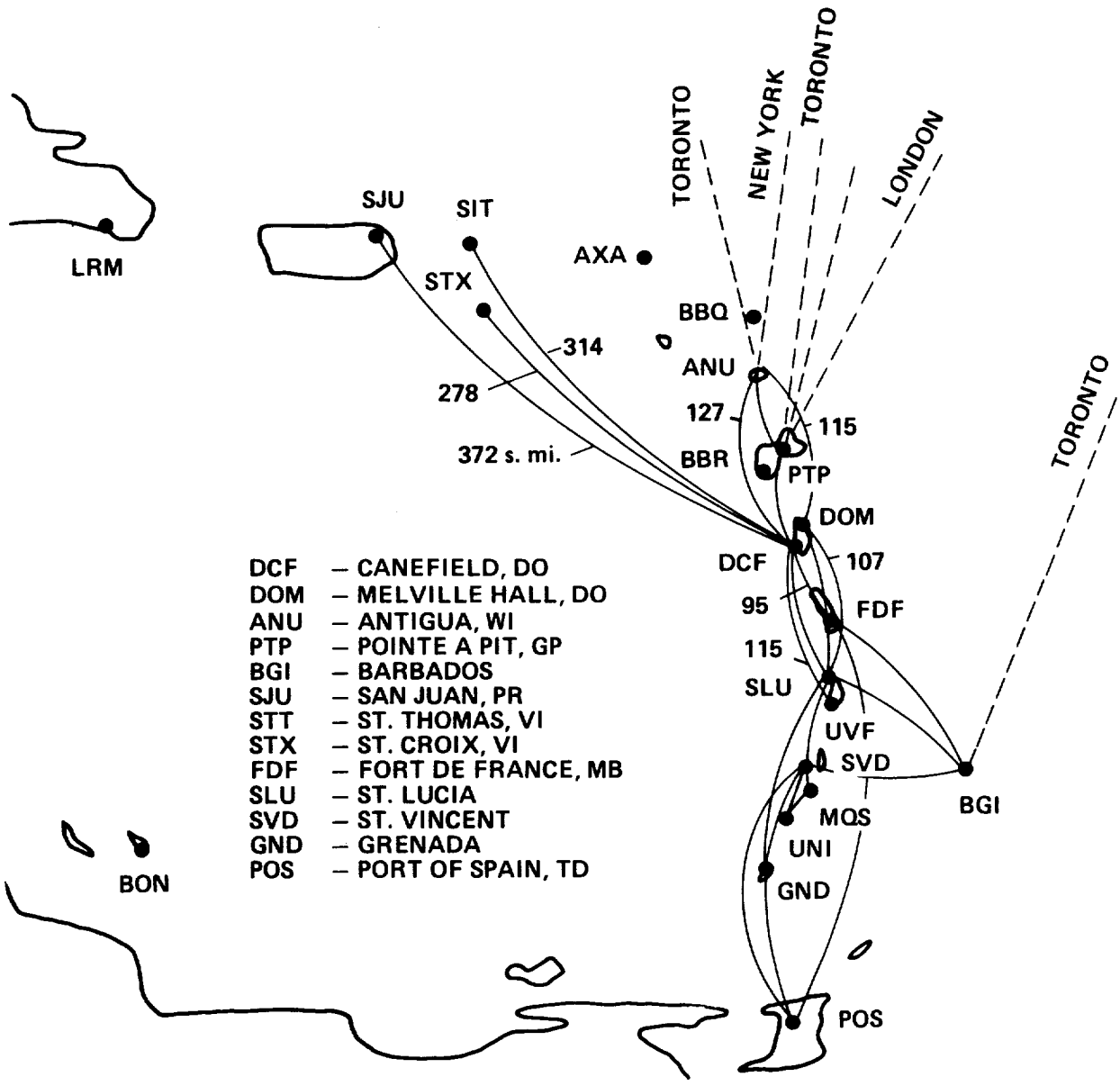


Figure 3.- Caribbean Basin flight distances.

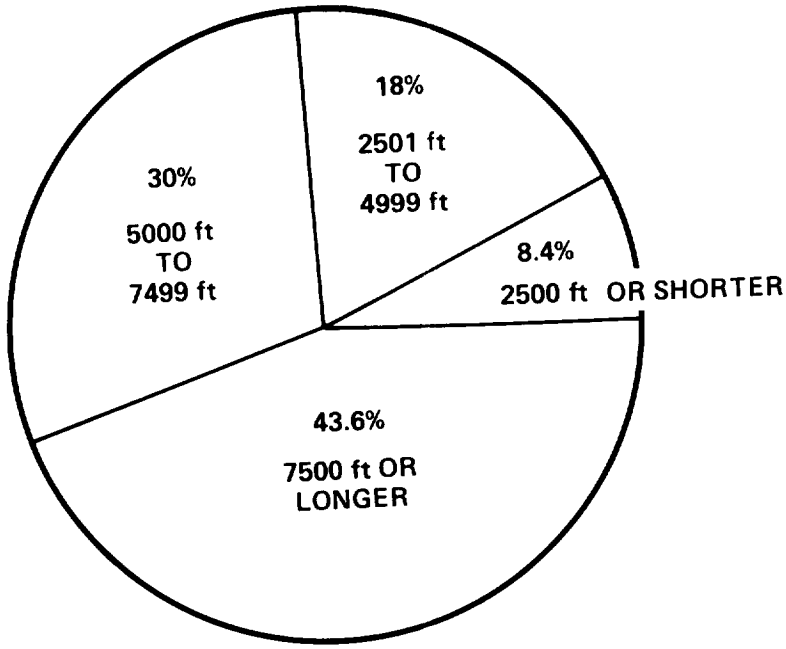


Figure 4.- Airport runway lengths for scheduled service.

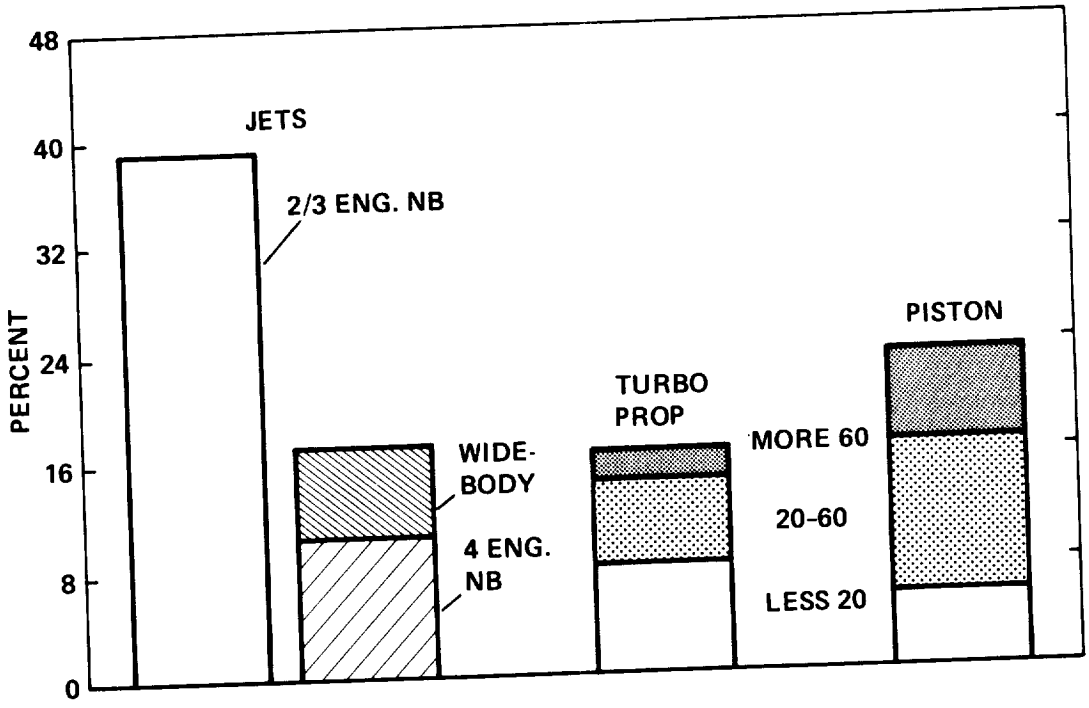
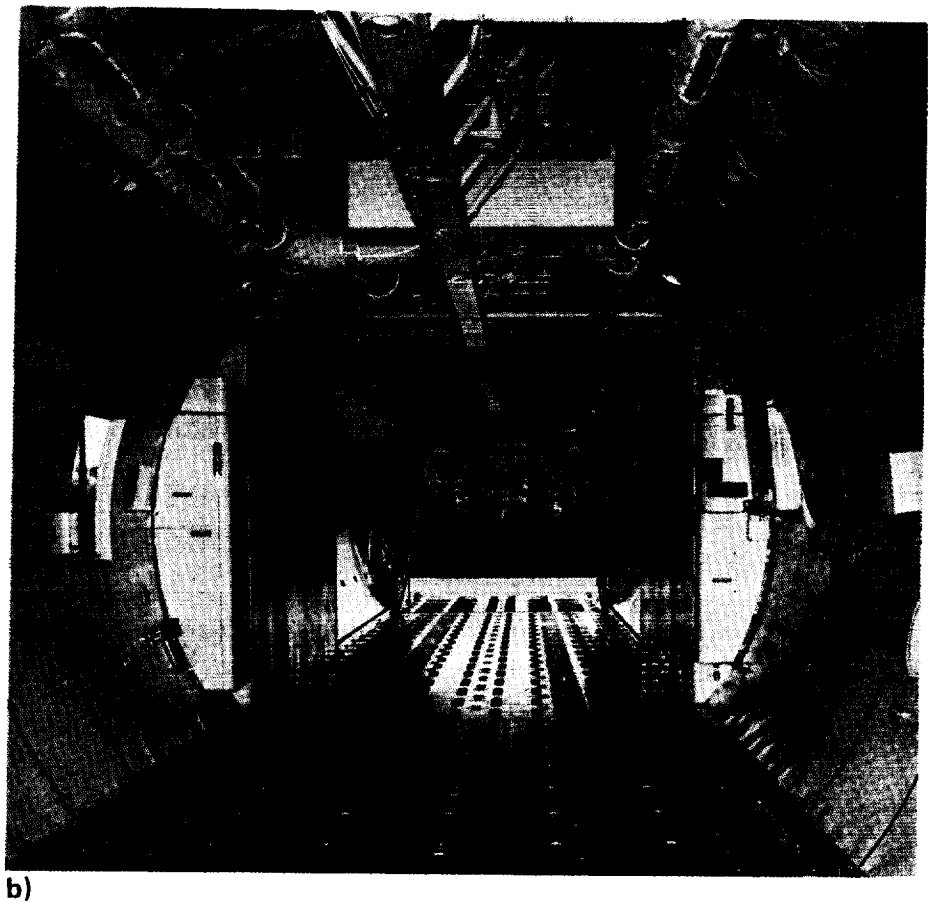


Figure 5.- Aircraft fleet composition by engine type.

