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ABSTRACT

This book, which is to be used only in the Air Force ROTC training program, deals with the kinds of civil aviation facilities and the intricacies and procedures of the use of flying. The first chapter traces the development of civil aviation and the formation of organizations to control aviation systems. The second chapter describes varieties of aviation for which the term "civil aviation" is used. This includes brief descriptions of agricultural, business, instructional, recreational, air taxi service, and civil air patrol aviation systems. The third chapter delves into the problems related to the management of aviation facilities. A chapter on air traffic control provides information on its role. One full chapter on the construction and operation of airports is very informative in nature. (PS)

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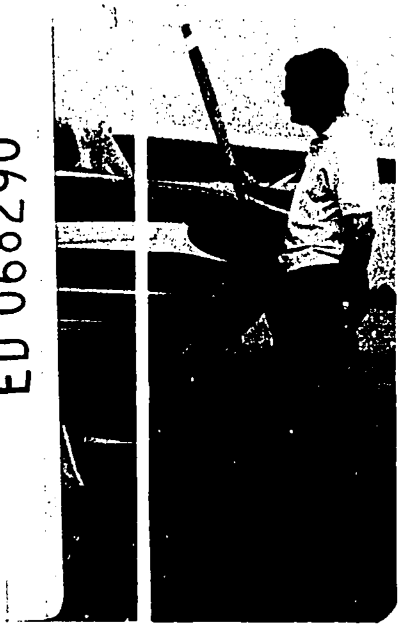

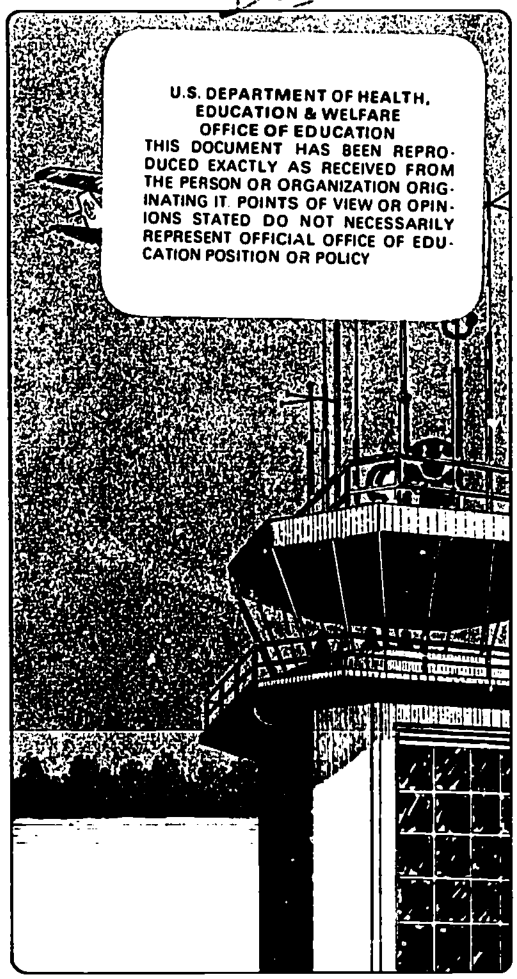

Aerospace Education

II

Civil Aviation and Facilities

SE 014 554

Air Force Junior ROTC
Air University/Maxwell Air Force Base, Alabama

AEROSPACE EDUCATION II

Civil Aviation and Facilities

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This publication has been reviewed and approved by competent personnel of the preparing command in accordance with current directives on doctrine, policy, essentiality, propriety, and quality.

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This book will not be offered for sale. It is for use only in the Air Force ROTC program.

Preface

EVERY DAY THOUSANDS of aircraft of various types are in the air. Most of these aircraft are a part of civil aviation. You will remember from other booklets in your AFJROTC course that civil aviation includes all types of flying except military flying. When we think of aviation other than military, we usually think of the flying done by commercial airlines. If we limit our thinking to commercial flights, however, we will be only partly right, for civil aviation includes not only the commercial airlines but also general aviation. You undoubtedly are familiar with military flying and commercial airline flying, but the term "general aviation" may be new to you. This category of flying consists of nonscheduled flying activities in business and agriculture, contract cargo transportation, industrial aviation, flight instruction, air taxi service, and recreation flying.

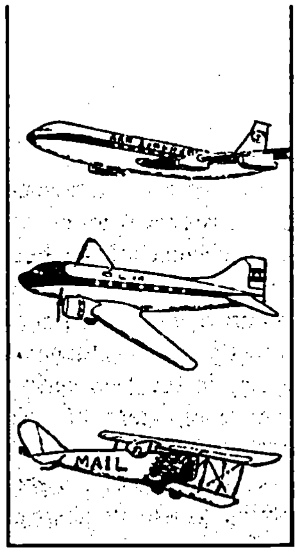
The growth of flying activity has increased the necessity for regulation of flying by the Federal Government. At the same time, it has, of course, greatly increased the necessity for improved facilities of every type. It has also made imperative an effective air traffic control system. This booklet, then, is concerned primarily with these broad subject areas—the relationship between civil aviation and the Federal Government; the types, growth, development, and status of both general aviation and commercial airlines; the major facilities provided for civil aviation; and air traffic control.

Some people argue that, despite the fact that aviation is now nearly 70 years old, air transportation is still in its infancy or at least that the full potential of air transportation has not been realized. Certainly civil aviation has grown by leaps and bounds since the close of World War II. Just how far it will go and the extent to which we will depend in the future on air transportation remains to be seen. But to anticipate the future and appreciate the developments under way, we should try to understand the background of civil aviation and its present status.

Contents

Chapter 1

The Government and Private Aviation



THIS CHAPTER explains the need for Federal control over civil aviation. A brief history of civil aviation is followed by a section stressing the close cooperation between military and civilian air resources during World Wars I and II. Governmental cooperation with civilian authorities is further demonstrated by Project Beacon, the role of the civil reserve air fleet, and the establishment of an international civil aviation organization. After you have studied this chapter, you should be able to do the following: (1) tell how civil aviation in this country worked together with the Government, especially during wartime; (2) explain the role of the civil reserve air fleet in the defense of our Nation; and (3) outline the main areas of responsibility of the Federal Aviation Administration.

CIVIL AVIATION includes all flying other than military, but our attention usually focuses on the commercial airlines with their cargo and passenger services. Most people are aware of airline flying. Relatively few people, however, are conscious of general aviation which includes private flying for business or pleasure as well as such diverse activities as agricultural crop dusting, geological prospecting, mapping, and highway traffic regulation. Yet general aviation traffic is quite heavy and has compounded problems at some of the busier airports.

CIVIL AVIATION AND FACILITIES

During the years since the Wright brothers' first flight, civil aviation has grown to maturity under the stimulus of war and the paternal guidance of the Federal Government. Virtually every contribution of research to military aviation is ultimately reflected in the progress of civil aviation. At the same time, the Government has directly and persistently fostered the growth of civil aviation, particularly in the lean early years. Today the airlines—the most important component of civil aviation—are on the point of financial independence.

Civil aviation is a major element of aerospace power. A nation's ability to use its airspace is measured by the density of its civil air traffic. Civil aviation occupies an integral position in the larger complex of national aerospace power and contributes in important ways to the security of the nation.

Throughout the spectrum of aerospace power, technological development and efficiency of the civil and military establishments go hand in hand. Without the stabilizing influence of uniform air navigational and communications facilities worldwide, without the steady advance in flight safety, and without the progressive evolution of international air agreements, regulations, rules of flight conduct, and regulatory agencies that establish a worldwide operating code, today's crowded airspace would be completely chaotic.

BEGINNINGS OF AIR TRANSPORTATION

The flight of the Wright brothers in 1903 marked the dawn of a new era in transportation. After the historic flight, the Wrights continued to develop their invention. Practice brought rapid progress. In Europe, Santos-Dumont, Henri Farman, Louis Blériot, and others continued to experiment and improve aircraft. European enthusiasm was highlighted by the establishment of international speed races at Rheims, where leading European governments offered prizes for improved aircraft engines. Rapid acceptance of the airplane in Europe is indicated by the number of licensed pilots in 1911. In that year, there were 353 pilots in France, 57 in Great Britain, 46 in German, 32 in Italy, and 27 in Belgium. In that same year, there were only 26 licensed pilots in the United States.

Despite the small number of pilots in 1911, the United States' interest in aviation was not completely lacking. In 1908 the Army Signal Corps contracted with the Wright brothers for its first plane.

Orville Wright was teaching Lt Thomas Selfridge to fly the aircraft on 17 September 1908 when the ship went out of control. Wright regained control too late for a smooth landing. When the plane hit, Selfridge suffered a fractured skull. When he died a few hours later, the Army lost its first military pilot.

The Wrights built another plane, "Aeroplane #1, Heavier-than-Air Division, U.S. Aerial Fleet," and trained Lieutenants Frank P. Lahm and Frederic E. Humphries to fly. However, a crash on 5 November 1909 destroyed the plane, and the men were transferred back to Artillery. The Army was left with neither a usable plane nor a qualified pilot.

Flying activities were transferred to Ft. Sam Houston, Texas, and on 2 March 1910, Lieutenant Benjamin S. Foulois began taking flying lessons—by mail! His first flight was a solo flight, of course, and until 1911, he was the Army's *only* pilot flying its *only* plane.

By 1914 the United States was still behind most other major nations in the field of aeronautics. Safely surrounded by oceans, the United States felt no need to compete with Europe in building up the military aeronautical establishment. Because of the lack of public interest, money and planes were hard to get. Pilots were hard to get and harder to keep because flying was dangerous. Army aviation finally received recognition in 1914. It was put on a firm and permanent basis. The Army Aviation Act of 1914 created the Aviation Section of the Signal Corps and authorized 60 officers and 260 enlisted men.

The Aviation Section expanded its organization, but it still lacked funds. By 1916 things had become so intolerable that, when the 1st Aero Squadron pushed across the Mexican border to capture Pancho Villa, the aircraft lasted only six weeks. The planes and their replacements were unfit for field service. Thus, the strength of the Aviation Section had sunk to 35 pilots and no aircraft suitable for combat.

Civil interest in aviation was not completely lacking during the lean, early years. American Glenn Curtiss, famed "fastest man on earth," turned his interests from motorcycles to airplanes. He went into business making flying machines. In 1910, Curtiss flew an aircraft from New York City to Albany, New York, a remarkable feat for the time.

In 1911 Calbraith Perry Rodgers completed the first continental flight across the United States. His trip naturally was not non-stop, but rather a series of short hops. Rodgers' actually flying distance was 4,251 miles. His average flying speed was 52 miles per hour. The total time taken from Long Island to Pasadena was 49 days. Aircraft repairs had slowed him down, or he might have made the trip in 30 days and won the Hearst $10,000 prize. Even though he won no prize, he had made the flight without the aid of prepared landing fields, advance weather information, special instruments, or adequate supplies or facilities. He had shown the potential of the airplane as a means of transportation in this country.

In 1914 the St. Petersburg-Tampa Airboat Line made the first attempt to operate a regular passenger service. The company flew passengers across Tampa Bay in a Benoist flying boat. There was a $5 charge for the 20 minute journey. The line stayed in business 4 months and carried 1,200 passengers.

By this time the airplane itself had taken on the basic features of the modern aircraft. The fuselage was enclosed; landing wheels were added; and more efficient power units were installed. Improved power plants enabled the pilots to climb higher, reaching altitudes of 26,000 feet.

Yet both civil and military aviation growth in the United States lagged behind the rest of the world. The lack of public support and the lack of a clearly defined status for aviation caused this lag. Until the outbreak of World War I the airplane was regarded as of *potential* use only for sporting or military purposes. The far-reaching effects of air travel had not yet been felt by civil or military authorities, must less by the general public.

From the advent of the airplane until after World War I, the Federal Government did little toward establishing rules and regulations to govern aviation. As early as 3 March 1915, Congress created the National Advisory Committee for Aeronautics. This body, however, was not a regulatory agency. Its chief function was to supervise and direct scientific study of the problems of flight and to direct and conduct research and experiments in aeronautics. Whatever interest the Government had in aviation was limited to military aviation until after World War I.

WORLD WAR I AND AFTER

The achievement of Army aviation and the American aircraft industry in World War I was never as great as the promise. The task assumed by the Army air arm at the urging of the Allies was beyond this country's capabilities. It was not possible to overcome in a brief 19 months the effects of almost a decade of neglect and unpreparedness.

The air resources in April 1917 were indeed meager. We had fewer than 150 pilots and fewer than 250 planes. None of these planes could be classified as higher than trainers by European standards. Furthermore, these planes could not perform by European standards. The United States lacked plans and programs for building an air force that could fight in Europe. Moreover, the country even lacked the basic knowledge on which to base such a program.

The idea of planning for a war before it began was still new to the Army, and it was also alien and repugnant to much of the public. The United States had always begun its buildup after hostilities started. We followed this philosophy in both World War I and World War II.

We entered World War I on 6 April 1917. Our allies asked us to build a great armada of planes and send them to the front. The French asked us to provide 16,500 planes during the first six months of 1918. From 1913 through 1916. the American aircraft industry produced fewer than 1,000 military and civilian planes; now Army planners were asking 22,000 military planes in one year!

The American fancy had been tickled by thoughts of great fleets of American planes turning the tide of battle in Europe. Ample money was appropriated, but time and technology had been lost. The 11.000 planes we produced used European know-how and British design. However, American technology produced the 420 HP Liberty engine. The Liberty engine greatly improved aircraft performance and was even borrowed by European producers.

When World War I ended, almost 9,500 men were in the Air Service. During the frantic demobilization of 1918–1919, almost 95 percent of these men were released to return to civilian life. Many of these young fliers were happy to be home again. But before long they became restless. Flying had been their life, and they didn't want to give it up. But what could they fly? and why?

There were a few small commerical airlines being formed, but these needed few pilots because most people were afraid to fly. These former pilots had to buy their own planes and play against luck if they wanted to fly. A few eked out a living by taking up passengers who wanted a thrill and by giving flying lessons. A few others started small airlines.

Many became "barnstormers." By putting on flying exhibitions at county fairs, carnivals, or anywhere crowds gathered, they publicized aviation. When World War I ended, few people had ever seen a plane, and most people feared or disapproved of aviation. Then came the barnstormers who may not have dispelled the fears of the general public, but they certainly did create interest in fliers and flying.

Still the United States hesitated to recognize the "aeroplane" as a potential passenger vehicle. Speed was not much greater by plane than by train. Furthermore, public interest had not yet been sufficiently aroused.

Up to 1917 neither private American enterprise nor the Government was ready to adopt any system of subsidized air transportation. But in March 1917, Congress, newly aware of the defense value of the plane, granted the Post Office Department $100,000 for airmail transportation. Post Office officials had requested such funds as early as 1911.

The Post Office Department, with the help of Army pilots, opened an airmail route between Washington and New York. The first flights took place on 15 May 1918. In Washington, the first plane was loaded with four bags of mail, but it failed to start. Its fuel tanks were empty. It was finally fueled with gas siphoned from another plane at the air field and took off. But it got off course and landed on a Maryland farm, 25 miles from Washington. The plane from New York to Washington made the trip in 3 hours and 20 minutes. Airmail service was on its way.

This initial airmail service was uneconomical; therefore, it caused considerable doubt concerning the potential of air transport. It was, therefore, in the face of much doubt and opposition that the Post Office Department continued its pioneering efforts in air transportation. Service was begun in 1919 between New York and Chicago and extended to San Francisco the following year. In 1922 the Post Office Department took the unprecedented step of adapting airplanes and airports for night travel. This step was necessary for airmail to compete with first-class mail on trains.

By establishing beacon lights along the transcontinental run at 10-mile intervals and constructing emergency landing fields every 30 miles, the Post Office established the world's first lighted airway. On the lighted airway between Chicago, Illinois, and Cheyenne, Wyo-

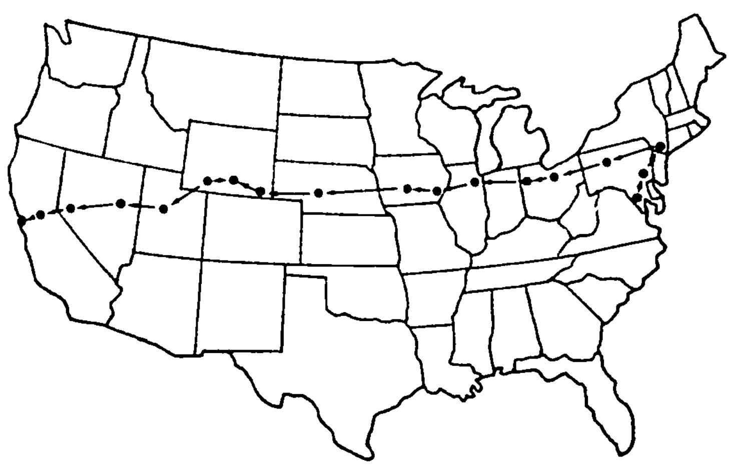


Figure 1. First Transcontinental Air Mail Service

ming, the world's first regular night service was started on 1 July 1924. Transcontinental airmail service was soon established with schedules 34 hours and 20 minutes westbound, and 29 hours and 15 minutes eastbound. This day-and-night airway from coast to coast became the central trunk of a growing and spreading tree of regional branch lines. The airway was later named the transcontinental route or Columbia Line. We will see this airway again later in the section on air traffic control.

Though this day-and-night airway system had molded regional lines into a national airway system, many problems remained to be solved. No substantial progress had yet been made in two-way radio communications with planes, adequate weather reporting, development of an efficient aircraft, or methods of coping with bad weather conditions.

The new lighting system brought a new scale of airmail rates—10¢ per ounce up to 1,000 miles, 15¢ up to 2,000, and 20¢ over 3,000 miles. Still, all-weather flying was deemed necessary to meet competition. Stubborn insistence on all-weather flying led to mounting pilot fatalities. After a pilots' strike, a compromise enabled the local station manager, rather than an official in Washington, to order or cancel a flight. After that, pilot fatalities dropped sharply.

By 1925 the Government considered opening airmail contracts to commercial carriers. The Kelly Air Mail Act of 1925 provided an economic basis for the air transport industry. It provided for the transfer of air mail service to private operators, under competitive bidding, for four years. The rate was fixed at not less than 10¢ an ounce.

This act readily attracted private capital, and a number of airlines opened up during the latter 1920's. In effect, the Government's awarding of contracts according to the need of the companies amounted to indirect subsidy. (Webster says that subsidies are chiefly granted to transportation enterprises. A subsidy may be a simple gift or it may be the amount paid in excess of the usual charge for a service, such as carrying the mail. The payment for carrying the mail is not a subsidy, only the amount in excess of the usual charge for the service.)

Congress went a step further. In the Air Commerce Act of 1926, Congress said it was a responsibility of the Federal Government to build, maintain, and regulate the airways without which the air carriers could not have continued systematic operations. Responsibility for the airways was given to the Department of Commerce.

The airlines were struggling along when the industry was given a tremendous shot in the arm. The transatlantic solo flight of Charles A. Lindbergh in 1927 probably produced greater mass enthusiasm—both here and abroad—than any other event in the history of aviation. This feat suddenly made Americans aware that perhaps the airplane was a safe, speedy, and useful vehicle. As a result, more people now wanted to discover the thrill of flying. More important, businessmen began to consider aircraft building and operating as a profitable investment. This led to a boom which brought 44 scheduled airlines into existence in 1929.

In May 1928, a number of prominent industrialists formed the Transcontinental Air Transport (T.A.T.). Wright and Curtiss Aircraft Companies and Pennsylvania Railroad held large interests. Colonel Lindbergh headed the Technical Committee in mapping out and organizing the coast-to-coast route. This was the turning point in the development of civil air routes. Suddenly, emphasis shifted to transcontinental routes and nation-wide systems. Furthermore, financial participation shifted to Wall Street. Airlines became big business with manufacturers, such as Boeing and Curtiss, forming airline combines. These combines fought for supremacy on the

Columbia Line or transcontinental air route. The airlines went through a few changes during the years, but they still survive today as the big four (American, Eastern, TWA, and United). Moreover, their route patterns mapped out between 1927 and 1930 remain the backbone of the country's air route structure.

In the years immediately prior to the stock market crash of 1929, the airlines were well on their way to becoming Wall Street big business. When the national economy suffered during the depression following the crash, the airlines suffered, too, and it was left to the resources of the Government to help the airlines through the lean years.

The Wall Street collapse brought disaster to many airlines and led to the passage of the McNary-Watres Act of 1930. Under this act, the Government encouraged the development of passenger traffic by varying mail payments in accordance with the provision by the airline of increased space and various facilities for passenger safety and comfort. Largely as a result of this legislation, airline passenger accommodations improved materially, and passenger traffic on domestic air routes increased substantially. Of course, technological improvements of the airplane and airways also helped increase the efficiency and safety of air travel.

The airlines up to this time had depended on airmail payments for financial stability. But President Franklin D. Roosevelt forced the airlines to turn to passenger and express revenue for their main source of income when he drastically lowered airmail payments. On 9 February 1934, he went a step further; he cancelled all airmail contracts and had the Army fly the mails. The Army pilots were inexperienced in flying over vast stretches of unknown territory and were unlucky enough to strike a period of especially bad weather conditions. They were not equal to the job, and, as their casualty rate grew, so did the hopes of the airlines for airmail contracts. On 10 March 1935, all mail flights were cancelled. Soon after, airmail contracts were again awarded to civil carriers who have carried the mail ever since.

Vast technological advances had taken place since 1925. The industry was trying to create a plane that could fly cheaply. Some of the major technical advances made between 1925 and 1936 included the increase of wing loading and the development of multiengined ships, engine nacelles, cantilevered wings, and high octane gasoline. The first planes to incorporate all these dynamic improvements were

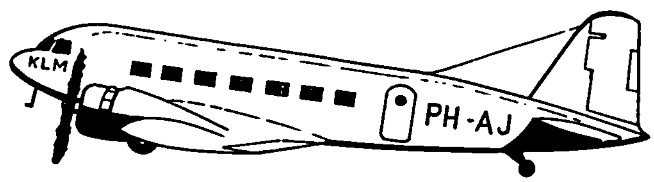


Figure 2. DC–2.

the Boeing 247 and the Douglas DC–2 and DC–3, which made their appearance as air transports in the period from 1933 to 1936.

Equally important, the development and expansion of safe airways during the 1930's made air travel more efficient. The Government provided more revolving beacon lights, radio range and broadcast stations, weather teletype service, and emergency fields. Airway facilities were, in fact, about adequate for the flight requirements of the period.

Still, an adequate volume of travel, essential to successful air transportation, eluded the airlines. Too many people were afraid to fly. News of spectacular air crashes instilled even greater fear into the hearts of many potential passengers.

The introduction of better equipment and improved air facilities, which made flying safer, lessened people's fear of flying. The airlines had become safety conscious. This new consciousness led them to accident research and investigation which disclosed mechanical and personal errors. They have been ever improving their equipment and facilities until, today, air crashes are big news because they occur so seldom.

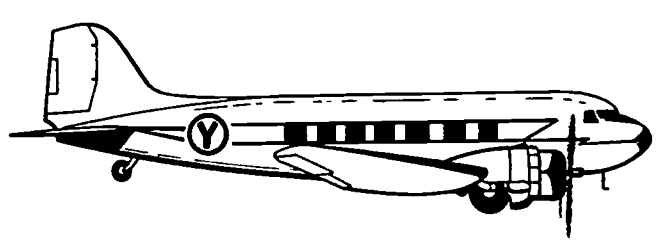


Figure 3. DC–3.

THE GOVERNMENT AND PRIVATE AVIATION

The Black-McKellar Bill of 1934 assigned the Interstate Commerce Commission the responsibility of establishing the rate of mail payments made to air carriers and recommended that a study be made of commercial aviation. This bill forced the airlines to compete for passenger business. They used up-to-date advertising methods and promotional techniques to make airline service more attractive. They added many little extras to make the trip more pleasant—meals, stationery, maps, picture postcards, newspapers, magazines, blankets, first-aid medicines, and help in the care of children. Many of these extras attract passengers today.

Reduction in fares now made air transportation competitive with first-class Pullman rail travel. The price per passenger mile in domestic air transport dropped from 12 cents a mile in 1929 to an average of 5.4 cents in 1935 and 5.2 cents in 1938—a level maintained, with some fluctuations, well into the 1950's. This reduction in fares was only partly due to increased efficiency of operation and competition among air carriers; mail contracts also played a role, for they permitted the airlines to distribute the costs of operation over mail service and passenger transport.

Growth was not limited to passenger transport. Many businesses had discovered the value of air cargo transport. Those technical improvements that made passenger service more economical and safer also made for improved cargo carriage.

Fundamental, of course, in appeal to the traveling public then, as now, were the advantages of speed and frequency of schedules offered by the airlines in passenger service. No other means of transportation has been able to match them in this combination of services. Air transport offered increasingly frequent schedules between the great commercial, industrial, and political centers of activity.

In Europe, air transport had early been recognized as an important instrument of national policy and defense. In the United States, the defense concept of civil aviation, while early recognized and always accepted in principle, has never been as heavily stressed. This concept was reviewed in the study conducted under the Air Mail Act of 1934.

The study of commerical aviation led to the Civil Aeronautics Act of 1938. With its passage, one Federal statute and agency were substituted for the several which had been regulating the industry. The Civil Aeronautics Authority (CAA) consisted of three practically autonomous groups: a five-man Authority, which dealt with economic and safety regulations; a three-man Air Safety Board, for the investigation of accidents; and an Administrator, who was in charge of the development and operation of air navigation facilities as well as general development and promotional work. Organizational difficulties, duplication of activity, and dissension within the ranks of the Safety Board brought about a reorganization of the regulatory agency in 1940.

The Civil Aeronautics Authority was, in effect, split and provided the nucleus for two new organizations. The five-man Authority became the Civil Aeronautics Board (CAB), to which was assigned the safety rulemaking function; the Administrator was transferred to the Department of Commerce, where he exercised his functions as head of Civil Aeronautics Administration (CAA). Hence the abbreviation CAA continued to be used.

After 1940, the CAA, under the Department of Commerce, was to encourage aviation's development to fill the commercial and defense needs of the United States. The 1940 reorganization did not solve all the difficulties the CAA experienced. Rather, the CAA underwent a series of small changes which eventually led up to the passage of the Federal Aviation Act in 1958.

On the eve of the Second World War, the Federal Government, on the premise of national interest, continued to provide an element of direct aid for the transportation of mail. This aid helped put the air industry on a financially sound basis. The subsidy element in airmail payments was on the whole less than the subsidy paid in most countries. The value of this investment became immediately apparent with the outbreak of World War II.

CIVIL AVIATION AND WORLD WAR II

The airlines and general aviation made significant contributions to the successful prosecution of the war in which the Nation found itself engaged on 7 December 1941. While contributions of general aviation were of a largely aeronautical nature (except for the civilian pilot training program and the Civil Air Patrol), contributions of the airlines were on the whole more direct and immediate. The assistance of both were particularly notable in the critical early days of the war when our military air power existed largely on paper. Among the tasks performed by the airlines during World War II, the most important are described below:

1. *Provided the Armed Forces with transport aircraft.* At the outbreak of war, the airlines turned over 324 aircraft, or half their domestic fleet, to the military forces. These commercial airliners formed the nucleus around which the Army Air Forces and Navy were able to build their huge transport commands. In addition, the airlines also delivered to the Armed Forces airplanes previously ordered for commercial use. Some of these planes were transferred even before Pearl Harbor.

Perhaps just as important to the successful prosecution of the war was the healthy condition of the airline business at the outbreak of the war. Had the United States lacked sound, thriving, and expanding commercial airlines, the aircraft industry would not have been so technologically advanced or economically important. Even with this commerical stimulus, aircraft production was inadequate for the immense military needs, and it was not until several years later (March 1944) that the required top production level was reached.

2. *Supplied key personnel.* In addition to supplying the Armed Forces with aircraft and crews, the airlines furnished the services with many experienced executive personnel to set up and operate the transport commands. These executives became the transport command organization commanders, chiefs of staff, etc. Without these top men, the gigantic wartime airlift operations described above would not have been achieved at so early a date.

3. *Supplied many technical services.* When the war broke out, the airlines were the principal source of maintenance and repair personnel. The military services turned to these technicians for servicing, maintaining, converting, and modifying their aircraft. They worked in both airline-operated and Government-controlled repair shops.

4. *Furnished contract flying service.* As stated earlier, the Armed Forces were not able to perform all the flying functions demanded by the war effort. The airlines filled the gap by supplying contract flying service to the Air Transport Command (ATC) and Naval Air Transport Service (NATS). These contract flying operations grew remarkably between 1942 and 1945.

5. *Trained flying personnel.* The airlines also helped the war effort by training navigators, pilots, mechanics, and meteorologists for ATC and NATS. In addition, private operators expanded their facilities and trained thousands of fliers under the Civil Aeronautics Administration's Civilian Pilot Training Program. Together, these

students became the backbone of the Army, Navy, and Marine air arms.

6. *Provided airbase facilities.* Civil authorities, in conjunction with CAA, established airbase facilities for the use of both scheduled and non-scheduled airlines in cities throughout the United States. These formed the nucleus for many military installations when expansion of such aviation facilities became vital for national defense.

7. *Met demands of accelerated war business.* Despite the tremendous inroads made into the civil air transport fleet, the airlines greatly speeded up the conduct of war business through commercial airline travel. Notwithstanding a forced cut of nearly half in daily scheduled plane miles, the airlines in 1942 were able to carry 82 percent of the last prewar year's number of passengers. In 1944, the airlines carried 15 percent more passengers. This was made possible by pushing up the hours aircraft were in use from 6.5 hours to 11.5 hours a day in 1944.

One of the most significant developments in domestic air cargo transportation was the vastly increased use of air express. Air express pound-miles jumped fivefold and previewed the postwar potentialities of cargo service.

POST-WORLD WAR II EFFECTS

The tremendous wartime advances made in the development of aircraft and engines during World War I had had a direct and beneficial effect on civil aviation. Later, it was developments in civil aircraft that benefited military aviation. Then, during World War II came unparalleled scientific and technological progress, which in turn profoundly affected civil aviation. Most significant was large-scale production and operational use of jet-propelled and rocket-propelled fighters and of guided missiles by the Germans. This foreshadowed the coming of a revolutionary new era in air transportation within a matter of years.

Jet propulsion, radar, and other scientific and technological developments brought about improvements in equipment and airways. These improvements aided the postwar expansion of civil aviation.

During wartime, there had been a great demand for air transportation and airline travel. This demand continued during the rapid demobilization following the war.

Both Government officials and airline executives were misled by the heavy demand for air travel. They based their future plans on the basis of increased demand. As a result, they overextended themselves. They failed to consider that the demand might be temporary or that thousands of military pilots would enter general aviation businesses. So they ordered more planes, hired more personnel, and filed for new routes. When the demand dropped, they found themselves in financial trouble great enough to ruin even a mature industry.

To counteract the crisis, the airlines cancelled their equipment orders. This threw the production industry into chaos. Their jobs eliminated by lagging production, highly skilled engineers and other technologists were forced to leave the aircraft industry. Those who stayed found the going difficult. Ultimately, both the aircraft industry and the airlines were threatened with collapse, a condition which would have had disastrous effects on military aviation. This situation was indeed critical.

The period 1946–1947 was a rough one for the airline industry. It was only through the creation of the CAA that it survived it at all. As early as 1938, Congress had foreseen the difficulties an airline crisis would bring.

The CAA Act empowered the Civil Aeronautics Board to adjust the mail pay so that the operating losses suffered by air carriers would not be fatal.

In addition to granting higher temporary mail pay rates, the CAB also approved some loans made to the airline industry by banks, insurance companies, and the Reconstruction Finance Corporation.

By employing newer and more thoroughly tested equipment and by taking advantage of the improved airways, the airlines were able to increase the safety and regularity of their service. The year 1950 saw the airline industry achieve an unprecedented safety record. The passenger fatality rate was only 1.1 per 100 million passenger miles flown.

Airline passenger business showed a marked upturn in 1949, and, by the latter part of the year the industry was out of the red. In 1950, the industry experienced its most successful year; with all categories of traffic at record-breaking levels for two years in a row, the industry's profits were the greatest since the end of World War II. Domestic air carrier operating revenues exceeded the half-billion dollar mark for the first time, giving the airlines a net profit of $63 million. About half of this profit would not have been possible without $30 million of mail subsidy.

The airline industry has emerged as a new and constructive force in the economy. At the end of World War II, the airlines were still a relatively minor factor in the Nation's production of goods and services, but they were growing in significance. Long-sustained expansion in passenger and freight traffic has made air transport one of the Nation's major industries.

The years since 1950 have seen an historic shift in the Nation's travel habits brought by an increase in speed and in service. Planes are now more comfortable and convenient than ever. Public response to these improvements has been remarkable. The airlines now account for more than 70 percent of all public domestic intercity traffic. A decade ago, the airlines carried only about 35 percent of this traffic. As passenger traffic has increased, the cost of a ticket has gone down. Currently, it costs an average of 5.49 cents to travel one mile in an airplane, less than the cost of this kind of travel more than 20 years ago. Air travel and aerospace industries have become "big business," accounting for something like $30 billion each year, representing about 4% of our gross national product.*

Because of the combination of improved equipment and enlarged route systems, the airlines today are producing eight times the revenue ton miles they produced in 1950. Not all of this growth has been reflected in profits. Because of the nature of aircraft and the speed of technological gains, much of the airlines' money is invested in capital outlays. Since each new jet is almost obsolete the first time it taxis for takeoff, continual replacement of equipment is accepted and, in fact, expected.

In the years since 1950 airline traffic has more than doubled, and general aviation traffic has doubled several times. This has led to a condition known as the "crowded air." Until 1958, the CAA controlled civil aviation, and a number of other agencies controlled military aviation. Often there was little coordination between these agencies. This lack of coordination caused confusion in the use of air lanes and culminated in a long series of spectacular air crashes in 1957–1958. In response to an aroused public, Congress enacted the

* A brief note on the statistics used here seems in order at this point. We have used the latest available statistics in preparing the material in this booklet. We have taken these statistics from such reliable sources as the latest editions of the Air Transport Association of America's annual publication *Air Transport Facts and Figures* and the Aerospace Industries Association of America, Inc.'s annual publication *Aerospace Facts and Figures*. Current editions of these works provide statistics on the preceding year's activities.

Federal Aviation Act which created the Federal Aviation Agency and gave it the responsibility for regulating all airspace over the United States and establishing a unified system of air traffic control.

The establishment of the Federal Aviation Agency in 1958 brought together in one organization the Civil Aeronautics Authority (CAA), the Airways Modernization Board, and the safety-rule-making function of the Civil Aeronautics Board. The CAB continued as an independent agency overseeing the economic aspects of the industry. Certain military personnel were assigned to FAA to insure civil-military cooperation.