Figure 6.- De Havilland Twin Otter aircraft.

a)



b)

Figure 7.- Lockheed Hercules aft loading of various cargo types. a) Outside view. b) View of cargo area.

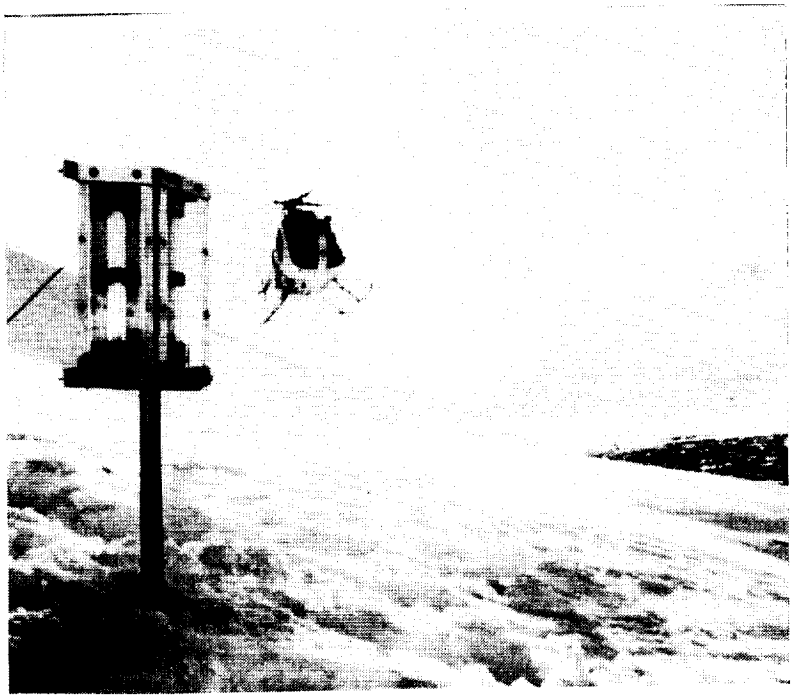


Figure 8.- Battery powered remote beacon for temporary helicopter landing.

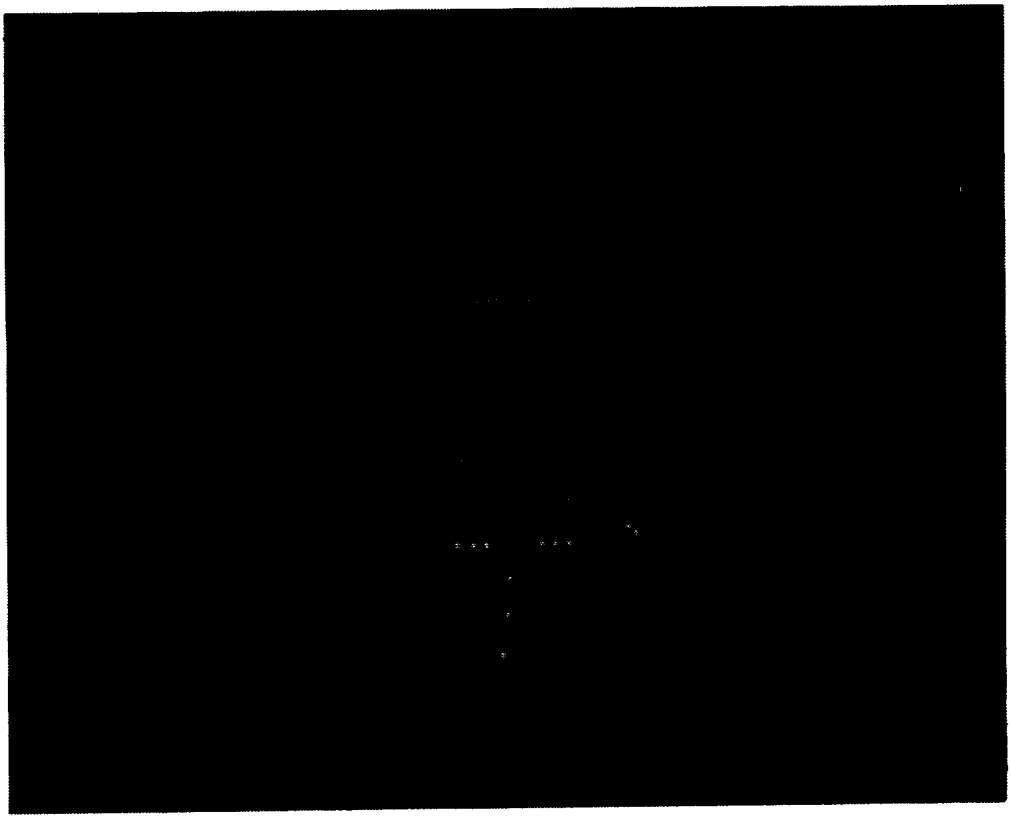


Figure 9.- Night view of runway lit by tritium lights.

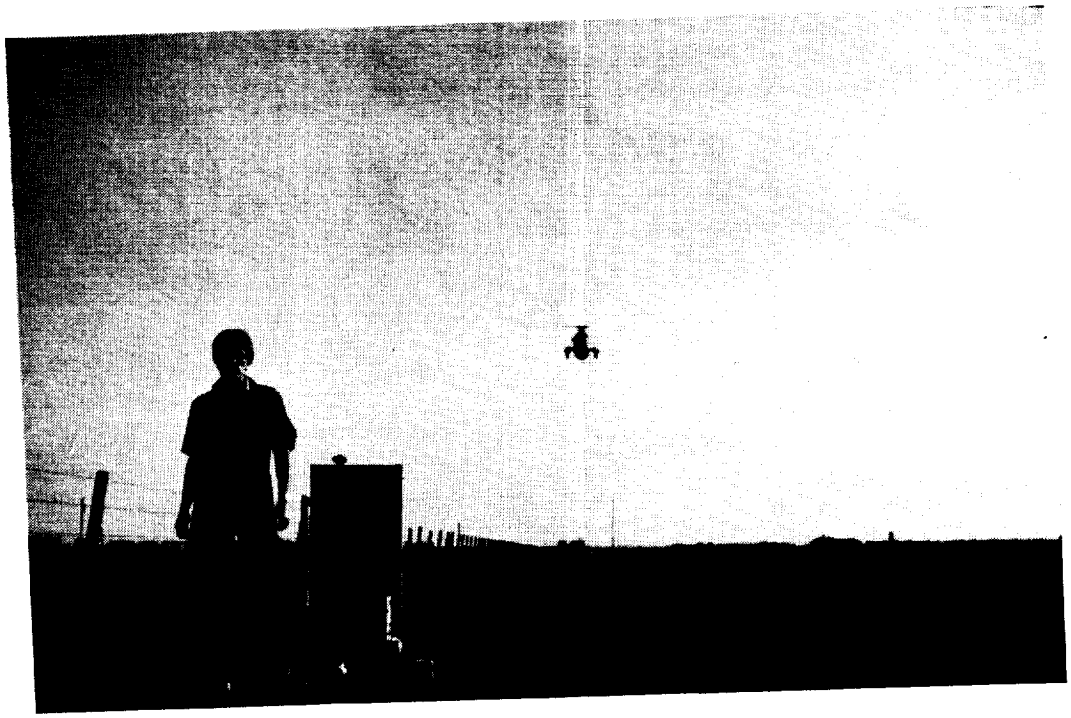


Figure 10.- Tritium runway light for remote sites.