The FAA is headed by an Administrator, appointed by the President with the advice and consent of the Senate. He must be a civilian with aviation experience.

For the first time in the history of aviation, the act assured coordination and cooperation between civil aviation and the military services. It also provided for the assignment of military personnel to posts within the Agency, thus insuring military participation.

The FAA continued as an independent Governmental agency from 1958 through early 1967. Then the Federal Aviation *Agency* became the Federal Aviation *Administration*, and it became part of the Department of Transportation. Because the initials are the same for each organization (FAA), you have to know what year is involved when people speak of the FAA. The current organizational structure is the result of all the previous efforts to organize this complex and rapidly expanding area, but by no means is it the final and ultimate organizational solution. New developments in the industry create new organizational needs, and the Government will adapt to these needs as they emerge.

Throughout the history of aviation, the Federal Government has played a role. The pioneering efforts of the Post Office Department proved that air travel could be both safe and efficient. During wartime, the Government saw how vital air power was to our national defense. This reinforced the strong air industry policy. The Government came to the side of the struggling air industry in times of need and gave the boosts that the industry needed to stay alive. In turn, as the air industry expanded, it brought growth to the national economy and promoted national defense. Thus, the relationship has been one of mutual cooperation. As aircraft increase their efficiency and air travel grows in popularity, Government regulation becomes more and more vital to public safety and the orderly movement of thousands of aircraft.

RELATIONS BETWEEN CIVIL AND MILITARY AVIATION

Because of the nature of aviation today, the roles of civil aviation, military aviation, and the Federal Government are necessarily tied together. The Federal Aviation Administration (FAA) itself is a combination of these three ingredients—whose personal interests may occasionally conflict. Today, there are fewer conflicts because each group has representatives in the FAA pushing its individual ideas.

The FAA provides the authority necessary for effective management practices. It stimulates intergroup cooperation. This intergroup cooperation was behind many of the advances made since the establishment of the FAA including a radar advisory service for jet aircraft carriers. This service provides positive separation of aircraft over 25,000 miles of jet routes. This service was made possible by joint use of 38 military air defense and 11 FAA long-range radar systems.

Other improvements were made in safety and efficient use of the airspace by consolidating some military refueling areas and eliminating others. Climb corridors were established for high speed jet aircraft to provide greater safety when the pilot's forward visibility was restricted during climbs.

Other studies on proximity (nearness) warning devices were initiated, and plans for greater use of military radar enroute traffic control were formulated. Restricted areas used by the military were revised, some were eliminated, and others were used on a prior notice basis. This practice provided extra airspace which had not been available previously.

Cooperation between the military and the FAA was further increased, since the military consulted the FAA before constructing new airports and runways. On several occasions this cooperative planning prevented conflicts in the use of airspace by integrating present needs with future plans.

Clearly, the FAA has increased safety and efficient use of airspace. Management of the nation's resources through joint efforts has saved millions of dollars.

PROJECT BEACON

At the request of President John F. Kennedy, a task force known as Project Beacon was established in early 1961. The purpose of this task force was twofold: (1) to conduct a scientific review of aviation facilities and related research and development, and (2) to prepare a practical long-range plan to insure efficient and safe control of all air traffic within the United States. Sound planning was to provide an orderly and economic evolution of the present system of air traffic control in pace with continuing advances in technology and national needs. Both civil and military representatives participated in the study. The study was completed, and a report on the results was sent to the President on 1 November 1961.

The study groups estimated a 44 percent increase in total flying by 1975. However, controlled traffic was estimated to increase by 300 percent. Although there had been sufficient improvements in air traffic control measures to handle the prevailing air traffic, it was obvious that many improvements had to be made to cope with future problems. Separation standards dependent on calculated position and pilots' reports were insufficient; radar control would be necessary to handle growing air traffic. The simultaneous use of both instrument flight rules (IFR) and visual flight rules (VFR) along the same airways was a problem. There were also problems of radio frequency congestion and pilot and aircraft controller overload due to the requirement for frequent position reports. In the terminal area, improvements in approach and departure clearance delivery were necessary to prevent inefficiency through excessive delays.

Project Beacon study groups recommended several future improvements in the area of controlling air traffic. First, the study groups recommended the development of a system for immediate and continuous aircraft position and altitude information to the air traffic controller. Other areas singled out for future improvement included the segregating of controlled and uncontrolled air traffic; the establishing of positive control areas above certain altitudes; and the establishing of speed limits in certain areas. Still other recommendations involved the employing of general purpose computers in air traffic control and the integrating of air defense radar with FAA radar in order to provide continuous radar service enroute. The plan was to provide safety, economy, and efficiency of operation for both civil and military operations.

By the beginning of 1965, many of the recommendations of Project Beacon had been completed, and others were nearing completion. In the area of safety, many scientific studies have been made concerning hazards of lightning strikes, problems of turbulence, and airframe fatigue. Radars used by traffic controllers have been modified to give suitable weather displays on radarscopes, a tremendous safety factor. Aeromedical research has provided information both on human factors in aircraft accidents and also on impact and acceleration considerations for future aircraft design.

Project Beacon recommends achieving greater air safety through better aircraft maintenance practices and procedures. An experimental Maintenance Management Audit System was developed to evaluate systems and practices used by air carriers in directing and controlling aircraft maintenance.

Although air safety indices have remained generally the same since the creation of the FAA, both aircraft traffic and speeds have increased at a tremendous rate. Without the improvements made by the FAA, undoubtedly the record would have suffered greatly.

Tremendous advances have been made in air traffic control. The airways structure has been streamlined to provide complete direction and guidance above 24,000 feet at all times. Instrument flight rules (IFR) are required above this altitude, and radar service is available in practically all areas of the United States. Joint use of the Air Force's SAGE direction centers has provided extra safety. SAGE is an acronym for "*s*emi*a*utomatic *g*round *e*nvironment." SAGE operates a type of electronic digital computer that reports and acts on a developing situation. The widespread use of radar, in addition to providing greater safety, has been a tremendous asset in expediting departures and arrivals in congested areas.

A traffic control radar beacon system, which displays a constant altitude and identification signal on the controller's radarscope, has been approved for development by both military and civil aviation. Present radar systems do not provide adequate altitude information although they do help the radar controller determine distance. This new system will display both altitude and distance information. The last chapter of this booklet will discuss this new system. It will also explain present air traffic control procedures and list other new aids to air traffic control.

The FAA, then, plays a significant part in maintaining our national defense posture. The military services and the commercial airlines can now use common systems of air traffic control, and, thus, they can work together to solve common problems. The commercial airlines aid the common defense in another important way—the Civil Reserve Air Fleet.

CIVIL RESERVE AIR FLEET (CRAF)

The scheduled United States airlines have a double mission. The first mission is to stimulate commerce by carrying passengers and cargo safely, dependably, and economically throughout the free world. The second mission is to provide airlift assistance to the Department of Defense and civilian disaster relief agencies in the time of national emergency or natural calamity. This double mission is defined in the Civil Aeronautics Act of 1938 which states that the airlines are to serve the domestic and foreign commerce, the postal service, and the national defense effort. The airlines have followed this mandate since then.

The airline industry responds flexibly to the needs of the military. It provides contract activity, commercial air movements, and individual ticketing. This service has satisfied some very large requirements without declaration of a national emergency.

In the event of a national emergency, there must be an established organization to insure quick response with as little loss of time and effort as possible. In aviation, CRAF is such an organization. The airlines and the Government together developed the *C*ivil *R*eserve *A*ir *F*leet (CRAF). Certain airplanes in the airline fleet are designated and specially equipped as CRAF planes and are available for emergency on Government call. The airplanes are an important part of CRAF, but there is more to CRAF than airplanes. Also included in this organization are the trained crews and mechanics. This fleet therefore is self-sufficient, in top condition, and ready to answer any emergency.

In time of emergency, efficient operation of transport for the domestic economy is also essential; hence, the Department of Commerce has a major responsibility for commercial aircraft allocations in the CRAF program. The Commerce Department is advised by the Defense Department for the military requirements and by the CAB for civil requirements.

The CRAF program, as it applies to international operations, is activated in three stages. The first stage does not require a declaration of emergency. A total of 100 cargo and passenger aircraft are available to the military with their crews and appropriate support. This is the stage currently operating.

Stage two is an "airlift emergency" as determined by the Secretary of Defense. At that time, a total of 234 cargo and passenger aircraft become available.

The third stage calls for the total activation of CRAF. This would occur in time of war or during an unlimited national emergency or a civil defense emergency declared by the President of the United States or the Congress. This would bring the full CRAF fleet in and would involve 260 aircraft. The totals vary from time to time as new airplanes are delivered.

When fully activated in a national emergency, the airline portion of CRAF can add more than three billion annual ton miles of lift to the military. (A ton mile is the movement of one ton of cargo one mile.) This is about a fifth of all the ton miles performed by all U.S. airlines, domestically and internationally, in 1967.

For troop movement and personnel evacuation, CRAF can make available more than 15 billion seat-miles annually, about a sixth of all seat-miles operated by the domestic trunk lines in 1967. (A seat-mile, as defined by the CAB, is a measure of the volume of traffic representing one passenger transported one mile.)

The concept of CRAF is a good one because it provides a force in being ready to respond to a national emergency. It does this at less cost to both the airlines and the Federal Government. It insures utilization of available aircraft. Finally, it guarantees that the aircraft and the crews that operate them are in top condition at all times.

The scheduled airlines are lifting a large percentage of the Military Airlift Command's transient passenger traffic into Southeast Asia. The airlines are lifting over 2,500 passengers and over 180 tons of cargo per day to Vietnam.

By traditional airline standards, this is a massive volume, more than double the comparable percentage during the Korean conflict. Then, the speed and carrying capacity of airline aircraft were far less than they are today.

THE INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO)

Global transportation systems faced the same problems of air traffic control that the United States did. The unprecedented air traffic following World War II made it mandatory to control and regulate the use of the air. As a result, national leaders sought to establish standard operating and legal arrangements for air travel on a worldwide basis. The delegates from 52 countries met in Chicago on 1 November 1944. There they established an organization which they called the International Civil Aviation Organization (ICAO). The purpose of this organization is to promote civil aviation on a global scale as a means of creating international friendship and understanding.

The ICAO has its headquarters in Montreal, Canada. It has been an effective organization making major contributions to world cooperation in air transportation. It sets technical standards and air operating rules, and it carries out accident investigations. In this, it resembles the FAA. However, the ICAO shows its distinctly international flavor when it makes recommendations aimed at eliminating prolonged inspections at border airports.

REVIEW QUESTIONS

1. **How did military aviation aid civil aviation? How did civil aviation aid military aviation?**
2. **Explain the Federal Government's role in aviation.**
3. **Describe the Civil Reserve Air Fleet (CRAF).**

THINGS TO DO

1. We noted in this chapter that the Federal Government exercises control over virtually all phases of commercial aviation. Much of this control is applied through FAA. You might, therefore, obtain from your local FAA representative (usually found at the local airport) copies of some FAA regulations. You might ask your AEI for permission for a committee to call on the local FAA office and invite a representative to speak to the class on the relationship between the Government and commercial aviation.
2. In relation to the above, you might also investigate the relationship between commercial and military aviation and determine the extent to which FAA exercises control over military aviation.

CIVIL AVIATION AND FACILITIES

SUGGESTIONS FOR FURTHER READING

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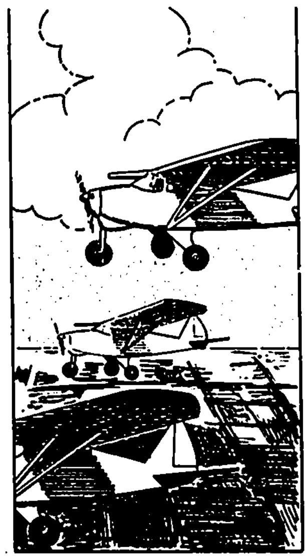
Chapter 2



General Aviation

IN THIS CHAPTER, we are concerned with the fastest growing segment of the aviation industry—general aviation. You will read about what it is, what it includes, and why it is growing so rapidly. You will learn about agricultural aviation, business aviation, instructional flying, recreational flying, and a new facet of air transportation, air taxi service. The Civil Air Patrol is also an important part of general aviation, and so you will read about its mission and how the organization functions. Just what the impact of such a rapidly growing industry will be on our country is explained at the end of the chapter. When you have studied this chapter, you should be able to do the following: (1) tell why aviation is so important to the business executive, the farmer, and the average citizen; (2) discuss why "air taxis" are such a popular part of general aviation; (3) outline the mission of the Civil Air Patrol; and (4) explain how the producers of private aircraft contribute to the growth of general aviation.

GENERAL AVIATION is a term used to designate that part of aviation which is neither military nor airline. Included in general aviation are agricultural aviation, business aviation, instructional flying, recreational aviation, and air taxi service. General aviation also covers such conservation activities as forest, power, and pipeline patrol; such public service activities as ambulance, rescue, and emergency service; and such law enforcement activities as automobile traffic surveillance.

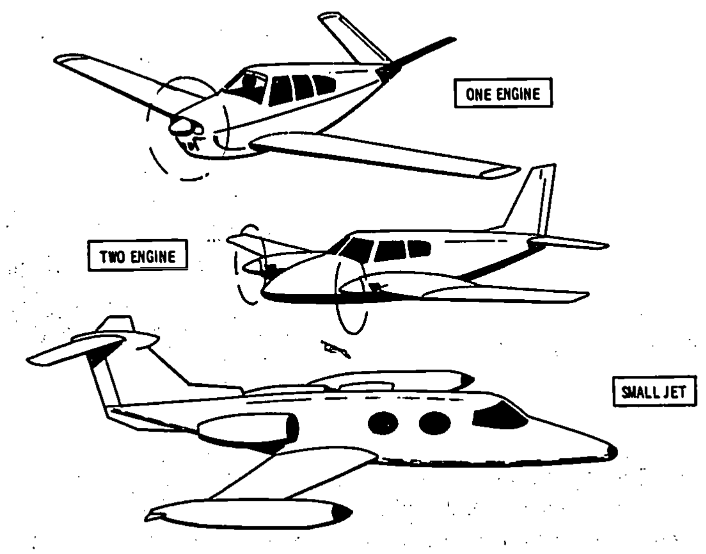


Figure 4. General Aviation.

General aviation is the most rapidly expanding segment of the total aviation picture. Its growth has a significant effect on both the national economy and on individual well-being. General aviation has brought airmindedness to many diverse businesses and industries, and today it carries a much greater volume of traffic than does the commercial airlines.

Not only is general aviation now the fastest growing segment of aviation, but all major criteria for measuring its growth point to a continuation of the trend which has existed for nearly 15 years. To cite a few figures: in 1957, there were 66,520 aircraft in the general aviation fleet. At the same time, there were 1,829 aircraft in the air carrier fleet. To put it another way, there were about 40 general aviation aircraft in service for every air carrier aircraft in service. In 1967, 10 years later, there were 112,000 aircraft in the general aviation fleet and 2,188 aircraft in the air carrier fleet. This means that there were about 55 general aviation aircraft in service for every air carrier aircraft in service. Another way to look at the growth of general aviation is to compare the actual number of hours flown. In 1957, general aviation aircraft logged some 10,938,000 miles, which represents about 71 percent of the total number of hours flown in civil aviation. By 1967, this figure was up to 22,-

600,000 miles, more than twice the number of miles flown a decade earlier. This figure represents some 82 percent of the total number of hours flown in civil aviation, an increase during the decade of more than 10 percent.

AGRICULTURAL AVIATION

The airplane has been used as a tool in agriculture since 1919, when the United States Department of Agriculture (USDA) aerially dusted fruit trees infested with caterpillars. From this pioneering experiment stemmed the aerial application business in agriculture. Many different types of crops are now treated from the air. Airplanes can be successfully used for spraying, dusting, seeding, and fertilizing crops. In a recent year, for example, airplanes were used to

	Year	1957	1962	1963	1964	1965	1966	1967
Number of General Aviation Aircraft		66,250	84,121	85,088	88,742	95,442	104,706	112,000
Number of Air Carrier Aircraft		1,329	1,831	1,832	1,863	1,896	2,022	2,188

Aircraft Hours Flown In:	Year	1957	1962	1963	1964	1965	1966	1967
General Aviation		10,938,000	14,500,000	15,106,000	15,738,000	16,733,000	21,023,000	22,600,000
Air Carrier Opn's		4,438,606	3,491,051	3,606,661	3,774,545	4,071,855	4,233,118	4,924,613

Figure 5. General Aviation Growth.

treat 1 out of 6 tillable acres in the United States with some 140 million gallons of spray chemicals and more than 700 million pounds of dry chemicals.

Aerial spreading of fertilizer is not uncommon in the South and Southwest. It is particularly useful in rice production. Aerial seeding is profitable with some crops, such as grasses, grains (especially rice), cover crops, and oil seed crops other than cotton. It is predominantly used in the South and Southwest where rice is an important crop. The airplane has been used for reforestation and pasture reseeding. Oddly enough, the airplane is also used to distribute defoliation chemicals which cause plants to lose their leaves and mature more rapidly. Defoliation facilitates mechanical cotton picking and makes possible a higher quality product.

Aerial application is not the only segment of agricultural aviation. Farmers and ranchers often own their own planes which they use to check on their crops and animals, to ship them to market, and to keep up the many business interests of the modern farmer and rancher.

BUSINESS AVIATION

Modern big business has turned increasingly to air transportation for a variety of reasons. Today there are fewer key executives to oversee large business and industrial complexes. Plants and offices have been scattered throughout the country for economic as well as defense reasons. Many of these plants are located far away from a large airport. Demands on executives' time are ever increasing. Directives handed down via teletype do not have the same results as face-to-face contacts; face-to-face meetings achieve much better results. But how does Mr. John Smith get from New York City, to Savannah, Georgia, for a two o'clock meeting, on to Birmingham that night to speak at a company banquet, and on to Knoxville for a conference the next morning? He flies the company plane. Thus, he saves his valuable time and accomplishes much more. He has a flexible schedule, and he can land at any one of the more than 9,000 general aviation airports.

This is not to say that every major company has its own plane. Many use the airline services. Others charter airplanes. Still others use air taxi service. But business has definitely taken to the air. Executives, salespeople, buyers, factory managers, and a host of others now use this time-saving method of getting their jobs done quickly and better through the use of company- or individually-chartered, leased, or owned aircraft.

Executives and others fly in increasing numbers every year. Demands on executives' time become ever greater. Long, leisurely business trips are no longer practical. Scheduled airlines do not go to every plant. FAA forecasts predict that for at least the next 10 years business flying will increase and will remain the largest type of general aviation flying. By 1977, business flying will account for 10.4 million hours of flying time in general aviation. This figure represents almost a third of the total number of hours of flying in general aviation. Business flying, then, is a large operation, and yet only a small percentage of the 400,000 or so businesses which need and can afford their own aircraft do so at the present time.

INSTRUCTIONAL FLYING

Every year many people learn to fly. Many more want to learn. Some of you are probably interested in learning to fly. Why? There are probably as many different reasons as there are people who learn. The reasons range from desire to boost company earnings to thoughts of dining in Memphis, shopping in New York, fishing in Alaska, or surfing at Malibu—recreation. Whatever the reason, a student pilot needs to be taught well.

The Federal Aviation Administration realizes this and has set up certain requirements and tests which the student pilot must pass to qualify for a Private Pilot's Certificate. The FAA has also certified flight schools which meet FAA curriculum requirements.

A prospective student pilot must be 17 years of age and able to pass an FAA administered medical examination to gain acceptance in an FAA certified flight school. On the first day of school, he is given a handout which describes the curriculum. He discovers that he will be given individual ground instruction before and after each flight. The ground instruction subjects are:

(a) Theory of flight (including airframe and engine operation).
(b) Federal air regulations and air traffic procedures.
(c) Meteorology.
(d) Dead-reckoning navigation, including the use of the E6B computer.
(e) Radio navigation and communication.

(f) Use of pilot information manuals such as the Airmans' Guide and the Flight Information Manual.

He is told that, before he can solo, he must pass a written examination on general operation of the aircraft, theory of flight, and Federal air regulations. This test has been designed to assure that the student has acquired the knowledge needed to be competent in solo flight.

A student pilot soon realizes that there is a lot to know about an airplane. He discovers that it will take a lot of time and practice to learn to fly safely. After many takeoffs and landings, stalls, banked turns, practices in emergency procedures, talks with the tower, and hours of cross-country flying, however, the student is ready to solo. He is not allowed to take passengers up until he receives his certificate. He works for his required 20 hours solo time. He can fly as frequently as he wants, whenever and wherever he wants to go, provided his instructor considers him competent. The instructor always considers the weather before permitting a trip. Soon, the student has accumulated his 20 hours solo time and is ready to be tested by the FAA. When he passes, he is awarded a Private Pilot's Certificate.

RECREATIONAL FLYING

A trip to other countries used to be possible only for persons who could spend several months in travel. This left out average persons with only a two- or three-week vacation. Now many people fly to other countries for vacation travel. The travel time to and from other countries by air may be only one or two days, or less. This leaves most of the vacation time free for sightseeing and other pleasures.

Many persons own their own aircraft to fly for pleasure. Quick trips to the beach, to resorts, or to vacation spots in the mountains can now be made over week-ends. For many persons, flying itself is a form of recreation. The thrill of being able to look down at the earth from the sky is an enjoyable sensation to flying enthusiasts.

AIR TAXI SERVICE

Small planes are becoming faster, more comfortable, and safer because of modern equipment. These improvements make a major contribution to the boom in personal and business flying, but the boom does not stop there. It opens up a new field of operation commonly called "Air Taxi Service."

All the signs are good for this young industry.

First, the whole air transport industry is growing faster than was dreamed possible a few years ago. The airline fleet is getting larger; its airplanes are larger; and they are flying more trips and carrying more passengers.

Second, this growth is going on in the face of a decline in all kinds of public short-haul transportation such as trains and buses except intercity buses. The local service airlines are rapidly becoming baby trunk lines. Because of the availability of the private automobile, other forms of short-haul transportation are losing ground. Instead of taking commuter buses or trains, airline passengers are driving their cars to the airline terminals to meet their flights. At many airports, it takes longer to find a parking space than it does to catch a plane. The situation is likely to get worse before it gets better.

Third, the Post Office is faced with short-haul problems just as everyone else is. The number of mail trains has decreased by 90 percent since 1925, and traffic congestion interferes with mail trucks as with everything else. The Post Office needs to improve its service and is looking at air taxi service as a possible way to do so.

Let's look at air taxi service more closely.

There are two types of "air taxis": those which provide demand service, like regular ground taxis or airplane charter operations, and those which fly their routes on schedule.

The demand people have small equipment needs, and they can work as little or as much as they like. Most demand companies start with small planes with one pilot per plane to keep operating costs down. Still, these companies will never get rich, because passenger volume on this type of operation is not high, and probably never will be high. Because costs are based on a minimum break-even fare, one person, traveling alone, seldom finds the cost-benefit ratio acceptable.

The scheduled air taxis are not really taxis. They refer to themselves as commuter airlines, but this description is not quite right either.

Some commuter airlines connect with the major airlines, and some fly between heavily traveled points such as New York-Washington. These feeders using single- and twin-engine planes will grow fast for they provide other lines with convenient connections. Though they call themselves airlines, they are not curtailed or regulated as such.

As air taxis and commuter airlines fill the short-haul gap, they increase in importance and also in problems. Two big problems confront them at the present: economics and regulations.

The economic problem was faced by the trunk airlines years ago. The answer then was subsidy. Now these same airlines frown on the use of subsidy for air taxis. United Air Lines has its own approach to the problem. United has realized that what is good for general aviation is good for United. So the company has become partners with the local carriers, and, today, profitable interline cooperation between this trunk and local carriers is an established fact.

One of the possibilities under consideration is subsidy by local governments. The amount of subsidy would depend upon the amount of use the community made of the airline. This way, the more they used the line, the less subsidy the community would have to pay. This would give the community pride of ownership and also would promote greater usage of the line.

The second major problem that the airlines are confronted with is regulation. Is there too little or too much? Are tighter operating standards needed? How soon?

There is considerable controversy about the present standards. The air taxi people think they are too strict, and others think that single pilot operation on any basis is not safe enough.

As the operation of air taxis and commuter airlines increases, there are bound to be greater demands placed upon them by both the Government and the traveling public.

CIVIL AIR PATROL (CAP)

It is hard to know exactly where we should discuss the Civil Air Patrol (CAP) in this booklet. We have chosen to talk about it here, simply because the aircraft used by the CAP are of the general aviation type.

The mission of the Civil Air Patrol is fourfold: (1) to employ its volunteer manpower resources and equipment in search and rescue; (2) to fulfill its role of readiness to meet local and national emergencies; (3) to motivate the youth of America to the highest ideals of leadership and public service; and (4) to further this Nation's air and space supremacy through a systematic aerospace education and training program.

The Civil Air Patrol (CAP), a civilian auxiliary of the United States Air Force, has performed this broad mission for more than two decades. More than 80,000 men, women, boys, and girls from more than 2,000 cities, towns, and villages participate in the CAP program. There are two types of active CAP members: cadets and seniors. A cadet may be no less than 14 years old, unless enrolled in high school, nor more than 20 years of age. A senior member must be at least 18 years old.

The active CAP cadet or senior member attends meetings, completes training requirements, wears the CAP uniform, performs duty assignments, and participates in unit activities on a regular basis. He is eligible for promotions, awards, and special activities.

Membership in CAP does not exempt the member from service in the Armed Forces. Furthermore, membership does not obligate one to active service with the Armed Forces or with CAP during a wartime emergency. It does, however, provide the member with an opportunity for executing serious tasks in the service of his country, as well as providing him with an opportunity for developing self-confidence, self-discipline, and knowledge—the qualities of a good military man.

The nature of CAP and its relationship to the Air Force makes it necessary that each CAP member understand military practices. For this reason, drill and ceremonies is an integral part of cadet training in CAP. Physical training is also important. Each of these is important, but it is the aerospace education program of CAP that demands our attention. The subjects taught in CAP aerospace education are similar to those taught in AFJROTC. The cadets learn about aerospace achievements, the effect of these achievements on our society as a whole, and their contribution to aerospace power. The cadets participate in both a guided reading program and leadership laboratories. The practical lab experiences help further their self-discipline and military education. In some instances, cadets can even learn to fly at lower cost through the local chapter of the CAP.

Some members participate in CAP both as a hobby and as a way to serve their country. CAP flies many kinds of missions. Primary among these is search and rescue. Under the leadership of the Air Rescue and Recovery Service (ARRS), the CAP, National Guard, Navy, Coast Guard, and local law enforcement units provide all inland search and rescue in the U.S. ARRS provides it services not only to the Air Force but also to other military and civilian activities upon request. The Civil Air Patrol flies most of the search and rescue missions in the U.S. Annually, CAP members fly 69 percent of all ARRS missions. In addition to this invaluable service, the CAP runs blood-life missions, provides emergency airlift for the sick and injured, and reports the tracking of forest fires.

CAP also helps in emergency work as it did following Hurricane Betsy in 1965, for example. The CAP also plays a role in civil defense readiness. The members work with radio stations and emergency planning centers. The seniors in the CAP program function as leaders in CAP flights, squadrons, groups, and wings. They provide much of the guidance for the cadet program, and they act as teachers in the cadet flight training program.

GROWTH AND IMPACT OF GENERAL AVIATION

At the beginning of this chapter, we said that general aviation was the most rapidly expanding segment of the total aviation picture. Think about that statement for a minute. What does it mean? It means that there are more general aviation planes, more general aviation pilots, more hours flown in general aviation aircraft, more people employed in the manufacture of general aviation aircraft, more general aviation airports, and more takeoffs and landings made by general aviation planes than all other types combined.

The growth rate experienced by general aviation has been incredible. For example, in 1965, the number of aircraft sold in ten months surpassed 1964's yearly total. The same thing is happening today. General aviation is growing and there are still many markets as yet untapped. While production of new aircraft surges, utilization of the entire fleet of more than 112,000 planes grows, flying more hours and miles and attracting new users.

We talked a little about instructional flying, but do you have any idea how many new student pilot permits are issued each year? About 100,000 new student pilot permits are issued each year despite the expense of instruction, which for most students runs between $500 and $1,000. A new high was reached in 1968, when FAA figures showed that 181,267 individuals held student pilot certificates.

We mentioned that more hours are flown by general aviation aircraft. These flights begin at airports with and without FAA control towers. Nearly 75 percent of the takeoffs and landings at the 313 airports with control towers were made by general aviation airplanes.

(In millions)

Fiscal Year	Total	Business	Commercial	Instuctional	Personal	Other
1962	14.0	5.6	2.8	2.1	3.4	0.1
1963	14.8	5.6	3.2	2.4	3.5	0.1
1964	15.4	5.7	3.2	2.6	3.7	0.2
1965	16.2	5.8	3.3	3.0	3.9	0.2
1966**	17.5	6.1	3.5	3.4	4.3	0.2
1967*	19.0	6.5	3.8	3.8	4.7	0.2
1968*	20.5	6.8	4.1	4.2	5.2	0.2
1969*	22.1	7.2	4.5	4.5	5.7	0.2
1970*	23.7	7.6	4.9	4.8	6.2	0.2
1971*	25.4	8.0	5.3	5.2	6.7	0.2
1972*	27.2	8.4	5.7	5.6	7.3	0.2
1973*	29.0	8.8	6.0	6.0	7.9	0.3
1977*	35.0	10.4	7.2	7.4	9.7	0.3

* Forecast
** Preliminary

Note. — Hours for 1962-1965 have been developed from calendar year date shown in FAA Statistical Handbook of Aviation.

Figure 6. Hours Flown in General Aviation.

This amounts to more than one movement every second, day and night, every day of the year. The number of aircraft movements at our more than 9,000 general aviation airports would stagger the imagination.

Aircraft producers are paying more attention to general aviation's needs and desires. They are producing a wide variety of aircraft to meet the increasing number of missions for private air travel. They have introduced dozens of new models from trainers to pure jet business transports. They have increased the passenger and cargo carriage capacity of many existing models. Their efforts have been rewarded by increased production schedules.

Increased emphasis on pilot training, improved marketing techniques, and equipment with greater capability have been but a few of the industry's efforts contributing to the accelerated growth pattern. Economic and social factors also played a part. Decentralization of business and industry plus greater demands on individuals' time have made long, leisurely business trips impractical. Business has taken to the air with the rest of the nation, and general aviation has moved into the picture to fill existing gaps with the finest scheduled service.

Scheduled air service, constantly improving and increasing, is, by necessity, concentrated in the larger metropolitan areas with 65 percent of all scheduled service concentrated at only 23 major airports. Ninety percent of the airline passengers are enplaned at only 90 cities. It is left to general aviation to provide both direct and connecting service to the vast areas not served and to those served with lower frequency of schedules.

Air taxi service is growing more than 32 percent per year to fill its spot in the air transportation system. In fact, air taxi service accounts for much of the growth in general aviation. Business has taken to the air; yet only a few of the many businesses which have the need for, and the ability to buy and operate, their own aircraft do so at the present time. The market potential is great, and the projected sales indicate even greater growth in business aviation as well as in general aviation as a whole.

Because of the growth of general aviation, many communities that never considered air transportation vital before are having to take a long hard look at their position. Air transportation is becoming a drawing card for businesses and industry. The town with the airport is likely to get the plant where the town a few miles away without an airport will be overlooked. There are many small general aviation airports scattered throughout the United States; yet general aviation is plagued with the lack of proper landing facilities. Why? Many general aviation airports are not much more than a dirt landing strip with an airport beacon. A few are not even lighted. In the face of rapid growth and improving technology, general aviation airports need to be updated. They are being considered in the National Airport Plan and other airport measures discussed later in the chapter on airports.

REVIEW QUESTIONS

1. Define general aviation. Why is it growing so rapidly?

2. Business aviation is growing more rapidly than any other type of aviation. Why?

3. Define air taxi.

4. Discuss the Civil Air Patrol.

THINGS TO DO

1. If there is a flying school in your community, you might contact officials at the school to determine how many pilots the school trains per year and report to the class on all that is involved in learning to fly.

2. You as an individual or as a member of a committee from the class might contact your local chamber of commerce or industrial development board to investigate the impact of aviation on your community.

3. If there is no local airport in your community, you might work up a report to indicate the economic advantage that would accrue to the community if an airport were added. Or you might justify the lack of an airport.

SUGGESTIONS FOR FURTHER READING

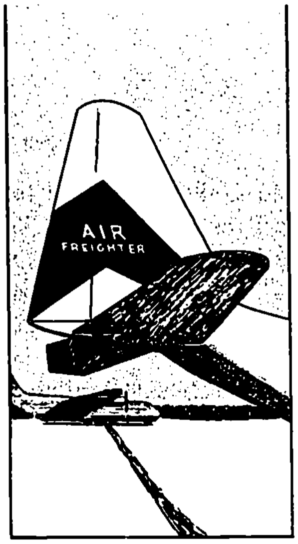
Civil Air Patrol. *Aerospace Education.* Ellington AFB, Tex.: Civil Air Patrol, 1963.

________. You may also find other publications by the Civil Air Patrol in your unit or school library.

Federal Aviation Agency. *Eighth Annual Report.* . . . Washington, D.C.: U.S. Government Printing Office, 1967.

Other sources: Perhaps the best source of recent information in this fast-growing field is magazine literature. Keep up with current developments in this area by reading such magazines in your detachment library as *Aerospace Technology, Aviation Week and Space Technology,* and *Air Force and Space Digest.*

Chapter 3



Commercial Airlines

IN THIS CHAPTER, we are primarily concerned with the Government's rules and regulations concerning commercial airlines. The restrictions placed on commercial airlines are for the good of all citizens. The Civil Aeronautics Board imposes restrictions which determine the eligibility of an airline. Also included in this chapter is a discussion of the responsibility of the Federal Aviation Administration to provide safety regulations. You will discover reasons for the phenomenal growth in the airlines industry. Modern equipment and technological improvements are encouraging reasons for people to use airlines more frequently. Rapid growth in any industry tends to create problems. With all the planes now in use, we can anticipate problems in the design of new planes and airports, the scheduling of these planes, and the efficient management of modern airports. A very important part of commercial airlines is air freight. The impact which air freight has had on our economy is discussed toward the end of this chapter. After you have studied this chapter, you should be able to do the following: (1) explain why air freight makes our lives more pleasant; (2) discuss some of the problems facing a growing commercial airlines industry; and (3) outline the responsibilities of the Federal Aviation Administration and establish proof that their concern for safety has paid off.