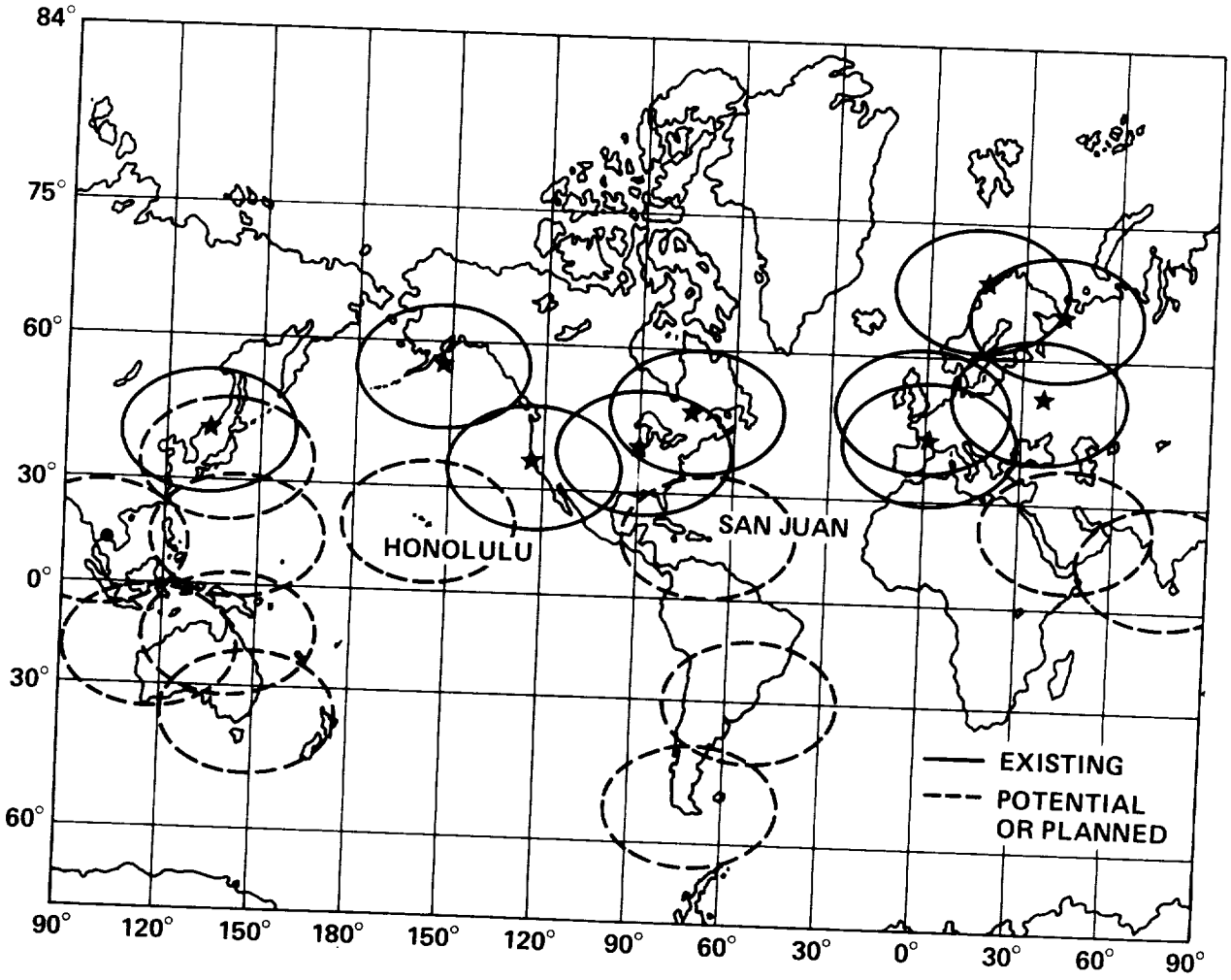


Figure 11.- Search and rescue satellite ground stations.

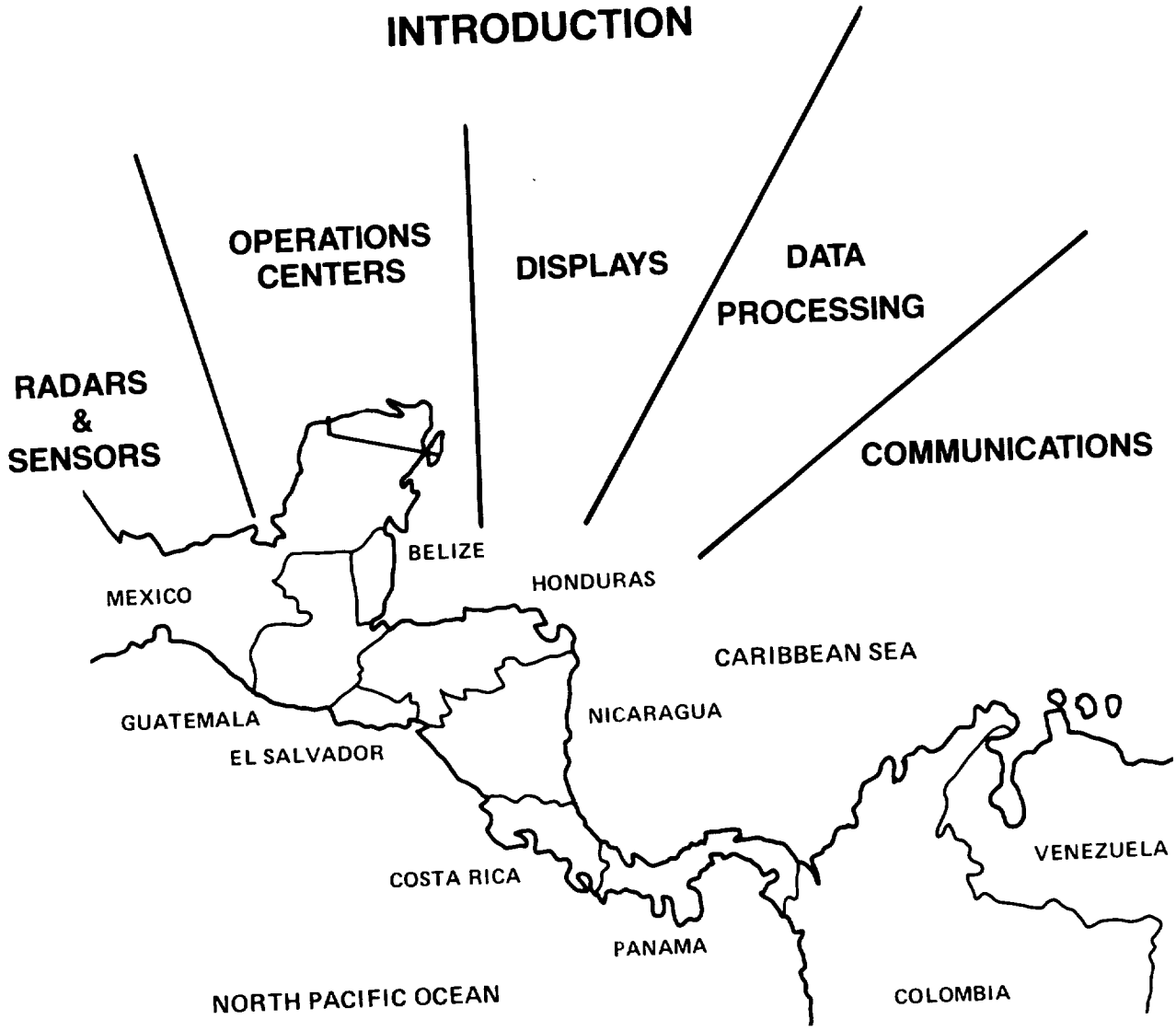


Figure 12.- U.S. Air Force Caribbean Basin radar network.

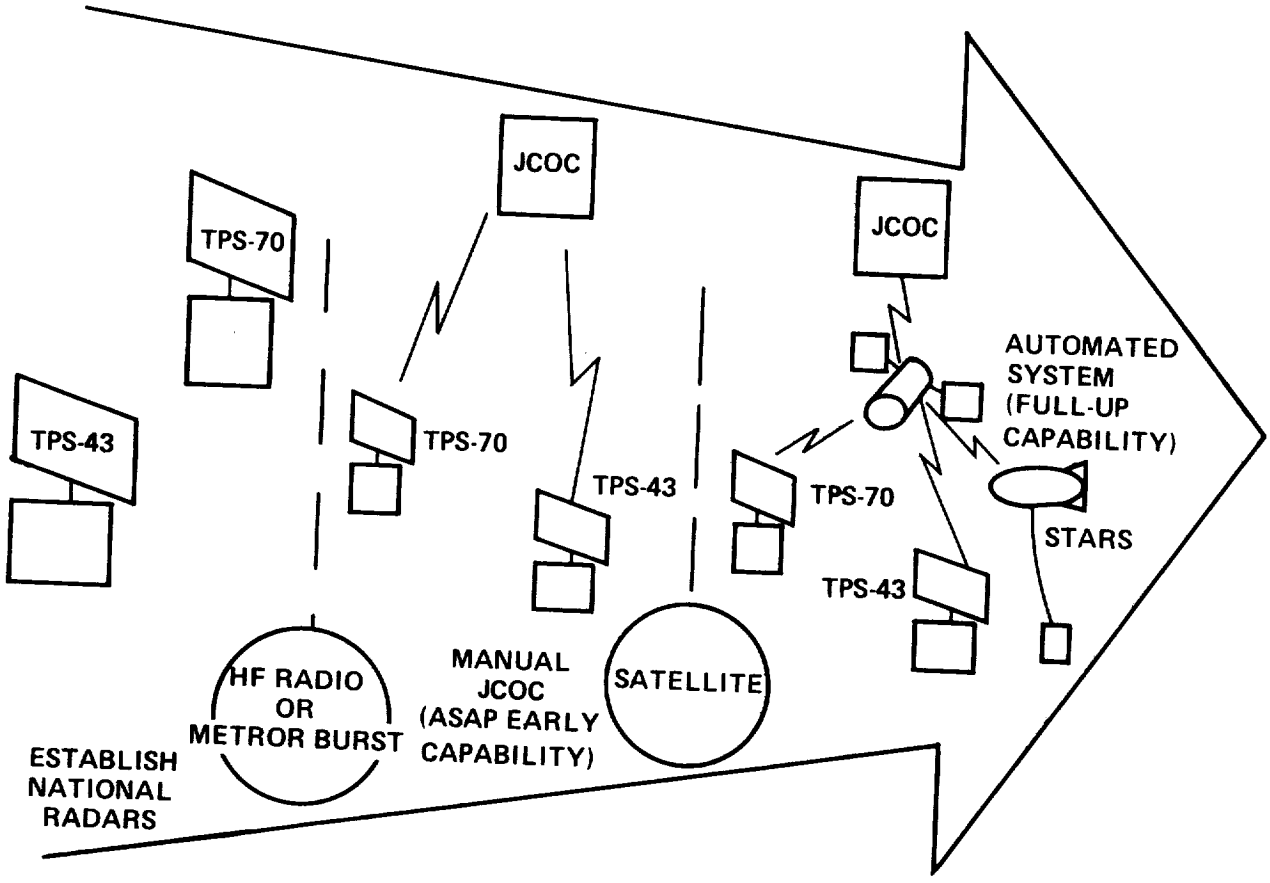


Figure 13.- U.S. Air Force Caribbean Basin radar network phased development.

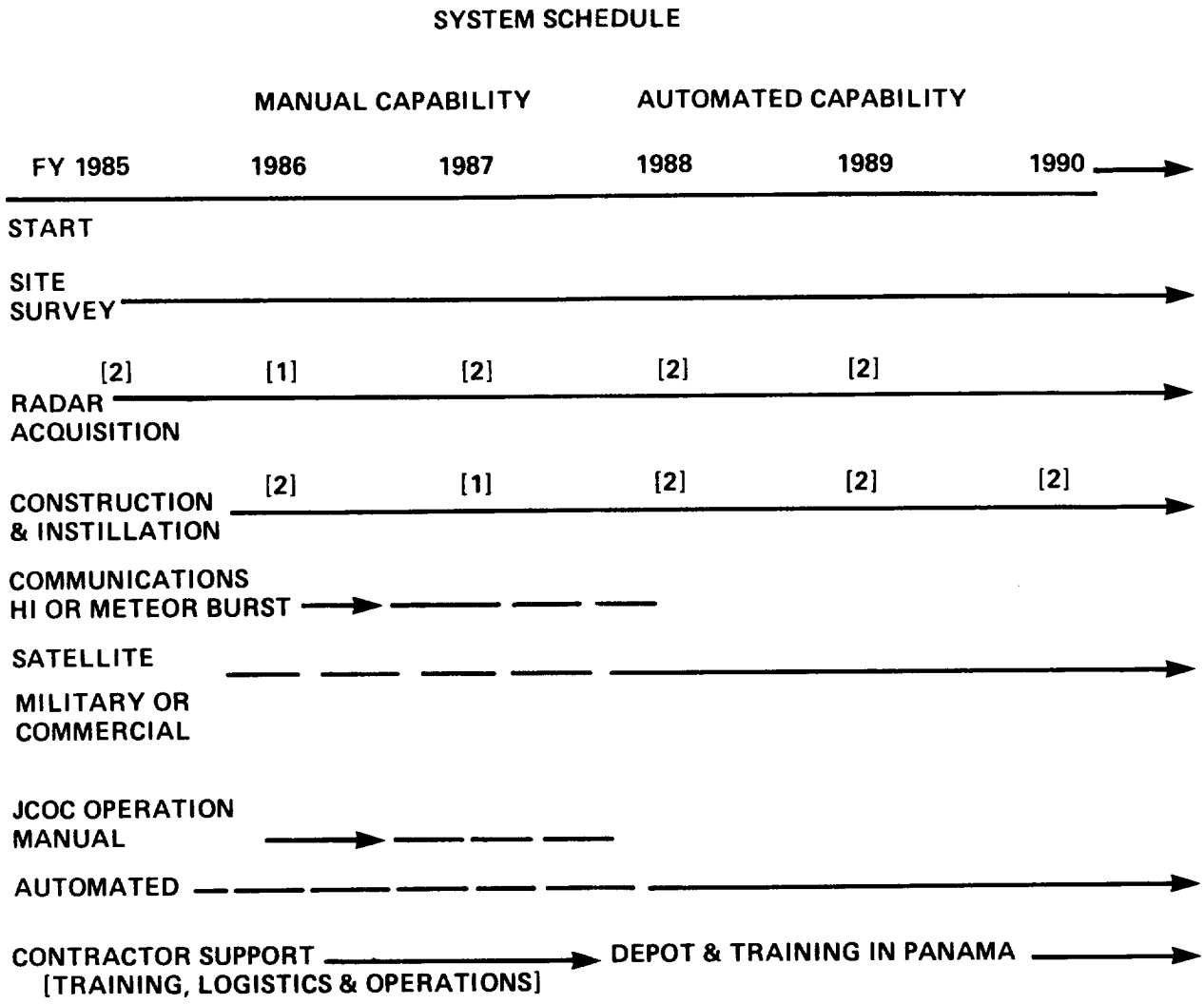


Figure 14.- U.S. Air Force Caribbean Basin radar network schedule.

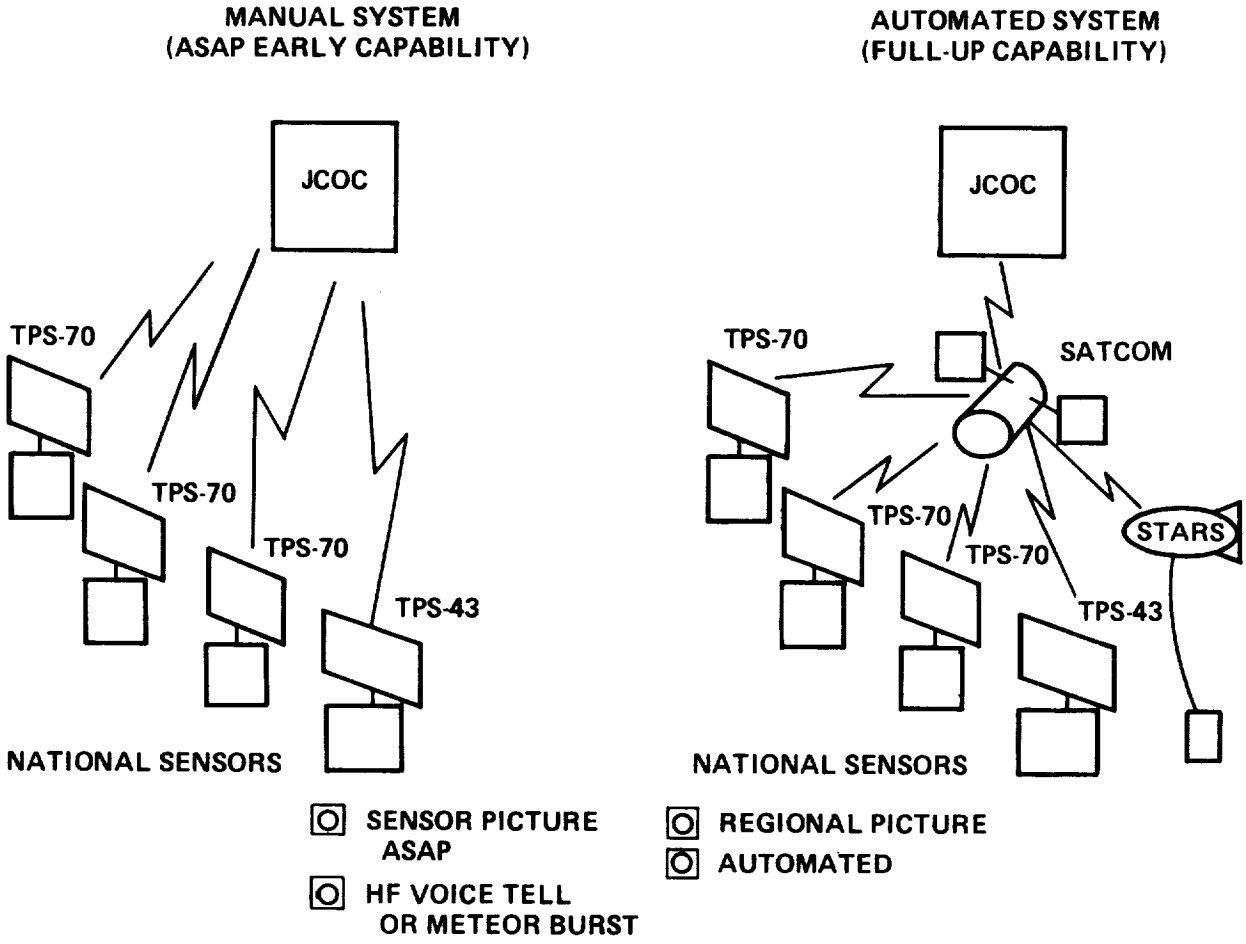


Figure 15.- U.S. Air Force Caribbean Basin radar network phased capability.

COMPONENT DENSITY

- 10x EACH 5 YEARS -- FACTOR OF 1000 GAIN BY THE YEAR 2000

SOLID STATE SENSORS

STORAGE

- 4x EACH 5 YEARS -- FACTOR OF 64 GAIN BY THE YEAR 2000

COMMUNICATIONS

- OPTICAL FIBERS -- UP TO 50 CHANNELS, EACH AT 0.5 - 1.0 GHz

- HOLOGRAPHIC INTERCONNECTIONS AT THE CHIP AND WAFER LEVEL

Figure 16.- National Academy of Engineering components technology forecast for year 2000.

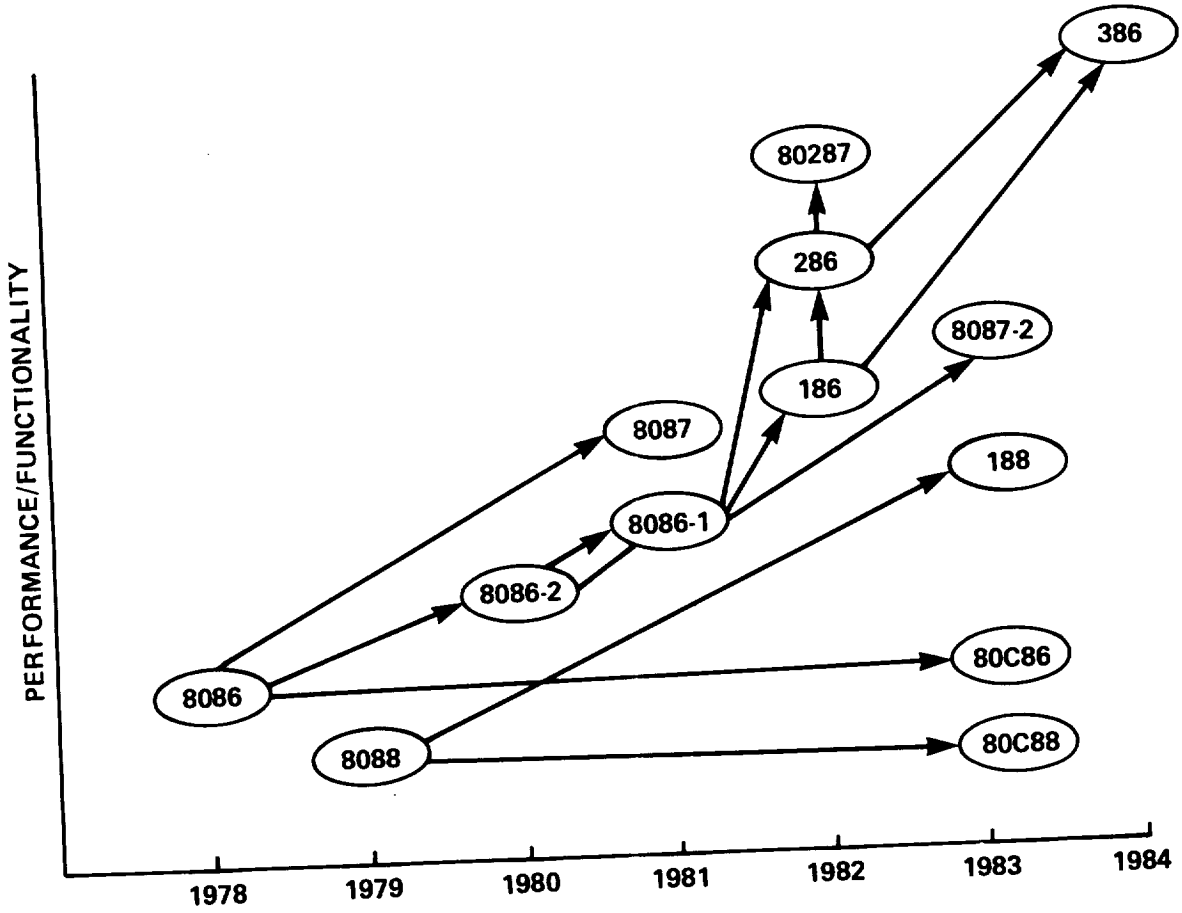


Figure 17.- Performance growth of Intel chips.