COMMERCIAL airlines is a term loosely used to include scheduled and nonscheduled airlines. When we think of the airlines, we usually think of the trunk lines (American, Eastern, Trans World, and United), but the term includes much more. Air freight lines, such as Logair* and Flying Tiger, are airlines; local service lines such as Delta, Western, and Braniff are airlines; even the commuter airlines, discussed in the chapter on general aviation, are airlines. All of these activities are lumped together and called scheduled airlines.

Yet scheduled airlines ("skeds") do not present the entire picture. There are still some nonscheduled airlines ("non-skeds") which operate on the basis of passenger demand. Most of the traffic carried by the nonscheduled airlines consists of charter flights and overflow traffic from scheduled airlines.

ROLE OF THE GOVERNMENT IN AIRLINE MANAGEMENT

The Civil Aeronautics Act of 1938—and later the Federal Aviation Act of 1958—established the Civil Aeronautics Board (CAB) as the economic regulatory agency for the airline industry. The CAB has the responsibility of regulating airline competition; that is, authorizing enough competition to assure ever-improving service, but not to the extent that it would destroy an airline's prospects for economic health necessary for progress.

CAB Responsibilities

In order to make this plan work, the Government imposes numerous restrictions on scheduled airline operations. It sets down rigorous tests of eligibility. These conditions are in full effect today:

To hold a certificate for interstate scheduled service, a scheduled airline must demonstrate that it is "fit, willing and able," including financially responsible, "to perform such transportation properly;" that its management is "honest, efficient and economical;" and that its operation will serve the "public convenience and necessity." The CAB awards a certificate of public convenience and necessity only after exhaustive investigation, including full public hearing. What follows is a brief list of some of the stringent qualifications an airline must meet.

A scheduled airline must serve all points designated on its certificate, even those that do not by themselves generate enough traffic

* Logair and Quicktrans are long term contract airlift services within continental United States for the movement of cargo or support of the logistic systems of the Military Services and Department of Defense agencies.

for economical service. It cannot suspend service at any city without CAB approval, which is based upon a review of the public interest.

A scheduled airline must provide regular service, according to a complete system flight schedule that must be published and filed with the CAB. These schedules must receive CAB approval as international schedules receive International Civil Aviation Organization (ICAO) approval.

A scheduled airline must publish and file proposed fares and tariffs with the CAB, which can reject them if it deems them not in the public interest.

A scheduled airline must carry the mail as required by the Post Office Department.

A scheduled airline must file full service, traffic, and financial reports with the CAB quarterly. It must also keep its records and facilities open for CAB inspection at all times. It must keep the CAB informed as to ownership. It cannot merge, consolidate, or acquire another airline without CAB approval.

As you can tell by the scope of the problems it handles, the CAB is constantly considering a variety of suggested changes. An airline can submit a new route plan to the Board for consideration. All lines objecting to this suggestion can, in turn, send in their objections. The proposal then goes before the Board for a hearing. The Board can dismiss the proposal, accept it, accept it on a temporary basis, or expand it. In reaching a decision, the Board does not necessarily decide according to precedent. It may reverse its decision completely from case to case.

Let's consider one of the areas handled by the CAB, namely trunk-line local competition. The CAB has proposed a rule change that would radically alter the competitive relationship between trunk and local service lines on some routes now served exclusively by the trunk lines. The Board hopes that by extending the non-stop distances local lines are permitted to operate it can reduce subsidies to the local carriers. This puts local lines and trunk lines in direct competition on the route segments in question. Some of the local airlines consider this the greatest advancement in their history while others frown upon drastically changing an effective working arrangement. Even among the trunk lines there is a variety of opinions, but most say that the CAB's policy of taking from the trunk lines to build up local service is going to seriously endanger the future of the trunk lines. Continued efforts to build better planes and improve services require a great deal of money, and the trunk lines say they are not so secure that they can place themselves in the role of great beneficiary offering financial relief to all other segments of the industry. They remind us that they have not been financially independent long enough for that.

FAA Responsibilities

The Federal Aviation Administration (FAA) has the responsibility for the promulgation and enforcement of safety regulations. The special Civil Air Regulations it has established for scheduled airline operations are more detailed and strict than those of any other class of aviation.

A scheduled airline is required to have a complete dispatch system encompassing communications for the dispatch and operational control of all its aircraft. No scheduled flight can take off without specific authority from a system dispatch office. Dispatchers, who must hold FAA dispatcher certificates, must be thoroughly familiar with the route, weather conditions, navigational facilities, and airport conditions under which they dispatch aircraft.

A scheduled airline can fly on instruments over a particular route only if the route is equipped with navigational aids approved by the FAA. It can schedule flights only into airports inspected and approved for the operation by the FAA.

A scheduled airline must show that competent personnel and adequate facilities and equipment, including spare parts, supplies, and materials, are available at such points along its routes as are necessary for proper servicing, maintenance, repair, and inspection of airplanes and auxiliary equipment.

Each scheduled airline flight captain must be pre-qualified on the routes he is to serve, demonstrating adequate knowledge of weather characteristics, navigational facilities, communications procedures, and the regular, provisional, and refueling airports he is to use.

A scheduled airline must maintain two-way ground-to-aircraft radio over all routes served in order to maintain system-wide contact. This is in addition to radio facilities operated by FAA.

A scheduled airline must fly "proving runs" under the supervision of the FAA before inaugurating a new route or aircraft.

A scheduled airline must have available weather information of a type prescribed in detail by the FAA. For example, a trip may not be cleared unless there is attached to the dispatch release form the latest weather reports, available weather forecasts for the destination, intermediate points, and alternate airports.

The FAA's concern for safety has paid off. The accident rate has dropped to a low of 0.22 passenger fatalities per 100 million passenger miles of operations. This low accident rate compares most favorably with an automobile accident rate of 2.4 fatalities per 100 million miles.

FAA is not complacent about the airline's safety record, and officials realize that the air is growing more crowded daily and congestion breeds accidents.

The U.S. scheduled airlines, in addition to observing the highest safety standards required of any segment of aviation, observe service and operational policies and practices above and beyond that required by the Government. They have exercised leadership in the development and use of many safety devices and procedures including (1) creation of the Nation's first air traffic control service; (2) pilot-operated airborne weather radar; (3) anti-collision lights on aircraft; (4) reversible-pitch propellers, and thrust-reversing mechanisms for jet engines; (5) preventive maintenance—through aircraft inspections at frequent intervals, and replacements of parts at prescribed intervals whether or not they need it; (6) swift notice to all airlines of a problem encountered with an aircraft of any one airline; and (7) a policy of flying under instrument rules and procedures even in good weather when operating above specified altitudes, as an added measure to assure safe separation of aircraft in flight.

The airlines and the FAA cooperate in this overall safety program for they believe it is their responsibility to protect the traveler from accidents which can be prevented.

AIRLINE MANAGEMENT

Management of commerical airlines has become exceedingly complex. There are, of course, numerous reasons to account for the growing complexity, but one of the most obvious reasons is the phenomenal growth of commercial aviation.

Growth

The airlines are far and away the fastest growing major industry in the country. Taking 1950 as a starting point, the airline performance is unique. The electric utilities have more than tripled in size;

the chemical industry has also more than tripled. The trucking industry has more than doubled. The motor vehicles industry has almost doubled. Steel is up 30 percent. Total industrial production in the country has almost doubled since 1950. But the airline industry is today 7 times as large as it was in 1950.

In the ten-year period 1957–1967, the gross national product did not even double. During the same period, airline revenues more than tripled, and revenue ton miles flown more than quadrupled.

The phenomenal growth of air traffic has been made possible by a great outpouring of capital funds. This investment in new equipment and facilities stimulates company growth by preparing for it.

What is the reason for this phenomenal growth?

Throughout history transportation and communication have gone hand in hand with each acting as a stimulus for the other. Although there have been great advances in the technology of communications (with telecommunications satellites, color television, and direct distance dial telephone service, for example), the basic efficiency of the face-to-face confrontation has never been equalled. Today, there is even greater demand for fast transportation to get one to a meeting and back again. This demand is growing even greater as our society becomes more complex. The reason for the meeting varies from passenger to passenger. Some are rushing to a business conference, others are going home, and perhaps still others are off for vacations. Whatever the reason for the trip, rapid transportation is appreciated for it allows time for valuable face-to-face communication.

The airlines have worked at serving the Nation's communication need in two major ways. They have first applied radical technological improvement. Public response to this improvement—in speed, comfort, convenience, and reliability—has always been dramatic. Hence, there is a constant pressure on the engineers to advance the state of the aviation art. Perhaps the greatest untold story of this industry is the long partnership between airline engineers and manufacturers, each stimulating the other to develop technological breakthroughs. A major part of this effort has been the adaptation of military technology to civil use. However, as the industry has grown in purchasing power, it has generated its own research and development support. In engines, airframe, electronics, communications, computers, training systems, navigation, fuel, and metallurgy, major U.S. and foreign industries are finding that it pays to develop innovations tailored especially to the airlines. This thrust, added to the

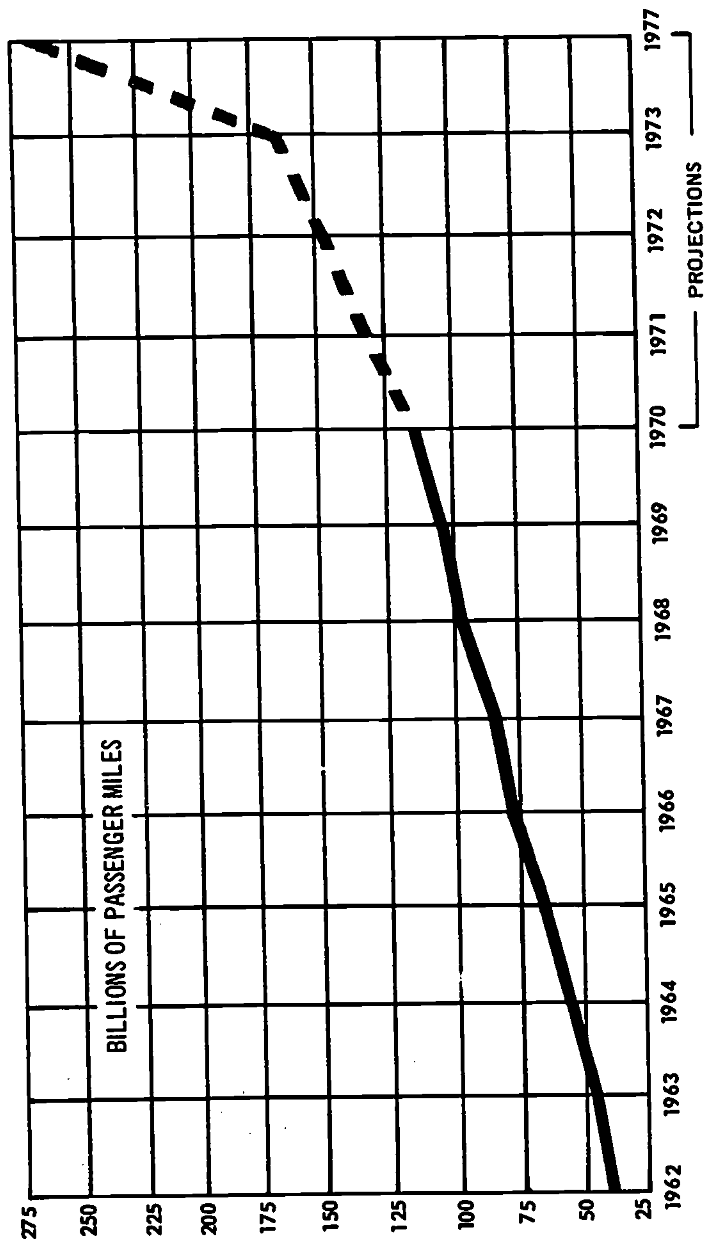


Figure 7. Projections of Passenger Traffic.

military research thrust, inevitably results in continued technological improvement.

In addition to the stimulant of improved technology, the powerful and constructive forces of competition have played a central role in the airline growth story. There is a highly dynamic relationship between the potential of the market and the energetic drives of each of the airlines to improve its share of the market. The ambitions of vigorous competitors are reflected in the size of their orders for airplanes. Where there is plenty of capacity, there is no restraint on surges in demand. Adequate capacity also produces a convenient and readily available service, a feature highly prized by the traveling public.

Rapid expansion of capacity, in part resulting from the pressures of competition, requires that top priority be given at all times to the task of expanding the market. Given large additions to capacity, airlines mount massive efforts to sell the additional seats. Promotional fares, which have proved so acceptable to the traveling public, have been one of the outstanding stimulants applied. This process has been a major contributing factor accounting for the remarkable development of the air travel market. In 1965, they sold 32 million more seats than in 1962. In 1966, they sold millions more and will sell even more in the years to come.

Critics complain that the process results in average load factors between 50 and 60 percent and that the industry is operating too many empty seats. Good service at peak times of day, of the week, and of the year inevitably means empty seats at other times. Running an airline is a little like running an elevator system in an office building. If the object is to maintain a high load factor on elevators, then obviously it might be possible to install only one elevator in a building and rent all the space normally given to large elevator capacity. Average load factors on the one elevator would be high, but some of the tenants might not get home until after midnight. Those who worked on the top floor, where relatively few people need to go, would have to wait forever. If, however, good service is the objective, the building operator has to increase the number of elevators at the sacrifice of average load factors.

Similarly, the airline industry could buy fewer airplanes and plan for a scarcity of seats. But this would assume some formula for reducing the vigor of competition as well as rapid deterioration in the ready availability of service. No advocate of artificially high average load factors would long survive the fury of an aroused public if his policies led to the deterioration of the convenience and ready availability of the service.

Coinciding with this phenomenal growth of air travel has been a major change in the habits of work and play of the entire Nation. A new mobility, unlike anything experienced by any nation before, is developing.

The usefulness of the airplane to the business world has long been appreciated. Mobility of the productive people in business stimulates the pace of economic development. Decisions are made faster, work gets started sooner, problems are resolved more readily, the whole process of selling and buying is aided by fast transport. Telephone and teletype have not replaced personal confrontation. The personal touch still sells the product best.

Mobility is valuable to the business world, but it is equally valuable to the arts, the sciences, religion, education, the law, government, and every other branch of human activity. Fast transportation is a strong stimulant to the pace of activity in every field. No man can hope for personal isolation if he plans to contribute to the massive cross-fertilization of ideas now characteristic of our civilization. More than ever the personal confrontation is essential.

Promotional Fares

Perhaps one of the most significant social changes that is taking place in the last half of the twentieth century is the change in the leisure activities of Americans. Demands for vacation and personal travel by air require the development of specific plans and programs and now occupy priority attention of airline managements.

There are dozens of ways of approaching the market and the airlines are prepared to try them all. The airlines expect to reap substantial benefits from the combination of an air trip and a rental car. As roads become increasingly crowded and super highways more and more monotonous, the airlines are strongly advocating the fly-and-drive combination.

But by far the most productive experiments are in the field of promotional price reductions. Numerous excursion, off-season, off-peak and other promotional fares are available both for domestic and international travel. The airlines have combined many of these low fares with hotel, car-rental and sight-seeing bargains and have developed highly attractive all-expense packages. The all-expense package is a well-tested method of getting the first time travelers away from home.

For the individual traveler the excursion rate is the most economical. To take advantage of this reduced rate, the traveler must purchase a round trip ticket. This seat will be tourist class. The excursion rate applies from noon Monday through noon Friday and from midnight Friday through noon Sunday.

Among the most successful promotions has been the family fare under which the husband pays full fare, the wife travels at a third off and the children at two thirds off. The response of the public has been spectacular.

The 50 percent space-available reduction for military men on leave has also been highly successful. More than eight million military men have taken advantage of it since it was introduced.

The airlines are now experimenting with a 50 percent space-available discount for young people between 12 and 22. Even with the fare reduction, the airlines see a profit for half fare is more than no fare on an empty seat.

These and other promotions started since 1962, including the rapid spread of economy and coach services, have resulted in a marked reduction in the average revenue the airlines earn for operating a passenger mile. The decline has been striking. In a recent year, passengers taking advantage of special discounts saved more than $115,000,000 compared to the fares previously in effect.

These reductions will continue; however, there are practical limits to fare reductions in a period of generally rising costs. The airlines, traditionally, have operated on a thin margin of profit. In their most profitable period, in the early 1950's, the margin was five cents on the dollar, or about the price of a limousine to the airport on an average $40 ticket. In the past five years, the profit margin has averaged three cents on the dollar, or considerably less than the price of a limousine ride. Profits of course have the task of underwriting vast expansion and improvement programs.

IMPACT OF THE JET AGE

Today one of the big four airlines has converted to an all jet airline, and the others will soon follow suit. Why? If the turboprop is more economical for shorter hauls, why is it being replaced? What has brought about this all jet demand?

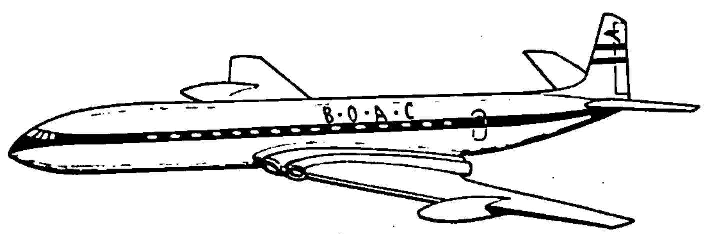


Figure 8. Comet I.

First, let's look back to 1952. This was the year the British airlines placed the Comet I in service and thereby became the first to use jet aircraft in commercial operations. Technology was advancing rapidly and manufacturers were designing and developing improved aircraft faster than the airlines had previously paid for them. This was indeed unfortunate for some airlines because the rate of aircraft replacement is one of the most vital features of an airline's whole economic structure.