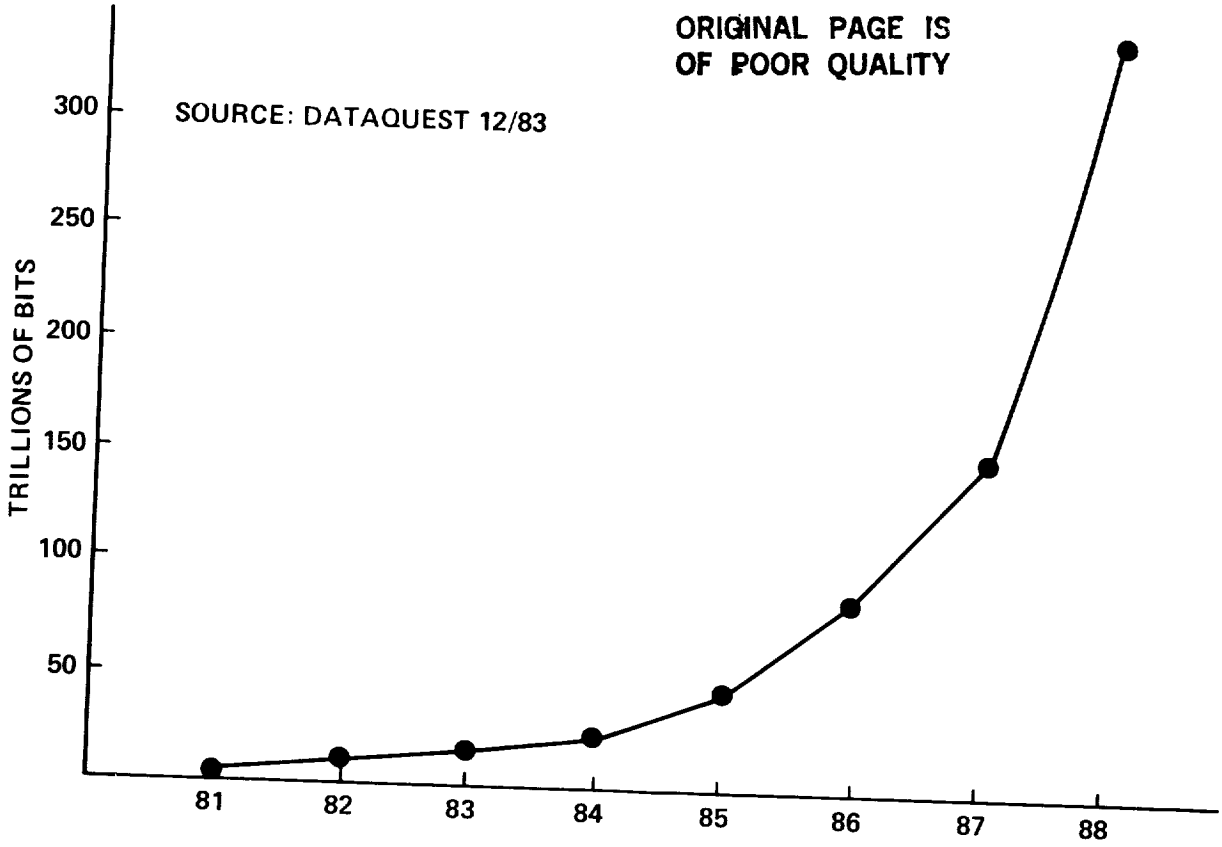


Figure 18.- Worldwide consumption of Eprom chips.

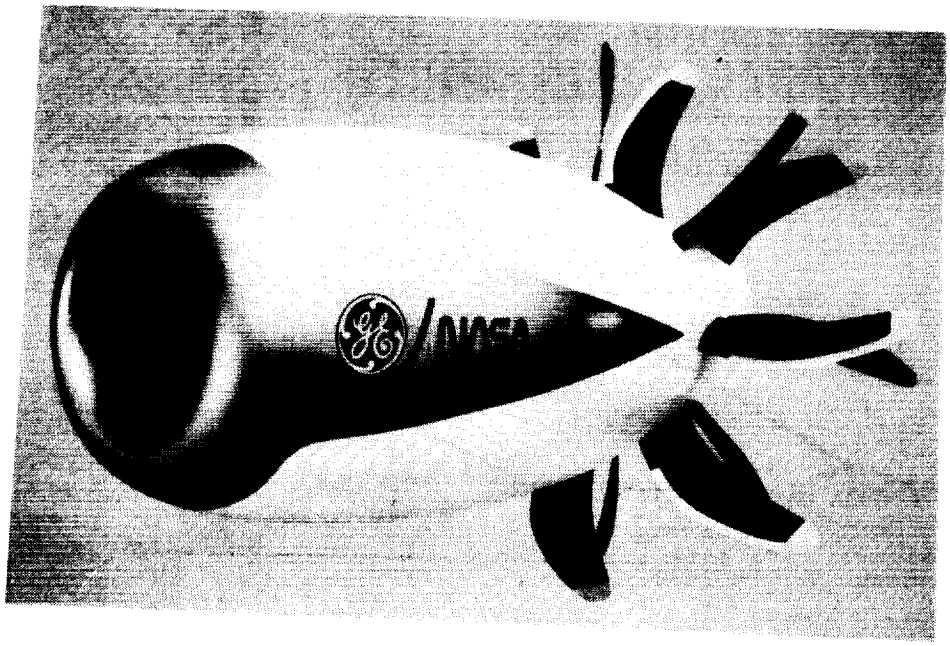


Figure 19.- Advanced aircraft engine, unducted, ultra-high bypass ratio concept.

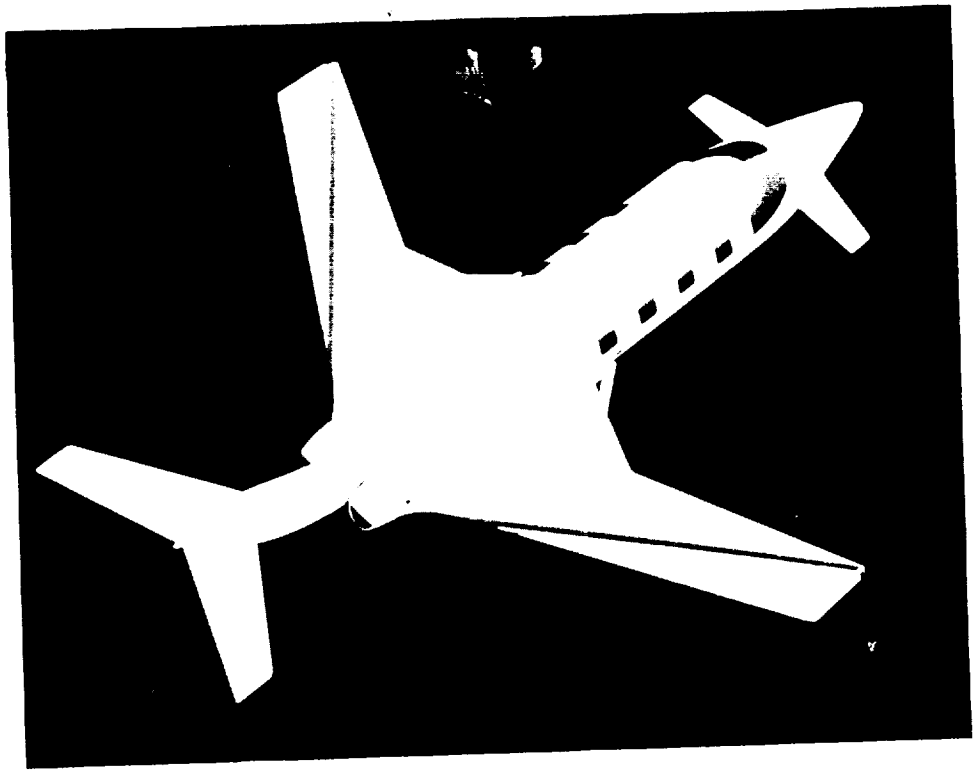


Figure 20.- Williams forward-swept wing advanced technology aircraft.

Figure 21.- Advanced technology commuter aircraft.

Figure 22.- Recently developed commuter aircraft.

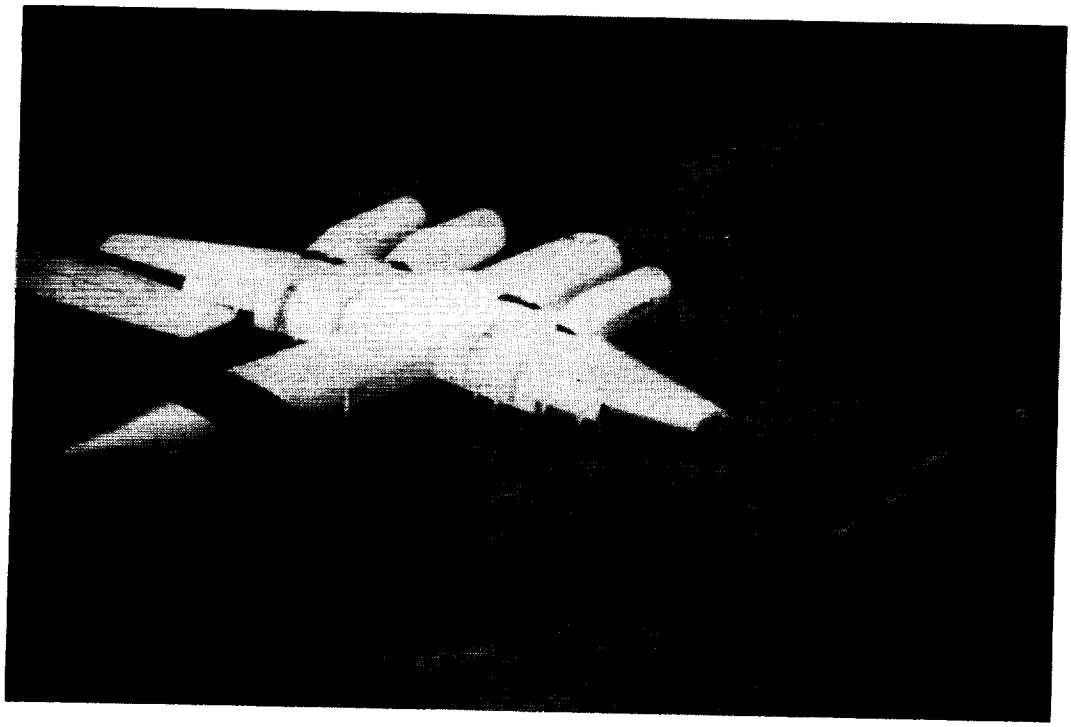


Figure 23.- NASA's Quiet Short Haul Research aircraft.

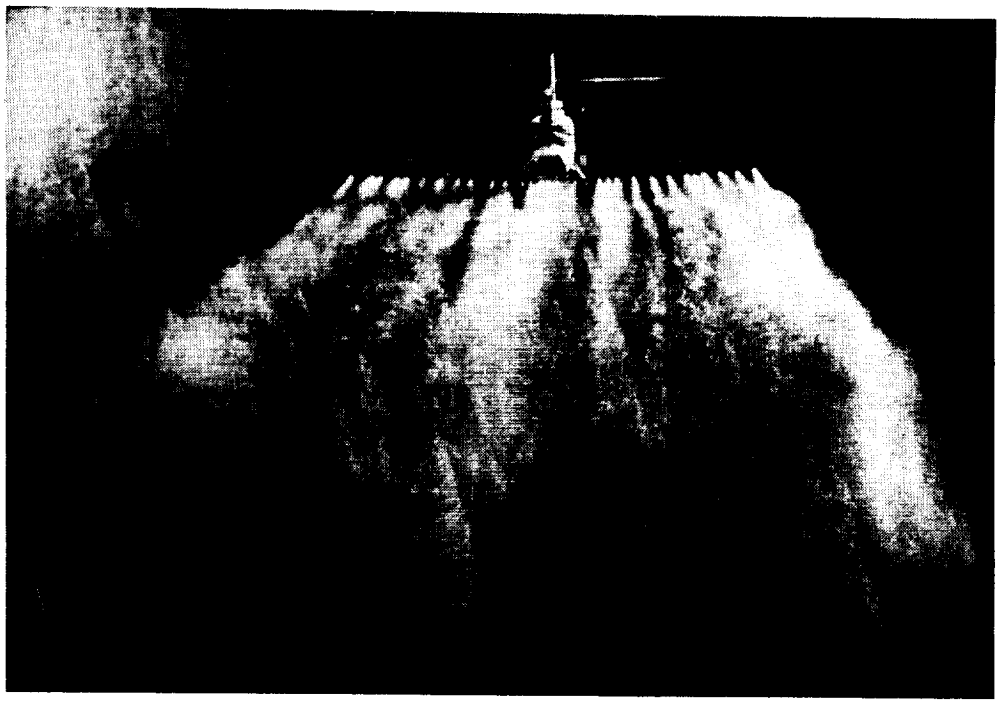


Figure 24.- Rotorcraft used for agricultural spraying.

Figure 25.- Rotorcraft in a medevac application.

Figure 26.- Rotorcraft used for search and rescue.

Figure 27.- Rotorcraft modified for fire fighting.

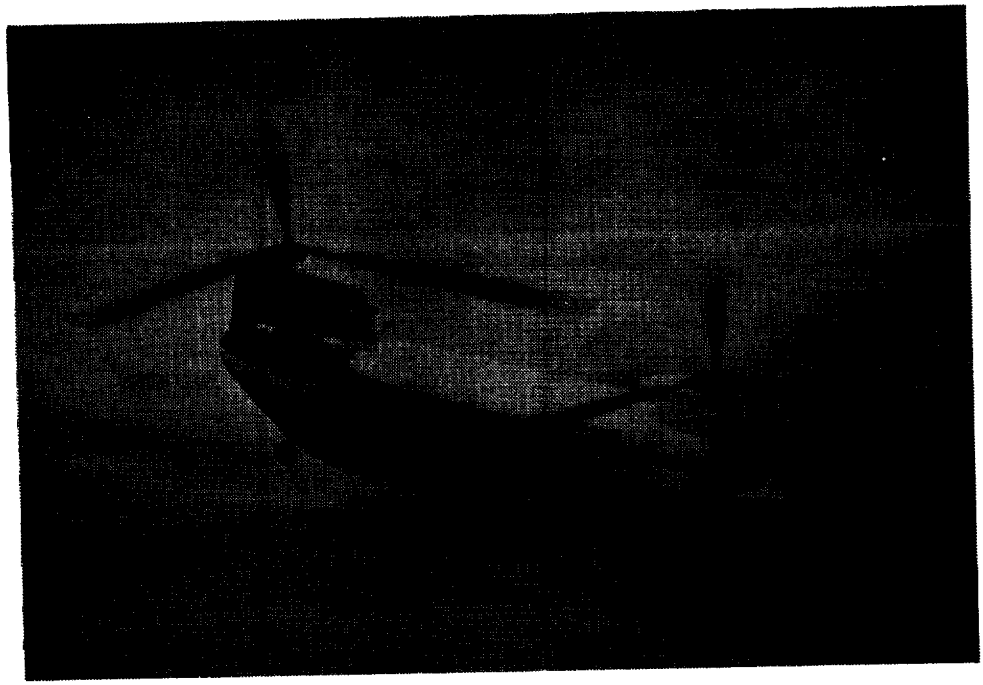


Figure 28.- Rotorcraft used in an air taxi application.

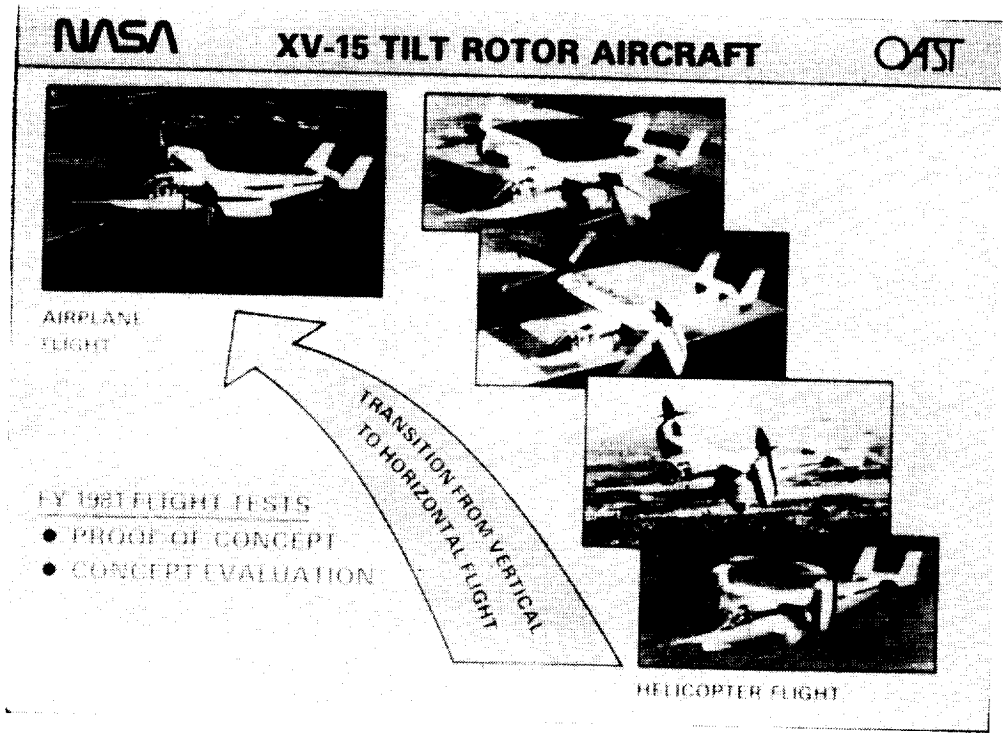
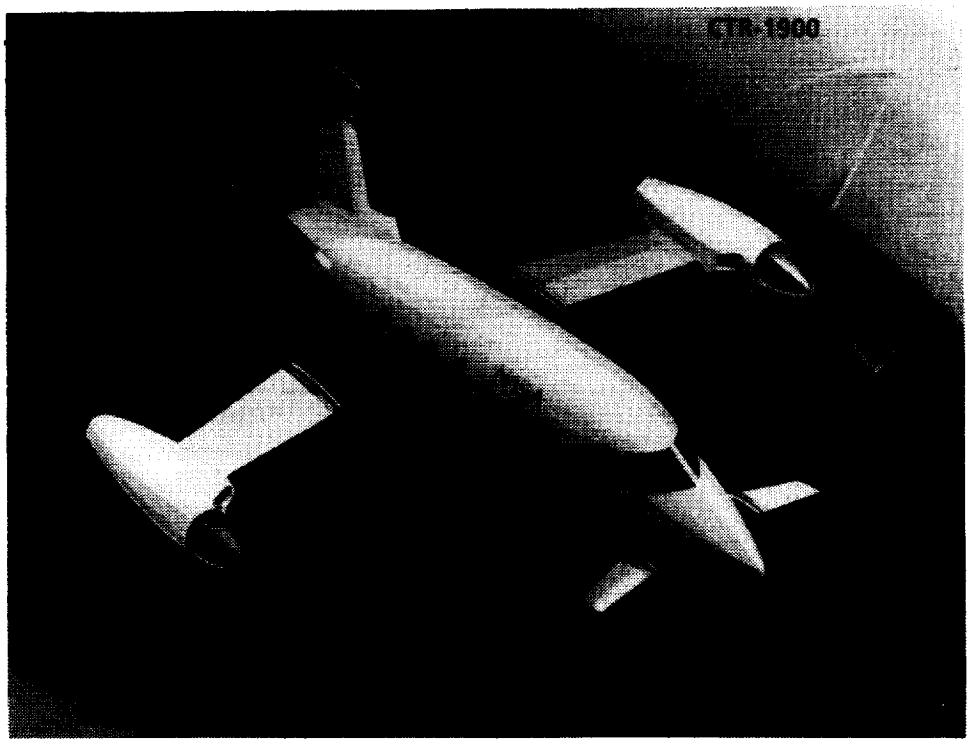