Boeing and Douglas were applying their technological knowledge in designing improved aircraft as well as in designing jets. Here again the military influenced civil airline progress and design. Without the B47 bomber there probably would have been no Boeing 707; and the theoretical advantages of turbo-props on the cost side would have been given more emphasis. But there was the B47.

American Airlines, using the Boeing 707, was the first to begin domestic U.S. jet service with its own aircraft. It inaugurated the transcontinental route from New York to Los Angeles on 25 January 1959. Jet service was underway. Another significant date in the progress of jets was Pan American's inauguration of its round-the-world jet service on 10 October 1959.

Once the appetites of the airlines had been whetted by the speed, reliability, and passenger appeal of the new aircraft, ways and means were found to extend the scope of the jet aircraft beyond the limits originally planned. In the early days the jets were believed to be best on longer ranges where their speed could be exploited; but on short-haul routes the turbo-prop would be more suitable. But even on short-haul routes the jet proved itself with its tremendous passenger appeal. Competition has brought the day of all jet liners into

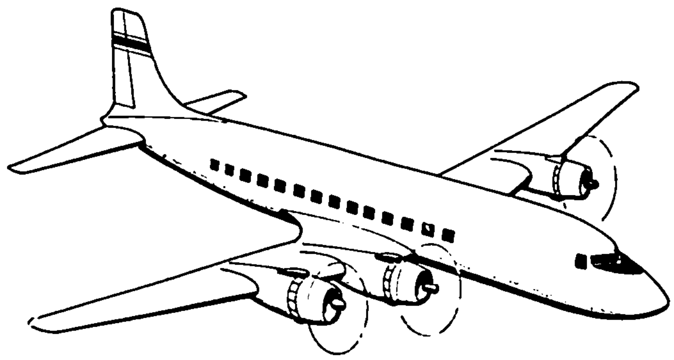


Figure 9. DC–6.

the near future. Trans World Airline already claims that distinction, and the others will rapidly follow suit.

The jet age has been speeded up because of interline competition. Without this spirit of competition there would be no incentive for improvement and no more progress.

The world trend is sensitive to our airline trend for our airlines carry about 55% of the world's traffic. Most of this traffic is carried by the Big Four (American, Eastern, TWA, and United) plus Pan American. These five airlines alone carry 40 percent of the world's total seat-miles.

Competition demands continuous updating of aircraft, and this process alone is a complicated and costly one. In the past five years, airline outlays for acquisition of modern equipment totaled more than $3.6 billion. At the end of 1962, there were 647 jet and turbo-prop airplanes in the fleet and 1,164 piston airplanes. At the end of 1967, there were 1,706 jets and turbo-props and only 460 piston airplanes. The year 1965, incidentally, was the first year in which jets and turbo-props outnumbered piston planes in the airline fleet.

Orders for new aircraft as of the middle of 1968 totaled some 1,055 airplanes, including 38 British-French Concordes with an approximate value of $760 million. In addition, the airlines hold 59 delivery positions for the Boeing 2707, the U.S. supersonic transport, and have already invested more than $70 million in advance payments for these aircraft. The total cost of the Boeing supersonic transport aircraft which the airlines have on order is in excess of $2 billion. Many of the other aircraft on order are medium and short range aircraft designed to improve the quality of air service for smaller communities. This fact has special importance for the more than 400 cities served exclusively by the local service airlines.

Three basic considerations influence airline equipment decisions at the present time.

First is the need to complete the current re-equipment, expansion, and modernization program.

Second is the development of a subsonic aircraft even more efficient than those already in operation. Continuing increases in every type of expense, including wages, fuel and material costs, landing fees, and rentals necessitate a maximum of management and technological economies. Consideration is, therefore, being given to a

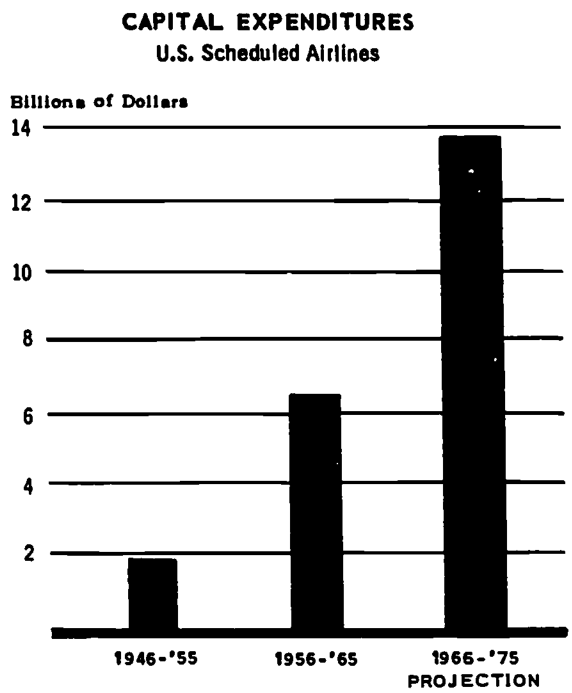


Figure 10. Capital Expenditures.

new and more economical vehicle which can contribute to maintaining or reducing still further the average cost of an airline seat. Designs made possible by the more powerful C–5A engine are being actively considered. These include the Boeing 747 and the DC–10, which are capable of carrying 400 or more passengers.

Lockheed's C–5A has been nicknamed "the Large One" for good reason. It is a giant inside and out. It can carry missiles, planes, tanks, trucks, helicopters, boats or anything else that would fit into a two-car garage that is 144 feet deep and 13½ feet high. This is the hold of the ship. On deck, there is the cockpit, flight engineer's station, pullman-style accommodations for the relief crew, and a troop compartment with 75 aft-facing seats.

This military giant is being modified by Boeing. The Boeing 747 is basically a passenger plane with a 490-seat 10-abreast interior. No airline is expecting to use this number of seats or service initially. The airlines are considering several interior designs. These include a five-class interior, with a luxury class at the nose, first class next, then standard, economy, and coach sections; entertainment section; and a section for non-smokers.

This giant is supposed to alleviate some of the traffic pressures in the air while creating some knotty problems on the ground. The strain one of these planes would place on today's airports would be tremendous. Much research is being done to foresee problems so that the airports will be ready when the planes are delivered.

Third is the development of supersonic airplanes which will make possible the tripling of present jet airliner speeds. Delivery dates of the very large airplanes could be as early as 1970, and of the first of a family of supersonic airplanes 1973. The FAA estimates that some 86 supersonic aircraft will be in service by 1977.

These considerations plus assumptions as to traffic growth make possible rough projections of future capital outlays. Projections through 1970 show a total outlay of $5.5 billion. As more expensive, but more efficient and productive airplanes come on the line, expenditures for the next 10 years may be double those of the last 20.

Orders for civil airplanes now account for over half of the volume of such military and civil aerospace producers as the Boeing company. Airline investment thus makes a major contribution to the stability of employment in the aerospace manufacturing industry. In 1967 U.S. airframe builders alone employed almost 75,000 persons in the manufacture of civil air transports for U.S. airlines.

The implications of airline investment are far-reaching. The improved efficiency and economy of operations made possible by modern equipment which the airlines have placed in service has been the most important single means of absorbing the steady advances which have occurred in wage rates, and material and equipment prices. By this process, airline investment has enabled the carriers to bring about the recent downward trend in average fares per passenger mile and thus contribute to an easing of inflationary pressures.

SOURCES OF FUNDS

An overwhelming proportion of airline earnings have been retained to help finance required investment in expansion and improvement. In a recent year, for instance, more than 85 percent of the record profits earned were reinvested in the industry's expansion and improvement program. Yet retained earnings were sufficient to finance only about 30 percent of these outlays and the balance was derived from other internal sources.

It is this investment program that enables the airlines to retain their position as the most modern and efficient airline service in the world.

ROUTE STRUCTURE

Route structure is important to an airline. It is the bloodstream through which traffic flows. Traffic flow determines the financial life of an airline. So each airline jealously guards its routes and strenuously objects to more competition on its established routes. But it joyously cheers when granted an additional segment.

More than 600 cities are served by the scheduled airlines. These cities vary in size and passenger traffic from Chicago, Illinois, to Moab, Utah. Of the total, more than 400 are served exclusively by local service airlines.

The routes shown on the map in Figure 11 are designated and regulated by the CAB. Service to Alaska and Hawaii has been omitted for lack of space. These routes are not permanent, but are subject to change by the CAB. Most changes which occur are additions to, rather than deletions from, the present system.

Although more than 600 cities are served by scheduled airlines, no one airline serves all of them. The trunk lines have greater route

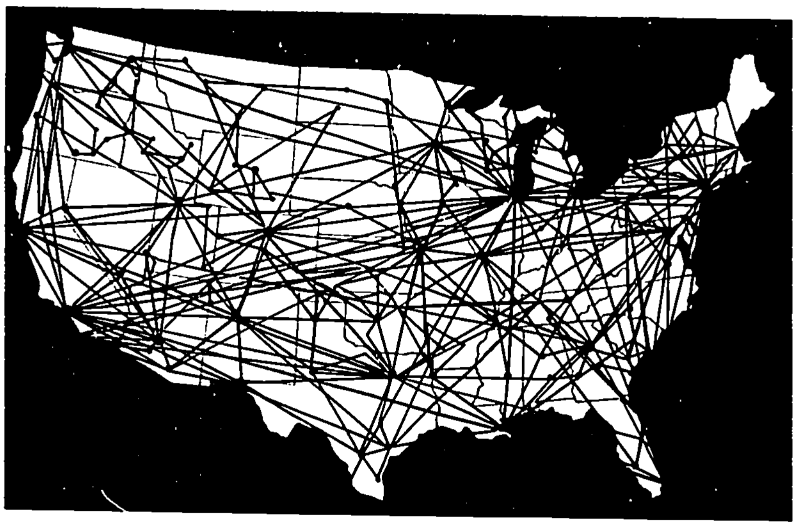


Figure 11. Airline Routes.

coverage than do regional lines, but Delta and Braniff are growing too large to be considered feeder lines. Braniff International Airlines has acquired routes to Mexico and South America. This changes the traditional division between trunk lines and regional lines.

Each airline has certain cities it must serve according to a published schedule. The CAB approves the route and regulates competition so that one segment is not overworked and another ignored. To add a segment to an established route, an airline must file projected plans with the CAB, which will run a feasibility study. If the Board decides the route segment could pay and no airlines strenuously object, it will grant a trial run authorization, which will change after the trial period.

On some of the routes local service airlines and trunk lines are in direct competition, while on others the local service airlines act as feeders to the trunk line long distance hauls. Yet even this elaborate route system fails to serve the public adequately. There are many areas left that receive little or no airline service. It is in these areas that the commuter airlines and air taxis have been growing to fill the gap. They can more economically serve the smaller communities. They use smaller planes and place smaller demands on the airports they use. Commuter airlines and air taxis are proving to both the scheduled airlines and the general public that they can provide good service and fill the gap. During the next ten years they will grow to fill an even more important place than they do today.

Thus far we have stressed interline competition as a stimulus to airline growth and improvement. But interline cooperation also plays its part in improving passenger service. Because the routes are drawn the way they are, it is often difficult to fly direct from one point to another without changing airlines. The airlines themselves realize this and cooperate fully to meet the passenger's needs.

Richard, for example, wanted to fly home for Christmas vacation. He was living in Montgomery, Alabama, and his home was in Salt Lake City, Utah. He called Delta Airlines in Montgomery to schedule his flight. Delta does not have a flight to Salt Lake, but they arranged his flight by checking reservations with other airlines.

Richard flew with Delta from Montgomery to Dallas. At Dallas, he changed to Braniff Airlines. Braniff flew as far as Denver, Colorado. At Denver, he changed to Western Airlines which flew to Salt Lake City. On the trip back to Montgomery, he was routed another way because of heavy traffic. He left Salt Lake City on Western, changed to Braniff at Denver, changed to Eastern at Dallas, changed planes (still Eastern) at New Orleans, and landed at Montgomery.

The entire trip was prearranged and booked by Delta Airlines in Montgomery. It is this type of cooperation that insures today's traveler the speedy and convenient trip he has come to expect.

Richard's flight was arranged by counter personnel who help schedule flights and check in passengers. This is only one job performed by airline personnel. The jobs of pilot, copilot, navigator, and airline hostess are important, but there are many people who perform support functions. Among these are the engineers, scientists and draftsmen who design the planes; the builders and flight test pilots and mechanics who test the designs; the mechanics who keep the planes airworthy; and the stenographers, public relations men, and others who try to make an airline profitable. *Aerospace Opportunities for the Individual,* in the Aerospace Education III series, examines these jobs in some detail.

AIR FREIGHT

In 1965, the last year for which air freight figures are conveniently available, the jet freighter fleet of the U.S. airlines represented an investment of $439 million. It consisted of 55 jet aircraft capable of all-cargo service. In addition, 23 turboprops and 85 piston-powered aircraft were providing freighter service. Assuming maximum loads, these aircraft could fly about 10 million ton miles of freight service a day, nearly four times the freighter capacity of 1960.

In addition, more than 100 jet freighters, valued at about $720 million, were on order and were scheduled to be delivered by the end of 1968. These aircraft will add some 8 million ton miles of service per day to the present 10 million ton miles per day peak.

All of these figures add up to this: air freight is becoming big business. The massive investment by the airlines in cargo aircraft will have favorable effects on the cost of producing and distributing goods. Improved efficiency and economy of operations made possible by modern equipment has been the most important single means of absorbing the steady advances which have occurred in airline wage rates and material and equipment prices. Airline investment has enabled the carriers to bring about the marked downward trend in air freight rates. Future improvement of efficiency made possible by larger airplanes of the immediate future will have a further favorable impact on freight rates.

Freight traffic more than doubled from 1960 to 1965. Airlines budgeted and planned for a 16 percent increase in the domestic freight field in 1965 and achieved a 25 percent increase. In international freight, the airlines planned for a 25 percent increase and achieved an increase of 46 percent. This makes it difficult to correctly project future growth.

Air freight as a major business is still new. For this reason there is a need for broader understanding of the business within the airline industry, within the Civil Aeronautics Board, and among the major shippers of the country.

The available capacity has become enormous and is growing rapidly, the quality of the service is excellent and improving, and the price is right and getting more favorable for the shipper every year. Air freight is an industrial product to be sold. The biggest gap is the information gap.

The development of air freight so far has shown some remarkable parallels with the history of the trucking industry. The trucks made possible a great speed-up in the processes of production and distribution for industry. In the radius of their most economic operations, they provided overnight delivery door-to-door. The impact of such increased efficiency in transport service on the organization of production and the processes of marketing was revolutionary.

Today, more attention than ever is being given in industry to shortening the time required to produce goods and reducing the time between production and sale of goods. Anything that economically contributes to cutting down the length of the cycle between reorder and delivery has tremendous significance, particularly in highly competitive industries. In each industry, of course, time has a different value. But, for a variety of reasons, the element of time in the production and distribution process is receiving more and more attention.

The key elements in air freight growth can be divided into two major categories. The first includes a list of things airlines have been doing on their own initiative to stimulate air freight. The second includes a number of basic trends in the engineering of production and distribution in industry which are highly favorable to air freight growth.

The most significant decision made by the airlines has been to provide capacity in advance of demand. Hundreds of millions of dollars have been committed to flight equipment in anticipation of the growth of the business. The consequences are two-fold. First, top priority is given by airline managements to expanding the market. With enormous capacity to sell, the airlines gear up their sales efforts to sell it. Second, plenty of capacity means that a convenient and readily available service is provided which can be relied on day in and day out. Surges in demand can be accommodated and new converts won for the reliability of air freight. The existence of plenty of capacity has thus been a major factor in creating freight traffic.

An important part of the capacity story, of course, is the growth of the passenger service. We are witnessing an historic shift in the basic travel habits of the American people. The jet airplane—a few hours to anywhere—has caught the imagination of the American people, and the organization and pattern of American life is changing.

Such an upsurge in jet travel has its impact on the freight business because the jets have very large freight compartments. As the switch to jets accelerates, enormous new capacity will open up on the local service airlines and on short-haul flights all over the country. The Boeing 727 "Quick Change" airplanes will significantly stimulate

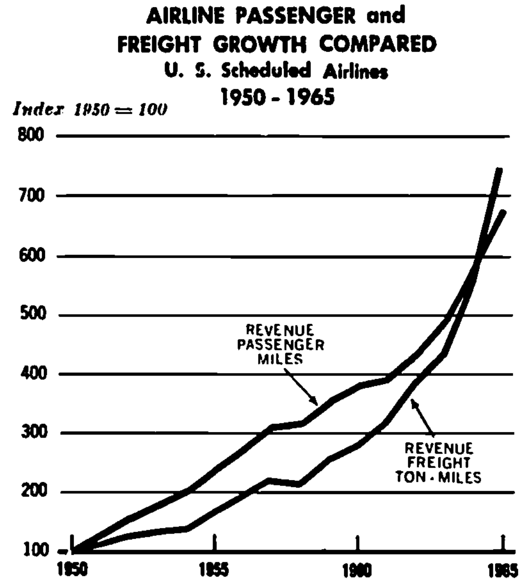


Figure 12. Airline Passenger and Freight Growth Compared.

freight capacity. Finally, a few years off are the very large Boeing 747, the Lockheed C–5A, and the Douglas DC–10, which will once more radically improve air freight capacity.