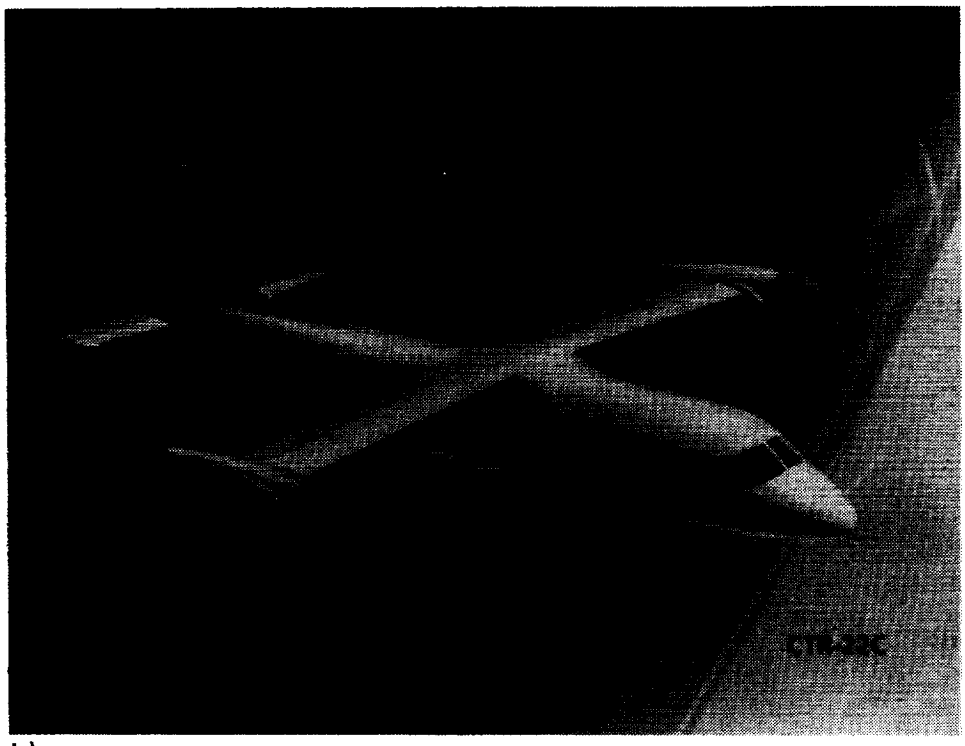
Figure 29.- NASA XV-15 Tilt Rotor aircraft in transition.

Figure 30.- Tilt rotor military and civilian concepts.

Figure 31.- Tilt rotor search and rescue application.



a)



b)

Figure 32.- 19 and 40 passenger civil tilt rotor concepts.
a) Nineteen-passenger version. b) Forty-passenger version.

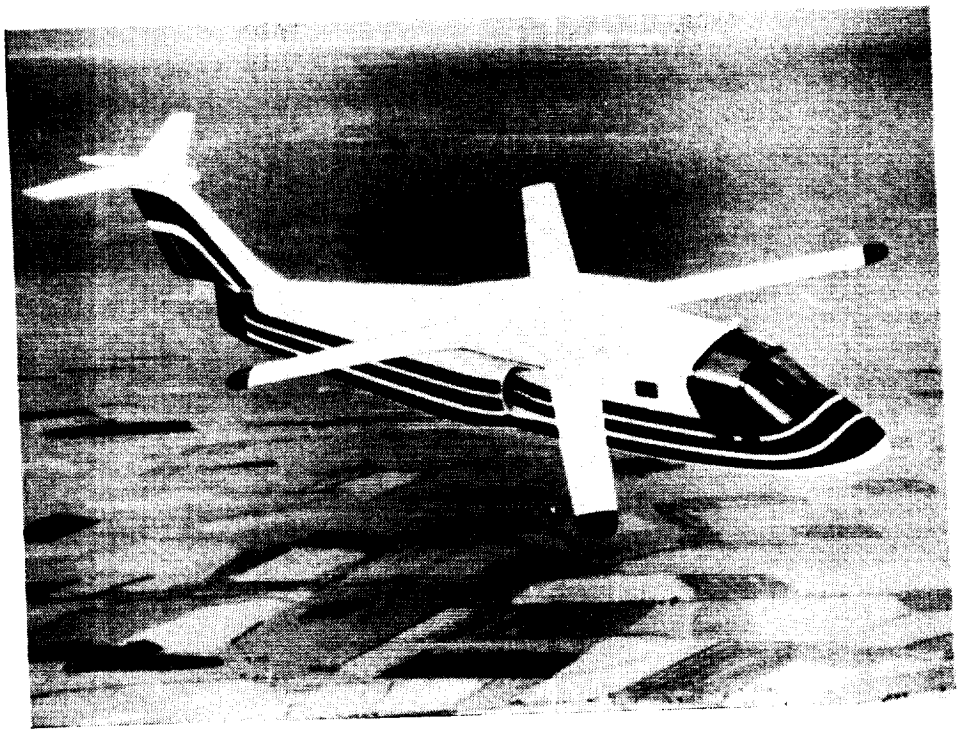


Figure 33.- High speed X-wing stopped rotor concept.

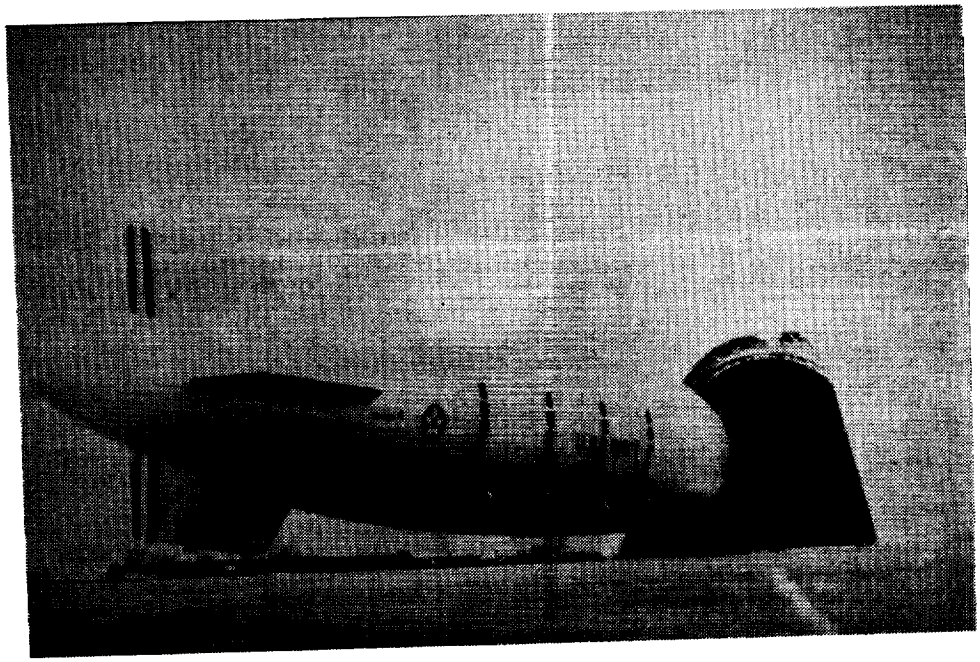


Figure 34.- Rigid technology airship (Macon, 1933).

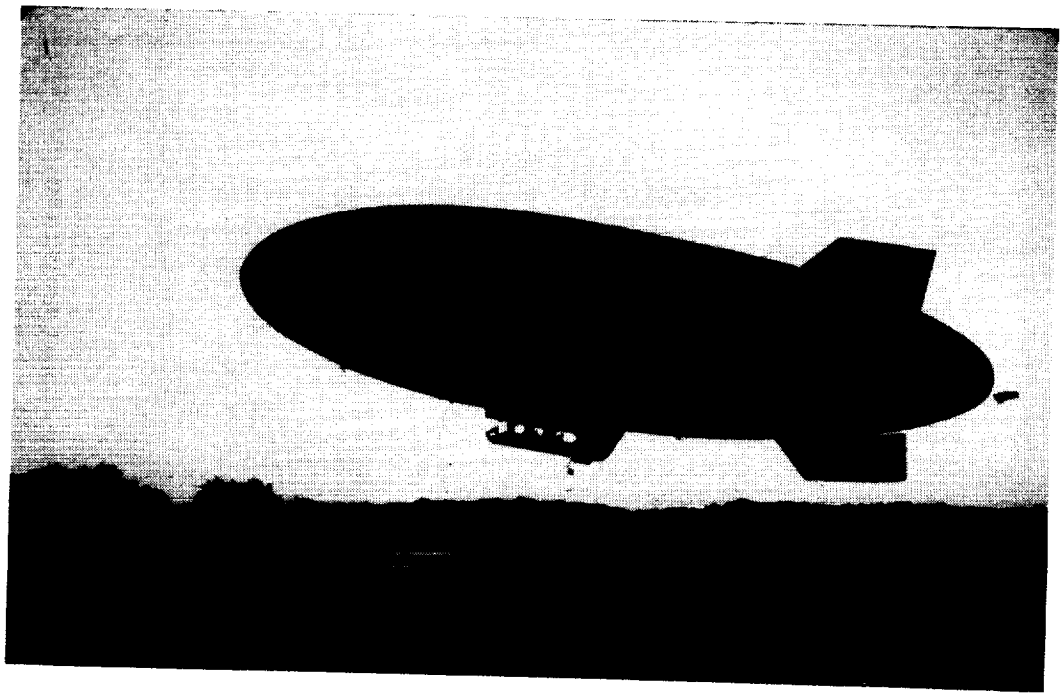


Figure 35.- Modern technology airship (British Aerospace Industries 500).