There is much talk today about the need to coordinate transportation service. The airlines have successfully coordinated line haul by air with efficient pickup and delivery service on the ground and coordinated air-truck movements and air-sea movements. The airlines recognize that there is great potential in improving the quality of service, of fitting the transport requirements to the needs of the shippers. Airlines have become expert at assembling shipments of component parts on a regular cycle from a wide variety of sources for consolidation and delivery to a manufacturing facility. Ground facilities have been improved and will be improved still more in the future. The most advanced automated terminals are able to accept and process freight within an hour of flight times.

Improvement in quality of service extends to the introduction of advanced electronic systems for keeping track of waybills and reducing documentation. Airlines even suggest markets for shipper's products. Particularly in the foreign field, they maintain special services and publications describing market opportunities for air freight shippers. As a result, many a domestic producer has found himself deeply involved in the export trade. The airlines have become experts on the distribution patterns of major industries and are constantly working with shippers to improve the production and distribution process. They give advice on improvements in packaging and are currently proposing a container program expected greatly to increase efficiency of handling and lower the packaging cost on a wide variety of commodities.

Much progress is being made in closing the gap between air and ground rates. Air freight revenues have dropped 20 percent per ton mile in the ten year period 1957–1967. What this means is that you can ship more goods by air for your money now than in 1957. By way of comparison, railroad average revenue per ton mile has dropped only about 12 percent, and truck revenue has actually risen 8 percent in this 10-year period. This decline in shipping cost is continuing. Major impact is expected from the reductions in shipping rates which have been filed with the CAB for the airlines' new family of containers. These reductions will average about 10 percent. In recent years, the airlines have introduced a variety of specific commodity rates for large-volume, regular shippers.

Thus, in capacity, improvement in quality of service and rates, the industry has been energetically stimulating traffic growth.

Average Revenue per Ton Mile – Intercity Common Carriers

(For Selected Years, In Cents Per Mile)

Scheduled Airlines:	1957	1962	1963	1964	1965	1966	1967	% Change 1957/1967
Domestic	21.39	21.31	21.72	20.97	20.46	20.21	19.89	– 7.0
International	31.94	25.04	24.78	23.60	20.76	19.92	19.63	–38.5
Total U.S. Scheduled Airlines	24.67	22.69	22.86	21.95	20.58	20.09	19.79	–19.8
Railroads, Class I	1.45	1.35	1.31	1.28	1.27	1.26	1.27	–12.4
Trucks, Class I and II	6.20	6.40	6.30	6.50	6.60	6.50	6.70 E	+ 8.1

E Estimated

Figure 13. Freight Revenues Compared.

Airline initiative has been paralleled by a number of important trends in the organization of production and distribution. These trends have been highly favorable to air freight. The most important trend is the increasing pressure on industry to speed up the production and delivery cycle. Modern management methods are increasingly being applied to eliminate lags in the production and distribution process. As management techniques become more effective, it is possible to turn over invested capital faster. Particularly in an industry where components have to be assembled from all over the country, significant savings can be made by speeding up the gathering process. Many complex industries are beginning to rely on air freight as a balancing factor in keeping production lines running in different parts of the country.

In marketing, the computer has made the difference. Particularly in products where there are tens of thousands of spare parts, or large varieties of sizes and colors, the economic advantages of maintaining a single national warehouse with a short reorder cycle via air freight are very great indeed. The trend in recent years to computerized inventory control has provided major stimulation for air freight.

However, the process is not automatic. There have been some failures. Overnight service across the continent will be of little value if the manufacturer's paper work takes 10 days to get the shipment started. Users of air freight will be disappointed unless every segment of the reorder cycle is streamlined, not just the transport segment.

As the modern production process grows more complex, airlines do not discount the importance of the emergency shipment. While the mainstay of the air freight business has become the regular shipper, emergencies are an important source of traffic and always will be. Whether the item is a new propeller shaft for a steamship or a miracle drug for a small boy, air freight provides an essential service.

Air freight has made great strides in the last five years. But the lines are still confronted with some major problems. Air freight is changing so rapidly that everyone connected with it needs a refresher course once a year. Second, the airlines need to develop more air freight specialists. Third, they need to move faster in developing and installing electronic systems to simplify documentation in air freight. Fourth, on the ground, they need to make further improvements in air-ground coordination and build more and bigger freight terminals in more and more cities.

The freight business is responding to the same powerful forces the airlines have applied to stimulate the passenger business. Demand is being anticipated with large increases in capacity. The quality of the service is being improved. Efficiency and economy of operations are passed on to the customer in the form of rate reductions.

With this combination, the airlines are consistently making even the optimists under-estimate the future.

MANAGEMENT PROBLEMS

Nationwide air travel is burgeoning fantastically. Over the past decade, passengers and passenger miles have more than doubled, and estimates for the next ten years predict they will redouble, triple, or even quadruple. The growth rate now averaging 16 percent per year is bound to increase as the larger planes come into action. The future holds prospects of $50 coast-to-coast fares and two-hour flights to London.

These things are still in the future, but the present has the task of ironing out some of the difficulties that slow traffic in the larger hubs and even in some of the smaller hubs.

Growing Traffic and Scheduling Problems

Scheduling problems confront many passengers today. Unless a traveler is traveling nonstop from one point to another, he is usually confronted with scheduling changeovers. Take Richard on his flight from Montgomery, Alabama, to Salt Lake City, Utah. He had two changeovers; first at Dallas, then at Denver. He ran into a few problems in Dallas. The plane which was due to arrive in Dallas at 11:15 A.M. was advised to hold over Shreveport, Louisiana, until further notified. Dallas' Love Field had been fogged in since 5 A.M., and planes were backed up for miles. Once the fog started to lift, it took over two hours to accommodate the planes already flying holding patterns. This is without regard for scheduled takeoffs which were thrown way off schedule. The airline personnel estimated that they were running 3 to 6 hours behind schedule, and, if the fog settled later in the day, planes would have to be rerouted.

Luckily for Richard, the scheduled layover in Dallas was four hours. Still the flight was delayed an hour and left Dallas behind schedule. The scheduled layover in Denver was 65 minutes. The plane landed in Denver 55 minutes late, allowing Richard 10 minutes to check in at the Western Air Line counter and run for his plane. He made the changeover with no time to spare. Upon arrival at Salt Lake City, he discovered that although he had made the plane, his baggage had not. It was still in Denver. Other passengers on the flight had the same problem so they filed baggage tracer slips with Western Air Line personnel at the ticket counter. These personnel called Denver about the missing bags and discovered that they had not made the connection, but would be sent on the next plane. They arranged for the bags to be delivered to the owners' door the next morning.

Richard had made his connection in Denver that time, but what would have happened if he had arrived from Dallas after his connecting flight had left for Salt Lake City? Had Richard missed his connecting flight in Denver, he would have checked the desk to find out when the next flight left for Salt Lake City. Because of interline cooperation this would not necessarily have to be the next Western Air Lines flight, but any air line flight. Then he would try to get booked for that flight. If the plane was filled, he might run into problems. If there were no flights available, he could go by bus or train and be reimbursed for that portion of his ticket which he failed to use.

Richard's schedule was upset by weather, but weather is not the only thing that can upset scheduled airline service. Heavy air traffic at peak hours of the day is causing hours of delays at many of the Nation's large airports. The situation is bound to get worse.

New York is the world's biggest air terminal with one out of four U.S. air trips beginning or ending there. Its three airports are rapidly approaching a volume of 100,000 passengers every day of the year. At Chicago's O'Hare International Airport—the world's busiest single airport—more than 78,000 travelers moved through the terminal in one record day recently. That day the airport accommodated 2,006 landings and takeoffs with one flight every 21 seconds during the busiest hour.

It is this kind of traffic that gives airport planners real problems. Many of the large airports are about as large as they can grow. Where can all the planes be put?

The result of this kind of traffic will be black days like 24 September 1965 in New York. The weather on that Friday was not quite bad enough to close the airports completely. Instead, it permitted only sporadic flying, and hundreds of flights were diverted to other cities. On the ground, hundreds of flights were trying to get out of Kennedy International with as many as 80 aircraft jammed nose-to-tail along the taxiways waiting for departure clearances. Individual delays amounted to four hours and more, and the jam was not cleared up until early the next morning. It had been a nightmare for all concerned.

Occasional problems are to be expected, but what aviation observers see in the future is increased demand, increased crowding on runways, and increased delays for airliners.

Such delays mean irritated passengers and heavy costs to the airlines. Loss in wasted fuel, crew costs, and other outlays have cost the airlines a minor fortune already and the situation is getting worse. Who knows for sure what delays will cost when the big planes holding 500 to 1,000 passengers arrive?

Delays occur daily across the country. They are considered when scheduling is done, but still problems come up to throw off the entire system. Little things like mechanical difficulties and weather can mar an otherwise perfect schedule.

Connection Problems

In many ways connection problems are tied in with scheduling problems. The route structure authorized by the CAB necessitates connecting flights. No one airline serves all areas, rather an interlacing structure of trunk and local service lines.

Since connecting flights are vitally important to air travelers, airlines cooperate in setting them up. One point in favor of rate regulation is that it facilitates connections. A passenger who misses his flight because of delay in flight can turn in his ticket with another airline and catch the next plane with a minimum of delay. In this way the passenger is satisfied and the right company gets paid for the actual flight. This is how it works most of the time; however, problems arise during peak periods with peak traffic. Christmas is one of these times. If a traveler were delayed enroute and missed his connection, he would have to wait until the next flight with an empty seat. At Christmas he could have quite a wait on his hands.

Since in the near future larger planes will bring ever increasing numbers of passengers to ticket counters, the airlines and airports must cooperate in planning how to handle the crowds. Already

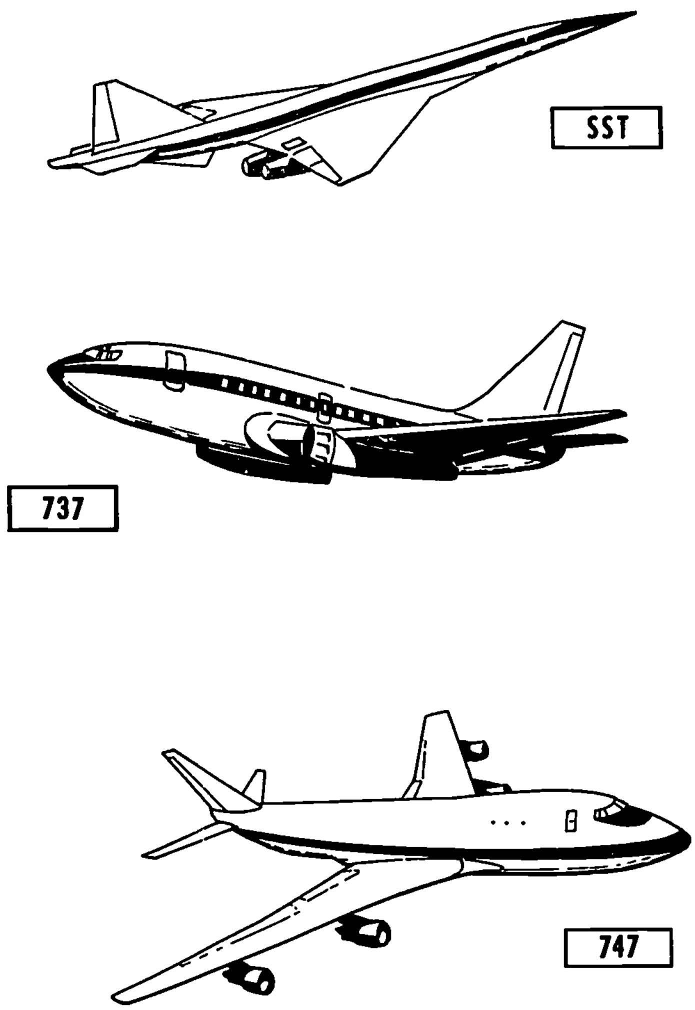


Figure 14. Planes of the Future.

waiting lines at ticket counters are long and slow; this is even worse for the passenger who only has 20 minutes to change planes and the line is 30 people long. Passengers have almost missed connecting flights because of the tiresome wait. Some companies are turning to computers to help cut down the time that counter personnel spend looking up schedules and cross checking connections. Computers may help, but their help is needed soon—now! In the meantime many a passenger has wondered why he must spend more time in waiting lines on the ground than he does in the air.

OUTLOOK FOR THE FUTURE

It would be wrong to ignore the major problems facing the aviation industry, to say that they do not exist. There are many problems yet to be solved, but with the cooperation of the airlines, airport planners, air traffic control people, and aircraft producers, these problems will be solved.

Giant strides are being made today. Airport designers are working out designs that will ease the congestion in ticket lines, waiting rooms, and the multitude of other terminal activities. Rapid transit people are working on designs that will ease the traffic parking problem by providing downtown to airport service quickly and efficiently. Heliports are being built as another alternative to the long drive to the more remote airport. Mobile lounges are being considered. Working with these, the airlines could have ticket counters downtown and take care of everything but boarding passengers there. These are just a few things that the future holds in store.

New aircraft are now being designed that will change the travel picture quite a bit. First, the small, shorter run jet is now on the market. Boeing calls the 737 the "baby bird" because it is smaller than either the 707 or 727, but it is not really small. In fact, it is longer and heavier than the largest bomber flown in World War II—the B–29 Superfortress. This plane should really do well on the shorter routes run by the local service airlines. It will provide many communities that have not had jet service up to now with economical jet service.

Both Boeing and Douglas are modifying designs for the military C–5A. Boeing will call the plane the 747 and Douglas, the DC–10. This supersize subsonic jet will be an airliner in the sky for it will carry 400 or more passengers in comfort. It will be more economical, and so costs to customers will be drastically cut.

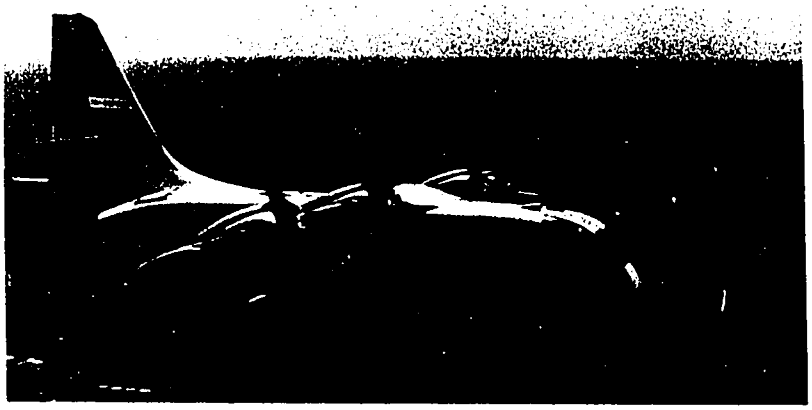


Figure 15. V/STOL: An Idea in Action.

The 300 passenger SST or Supersonic Transport is now being considered. If built, it will provide fast jet service anywhere in the world and will thus completely change man's picture of himself in this world of change. The SST is a dream plane, but the noise problem it would cause could prove to be a serious problem.

The SST has raised many questions. Noise control is one of these. Traveling at speeds up to mach 3, 3 times the speed of sound, the plane would cause a sonic boom wake up to 50 miles wide. Planners and designers have not decided how to deal with this problem. One proposed solution is limiting SST usage to overwater flights. Research is being done and some answers will be found before the SST's first commercial flight.

Another area that has captured man's imagination is the problem of combining vertical takeoff and landing (VTOL) or short takeoff and landing (STOL) with high-speed horizontal flight. This problem has interested researchers and designers since the late 1950's. Helicopters can rise vertically, but their top forward speed is far below the desirable limits. The development of a successful VTOL/STOL airplane would go a long way toward the solution of the airport problems. Such vehicles could pick up their loads in small areas, such as roofs, near population centers, rise vertically and proceed at high speeds to their destinations. Costly and time-consuming transfers to ground vehicles, as well as long trips between airports and industrial centers, would be eliminated.

Thus the face of the air industry is a constantly changing one, but one filled with promise for the future—a future where air travel will become universally accepted and used.

REVIEW QUESTIONS

1. **Define commercial airlines. Distinguish between scheduled and non-scheduled airlines.**
2. **Define the role of the CAB in airline operation.**
3. **Throughout history, transportation and communication have gone hand in hand with each acting as a stimulus for the other. Explain in your own words.**
4. **Describe the impact of the jet age on the airline industry.**
5. **Why is interline cooperation necessary?**
6. **What effect are the giant jets going to have on air freight?**
7. **What is a Boeing 747? an SST?**
8. **What effect will the 747 and SST have on current management problems such as scheduling flights and making connections?**

THINGS TO DO

1. Find out more about V/STOL aircraft and make an oral report.
2. Describe how some of the newer jet planes are designed and why.
3. On your visit to the FAA, you might get a sample of the type of FAA or CAB regulation used to regulate airlines.

SUGGESTIONS FOR FURTHER READING

BURKHARDT, ROBERT. *The Federal Aviation Administration.* New York: Praeger, 1967.

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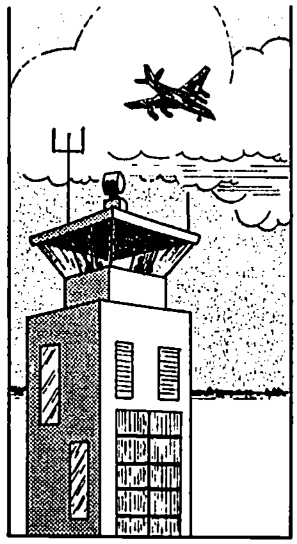
GLINES, CARROLL V. and MOSELEY, WENDELL F. *The DC–3, The Story of a Fabulous Airplane.* Philadelphia: J. B. Lippincott Co., 1966.