Figure 36.- Tiltable ducted propellers used on the BAI airships.

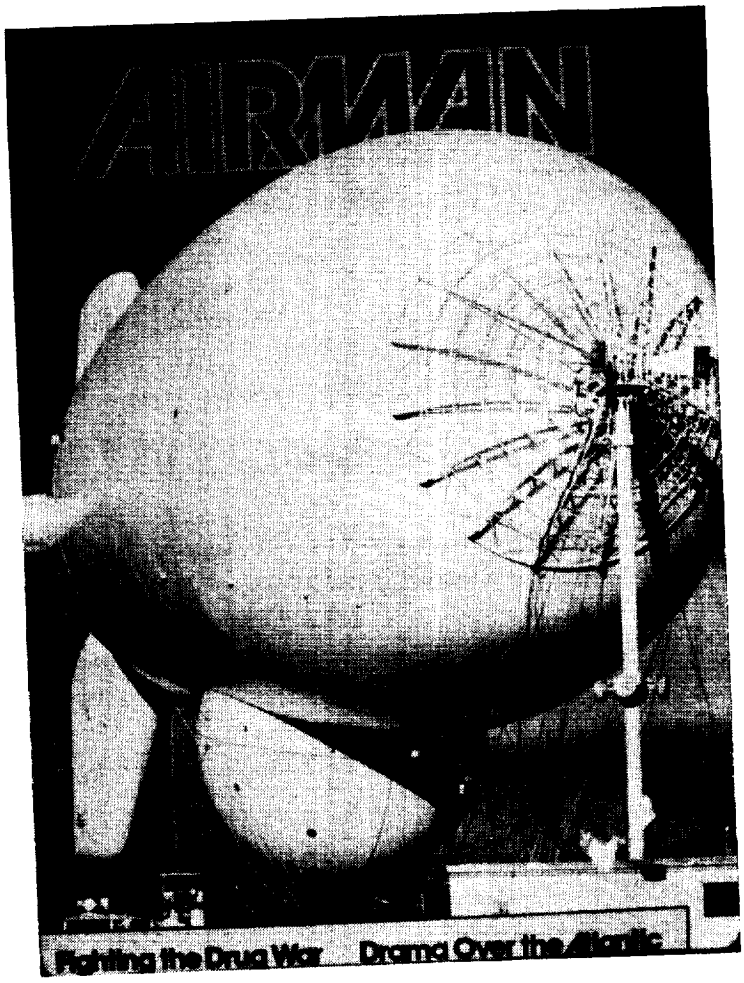


Figure 37.- Coast Guard unmanned tethered aerostat.

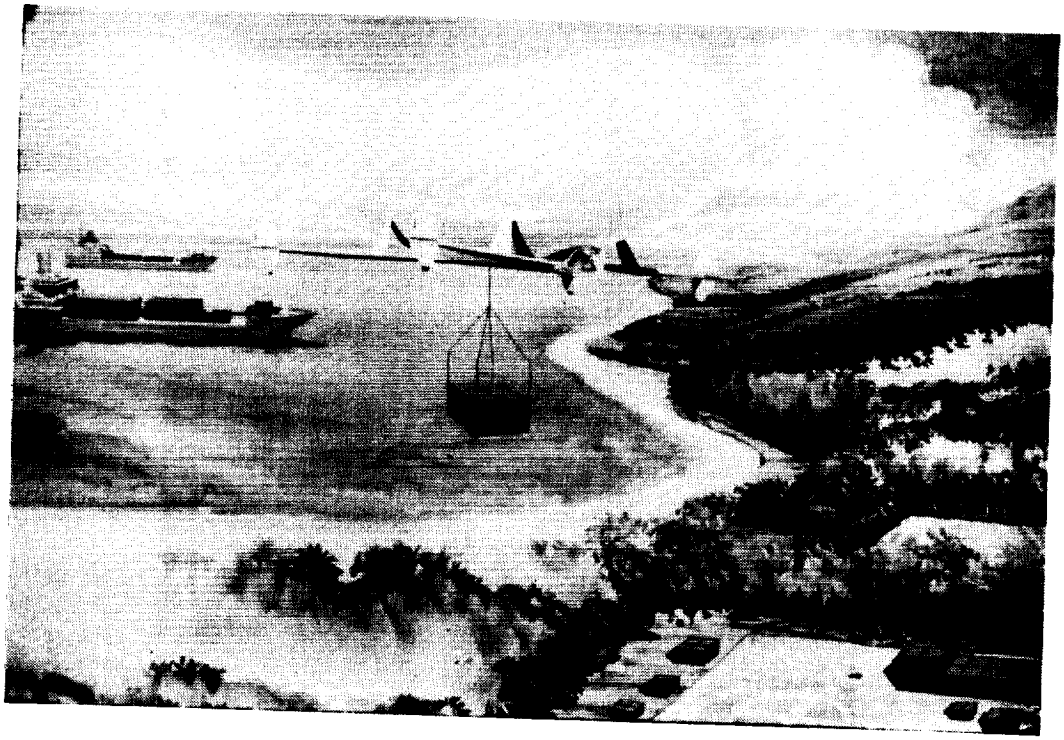


Figure 38.- Potential payloads for heavy lift airships.

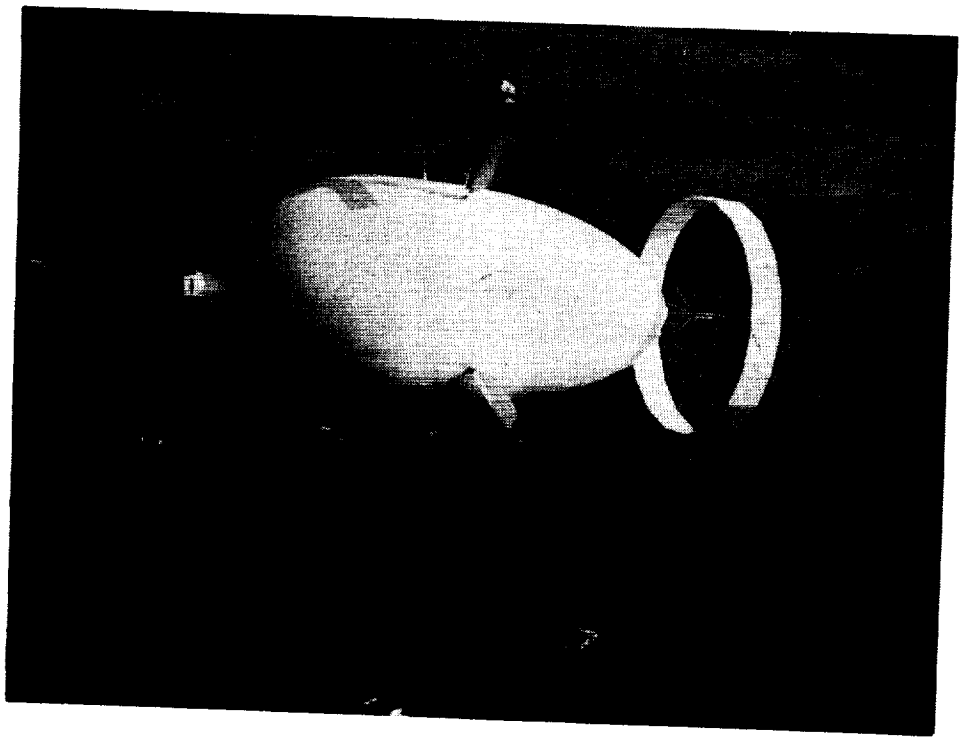


Figure 39.- Cyclotrane airship.

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM 89425		

4. Title and Subtitle	5. Report Date
Aviation Technology Applicable to Developing Regions	September 1988
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
John Zuk and Larry R. Alton	A 87093
	10. Work Unit No. 505-01-51

9. Performing Organization Name and Address	11. Contract or Grant No.
Ames Research Center Moffett Field, CA 94035	
	13. Type of Report and Period Covered Technical Memorandum

12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, DC 20546-0001	

15. Supplementary Notes

Point of Contact: John Zuk, Ames Research Center, MS 237-11
Moffett Field, CA 94035 (415) 694-6568 or FTS 464-6568 or
Larry R. Alton, Ames Research Center, MS 237-11
Moffett Field, CA 94035 (415) 694-5887 or FTS 464-5887

16. Abstract

This paper is an analysis of aviation technologies useful for formulation of development plans to the year 2000 for the emerging countries. The Caribbean Basin was used as a specific application. If we look at the context of this paper forward to the year 2000, about 15 yr from now, we are on a continuous technology explosion which will make it difficult to predict the technologies which will be impacting the developing regions such as the Caribbean Basin during those 15 yr in a comprehensive way. Technology moves so rapidly (table 1) that there will undoubtedly be technology developments which cannot be predicted at this time which will have an impact in the developing regions by the year 2000.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Civil transportation, Tilt rotor aircraft Aviation technology, Emergency services Developing regions, Caribbean basin Year 2000	Unclassified-Unlimited Subject Category - 03

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	96	A05

NASA FORM 1626 OCT 86

For sale by the National Technical Information Service, Springfield, Virginia 22161