HALACY, D. S., Jr. *Thirty Three Miles a Minute!* New York: Julian Messner, 1966.

INGELLS, DOUGLAS J. *The Plane that Changed the World.* Fallbrook, Cal.: Aero Publishers, Inc., 1966.

Other sources: Current periodicals and even your daily newspaper can tell you much about developments in commercial airlines.

Chapter 4



Airports

TO THE AIR TRAVELER, whether or not an airport is attractive and efficiently managed can "make or break" his trip. Airport development has roughly paralleled aircraft development. Originally a field or an open meadow, today's airport is now an essential part of the success of the actual flight of the aircraft. Present-day airport terminals are highly complex places of business. In the last chapter, you learned how the Federal Government helps and regulates the commercial airlines. In this chapter, you will read about the role of the Federal Government in building and regulating modern airports. You will also read about the basic facilities essential to all airports. You will find out the relationship between an airport's functions and its design.

After you have studied this chapter, you should be able to do the following: (1) list the essential facilities common to all airports; (2) tell how Dulles International Airport is preparing for the future and why this example should be followed by other large airports; (3) describe how much cargo can be carried in the Boeing 747, and tell why loading and unloading procedures will determine the success of this plane; and (4) list some problems facing most airports today, and make some suggestions as to how these problems may be solved.

THROUGHOUT the brief history of flight, growth in airport size and capabilities has accompanied growth in aircraft size, weight, and speed. When the Wright brothers flew their gliders, they needed a

Figure 16. Airports: Yesterday and Today.

place with slopes, no trees, and a steady wind. The Weather Bureau suggested they try the beach at Kitty Hawk, North Carolina. Later, when they were ready to attempt powered flight, they returned to Kitty Hawk. The flat beach was the perfect landing field.

The Wright brothers returned home and for a while went on experimenting. They built other planes and tested them over a 68-acre pasture near Dayton. The demands of the aircraft were small. Any level pasture could be used as a runway for takeoff or landing.

In 1911 when Calbraith Perry Rodgers made his coast-to-coast flight, he made 68 hops. There were no airports to land on, and Rodgers crashed 15 times. By the time he reached California, the plane had been almost completely rebuilt.

After World War I the pilots who "had to fly" turned to barnstorming. They would fly over a town, circle it to attract attention, land in a farmer's field, and take people up for a few dollars. A farmer's field made a fine landing strip for the Jennies and DH-4's.

In October 1919, the Army Air Service held a mass round-trip race across the continent. The DH-4's they planned to use had a range of only 300 miles, so the Army, with the help of cities along the 3,000 mile route, set up airports every 200 miles. These same airports were later used by the commercial airlines.

In 1927 planes were flying mail by night along an airway marked by gas and electric beacons, with emergency landing fields every 25 or 30 miles.

As time went on aircraft became larger and more efficient. They placed ever greater demands on runways and other airport facilities. A grass pasture was no longer an adequate landing strip. It could not support the weight of the larger, improved aircraft. Even the dirt strips were outdated. Asphalt runways came into use to be replaced later by concrete. Asphalt and concrete not only could support more weight but also had greater all weather capability.

The Federal Government helped speed up airport growth by furnishing aid for the construction or improvement of airports. Such aid was first made available in the early 1930's. However, it was not until passage of the Federal Airport Act of 1946 that a substantial aid program was set up. This act authorized a maximum expenditure of $100 million per year for airport improvement and corstruction. By 1960 the Federal aid program had contributed more than $500 million for the construction and improvement of 1,528 airports. These included seaplane facilities, heliports, and all other types of air commerce and general aviation airports.

The Government aid program applies to construction of runways, taxiways, control towers, and air traffic control aids. It is not available for terminal construction or parking lot development.

The National Airport Plan for the fiscal years 1968 through 1972 lists 4,015 existing airports which are keys to national air accessibility. This plan estimates the total cost of airport development from 1968 to 1972 at more than $1.5 billion. Of this total, the plan estimates that $927 million is needed for the 1968-1969 period. These amounts are only estimates, for the amount of money needed increases with the constant upgrading of requirements. Since no one knows for sure exactly what the new aircraft will demand in the way of airports, these plans have to be flexible. To insure this flexibility and to incorporate changed criteria, the National Airport Plan is reviewed and revised annually.

The Federal Government is not the local airport's only source of help. Some states have instituted grant-in-aid programs for their cities and towns. To qualify for such aid, the town must show need and justification for aid. The airports receiving state aid must meet special requirements; however, these state requirements are usually consistent with FAA requirements. State aid is in addition to Federal Government aid, not in place of it.

Air transportation is as dependent upon an adequate system of public airports as it is upon the aircraft themselves. Aircraft are refueled, serviced, and repaired at airports. Pilots receive current weather information from weather stations located at airports. Passengers enplane and deplane at airports. Cargo and baggage is loaded and unloaded at airports. Many other facilities are located there for the information, comfort, and convenience of passengers and crew members.

STANDARDS FOR CONSTRUCTION AND OPERATION

To insure that logical construction criteria apply generally to airports, individual governments establish airport construction standards. In the United States the Federal Aviation Administration establishes and continually updates construction standards.

To determine the number and types of airports required to serve a community, the planners must consider prospective volume as well as the character and capacity of available airports or airport sites. They must first project the type of use feasible in the future so that the site selected will be large enough to satisfy future as well as current requirements. (For current requirements see Fig. 17.) In this way, they can determine whether one or more additional airports will be required.

The critical factor in airport capacity is usually the number of *aircraft movements* which runways can accommodate in an hour. (An aircraft movement is a landing or takeoff.) An airport with only one runway can accommodate about 50 aircraft movements an hour in clear weather and about 30 under instrument operation. With two runways which can be used simultaneously, an airport can accommodate about 100 to 120 aircraft movements per hour in clear weather and about 70 under instrument operation. With the possible exception of large hubs, a second airport for a given community will not need be of as high a type as the first; a third not so high as the second; and so on.

The designation of airport type and construction should be a matter of public concern. Today, in the United States, most airports are publicly owned because this (1) makes them eligible for Federal

Airport classification	Runway		Taxi-way	Landing strip	Pavement loading (lb. per wheel X 1,000)	
	Length* (ft.)	Width (ft.)	Width (ft.)	Width (ft.)	Single wheel	Dual wheel
● Intercontinental express	8,400	200	100	500	100	125
● Inter-continental	10,500	150	75	500	100	100†
● Continental	7,500	150	75	500	75	80†
● Express	5,000	150	60	500	45	60
● Trunk line	6,000	150	75	500	60	40†
● Feeder	3,500	150	40	300	15	20

* At sea level elevation and zero gradient.
† All loading based on single wheel.

Figure 17. Construction Standards for U.S. Airports.

airport aid; (2) permits the use of the power of eminent domain to acquire land needed to assure their continued utility; (3) permits in some states the use of zoning power to prevent the obstruction of approach and circling airways; and (4) assures their continued availability as public airports.

The FAA has classified airports in the United States as follows:

Intercontinental express: airports serving major transoceanic flights.

Intercontinental: airports terminating long international flights.

Continental: airports serving aircraft making long nonstop flights.

Express: airports at important cities or at junction points on trunk routes.

Trunk line: airports serving smaller cities on airline trunk routes.

Feeder: airports serving certified feeder airlines.

While the construction standards establish various categories of airports, airline operators actually determine the purpose for which any one airport is used. A given airport may have been classified for short domestic flights and may be used for long-range flights because of a change in traffic demand. When this happens, runway length and surrounding obstructions can restrict aircraft performance. It may be so restrictive that some aircraft cannot operate out of it with full design weights.

Limitation of airport funds, as well as natural and physical limitations to expansion programs, impose airport limitations upon scheduled airline operation. To operate safely and efficiently under these conditions, an airline must carefully observe specifications for takeoff weights and landing weights at each airport in its system. These specifications consider temperature and wind at time of takeoff for each runway at each airport. Although such a process is time consuming, it points to the care and attention the airlines give to upholding high standards of safety.

LOCATION OF AIRPORTS

How well an airport can serve a community is partially determined by its location in relation to the businesses and residents it serves. Whereas bus and train depots are generally located downtown, the airports are away from town. This is necessary because airports cover large areas of land with a minimum of surrounding obstructions.

Most airport locations for the major cities were selected and activated in the 1920's and 1930's. They generally represented a compromise between convenience of location and space requirements. As aircraft have become larger and larger, they have required larger airports, and a number of cities have built more remotely located airports. Today airports plan for expansion, and yet, still more remotely located airports will be built to handle the burgeoning traffic.

In the last half century, aviation has developed from small beginnings to become an important part of the national transportation system. As a result, air transportation has had an increasing influence on the economic advancement of our country by providing greater mobility than that available by other transportation modes. People can now travel to places which were previously difficult to reach and can make trips in far less time than formerly. The increased accessibility of locations and the saving of travel time have broadened the markets for goods and services and permitted industries to locate more efficiently with respect to natural resources, labor supply, and markets.

With the increasing use of air transportation, the continued development of a sound system of airports is essential. The individual community with no airport or with an inadequate airport deprives itself of air access and the capability of sharing the related economic benefits. It is also true that the economic value of air transportation

AIRPORTS

LOCATION	AIRPORTS			HELIPORTS			SEAPLANE BASES		
	Exist.	New	Total	Exist.	New	Total	Exist.	New	Total
Conterminous U.S.	2,969	642	3,585	36	20	56	4	1	5
Hawaii & Guam	13	3	16	0	0	0	0	0	0
Alaska	205	51	256	0	0	0	72	5	77
P.R. & V.I.	13	7	20	0	0	0	0	0	0
Grand Total	3,200	703	3,877	36	20	56	76	6	82

Figure 18. National Airport Plan Airports: 1968–1972.

to the Nation is limited by the degree of air access available to all segments of the economy.

The National Airport Plan reflects the airport requirements for the individual community and for the Nation as a whole. It also applies certain planning considerations which are used to determine the proper location for airport construction or improvement.

For each airport or location in the system, aviation demand must be effectively measured to determine required capacity. Required capacity, in turn, must be properly evaluated in terms of needed airport facilities to avoid limiting the location's capability by underdevelopment or wasting resources by overdevelopment. The provision of sufficient capacity must be accompanied by a proper fitting of the airport into the community. This is necessary to assure good relations between the airport and its neighbors and to assure a desirable relationship with other transportation modes and community plans in general.

One of the most important considerations governing the location and selection of an airport site is the nature and composition of the soil and subsoil upon which the airport is to be built. Detailed knowledge of the land at the site, and especially its behavior in contact with water, is vitally important for the economical development of the land as well as for the life and durability of paved runways, taxi strips, and aprons. Adequate drainage is essential to the proper maintenance of paved runways because more runway failures occur with unstable subsoil conditions than with any other condition.

The need for further development at an existing airport or the construction of a new airport is responsive to several distinct forms of aviation demand. These include airline service and the associated numbers of operations and passengers, general aviation activity in terms of magnitude and types of operations of all potential users and numbers of based aircraft, and the types of aircraft used in these activities.

The flow of airline traffic is concentrated around the large air traffic hubs and greatly influences the Nation's air route structure. Nearly two-thirds of domestic airline passengers enplane at large hubs. Most through-moving traffic, either in the same aircraft or by connecting flights, likewise begins at large hubs.

Small hubs and nonhubs, in addition to generating low levels of airline traffic, are characterized by their inability to support nonstop service beyond the closest large or medium hub. Because of the geographic dispersion of the large and medium hubs and established route characteristics, the maximum nonstop flight expected for small hubs is 300 miles and for nonhubs, 200 miles.

Large hubs may have so great a demand at an airport used by air carriers that capacity is exceeded. This may cause congestion which may most economically be relieved by additional airports for general aviation. At other large hubs, congestion may more readily be alleviated by improvements to the airport used by air carriers in lieu of additional airports for general aviation exclusively.

Basic to the determination of airport configuration are the types of aircraft expected to use the airport with sufficient frequency to justify development to meet their requirements. The broad spectrum of aircraft types presented by the small, single-engine general aviation aircraft at the one end and the large, four-engine turbojet at the other results in an equally broad range of requirements. It is essential, therefore, that the type of aircraft or group of aircraft, used to justify development be carefully selected.

For airports used by both the scheduled airlines and general aviation, the airline aircraft is usually the more critical. Type determination must result from close collaboration with the airlines involved so that the proper consideration may be given to possible equipment changes or purchases. The most demanding aircraft requirements are imposed at the more than 200 airports used by the trunk lines.

Equipment employed by the trunks include such large turbojets as the DC–8, Boeing 707, Convair 880, and others. These aircraft require runway lengths in the 10,000-foot range with pavement of runways, taxiways, and aprons strong enough to accommodate weights up to 350,000 pounds. Additionally, apron dimensions, fueling and terminal facilities, and necessary land requirements, are quite extensive.

Less demanding are the requirements of the aircraft used by the local service airlines at over 300 non-trunk airports. During the next five years, it is expected that most local service carriers will convert present piston equipment to turboprop or light turbojet aircraft. The runway lengths required by the newer equipment will be shorter than that required by the trunk lines. Pavement strength must be capable of accommodating gross weights of about 75,000 pounds.

At airports not used by air carriers, the determination of a specific aircraft type is more difficult. For the purpose of this chapter, it is enough that you realize that there are specific criteria which project aviation demands.

The capacity of an airport configuration is expressed as the number of operations that can be accommodated within a given time period and within acceptable limits of delay. The basic requirements for an airport to accommodate demand include sufficient runway length to safely provide for the types of aircraft, along with an additional runway for crosswind coverage, if necessary. Beyond this, and when demand in terms of numbers of operations reaches a level where unacceptable delays to movements occur, capacity considerations become important. For example, delays to aircraft movements may indicate the need for an additional runway. Its required length may be substantially shorter than the primary runway, if capacity considerations show that the aircraft mix is such that separation of aircraft types by runway is feasible. This plan enhances capacity at minimum expense.

Air transportation has been a factor in the emergence of the metropolis. It will become an increasingly important factor in determining the nature and extent of future urban growth.

The impact of the airport on urbanization has been twofold. First, modern air transportation facilities have provided a spur to the "extensive" growth of the metropolis—that is the overall economic growth. One of the advantages of becoming a regional air center is that it contributes to the rapid growth of the whole metropolitan market area. The market area growth creates more jobs; more jobs bring in more people; and more people mean larger markets. Larger markets then complete the cycle of metropolitan growth by attracting more industry, and more service and distribution functions. For the metropolitan area, a first-rate airport is not merely a matter of civic pride but of economic necessity.

Airports have also had an impact on the "intensive" urban development of the metropolis. This means that the presence of the airport has resulted in a concentration of economic and physical growth around the airport. The airport has attracted motels and restaurants as well as office buildings, convention centers, resort hotels, stores, and shops. At some airports the result is a small airport city.

An airport industrial park is another type of "intensive" urban growth generated by air transport. An airport industrial park is a planned industrial district located on or near an airport. It is an industrial subdivision developed according to a comprehensive plan to create a community of compatible industries. Several outstanding airport industrial parks have been developed in recent years.

In addition to its impact on metropolitan growth, the airport has also influenced the growth of the smaller communities beyond the metropolitan area.

With increasing dependence on business flying and air cargo transport, the small town's general aviation airport can be a decisive factor in attracting new industrial development.

BASIC FACILITIES

Once a location is chosen, the basic facilities must be outlined. For most airports, the runways, the lighting, the control tower, and the terminal complex are basic.

Runways

Only a few years ago airport runways were virtually unknown. The first early frail aircraft used sod fields for take-offs and landings. These sod fields were ideal for these early aircraft, because, on them, the aircraft could take off and land in any direction. These aircraft were so light and so sensitive to the direction of surface winds that it was imperative that they takeoff and land directly into the wind. Because these aircraft were so light, the sod fields could easily support their weight.

As heavier aircraft began to be built in the late 1930's, it became necessary for airport builders to reach a compromise between take-off and landing direction and a load-bearing surface that would support the added weight of these heavier aircraft. This compromise required the construction of runways that were aligned with the prevailing winds, and which were of sufficient strength to support the aircraft weight. Although the new runways frequently required crosswind take-offs and landings, this was not too serious because the greater weight of the new aircraft made them less sensitive to the direction of surface winds.

These early runways were usually constructed of concrete or asphalt, with asphalt being the most common construction material. The new airports would commonly have more than one runway so the pilot could choose the one with the least amount of crosswind. As aircraft became even heavier and less sensitive to crosswinds, multiple runways were reduced until today, many modern airports have only one runway which is generally aligned with the prevailing winds.

With modern aircraft, the problem is not so much the direction of the runway as it is one of runway length and load bearing strength. The heavier an aircraft is, the more runway length is required for the aircraft to reach flying speed on take off. The heavier it is, the stronger the runway must be to support its weight. This is particularly true in the case of landings when an aircraft of many thousand gross pounds impacts with the runway at speeds near 100 knots. The pounding a modern runway takes under such conditions is hard to imagine. For this reason, most runways today are constructed of concrete with an extremely high tensile strength.

In addition to sufficient length and tensile strength, a modern runway must be built to support high density traffic; it must provide for take offs and landings under emergency conditions; and it must have a surface with a sufficiently high coefficient of friction to enable fast-moving aircraft to stop in a minimum distance. The demands placed on modern runways make highway building child's play by comparison.

Each runway should be served by a number of high-speed turn-off lanes. These lanes permit the plane to turn off the runway at speeds of 60 to 70 mph with the minimum use of brakes and blasts

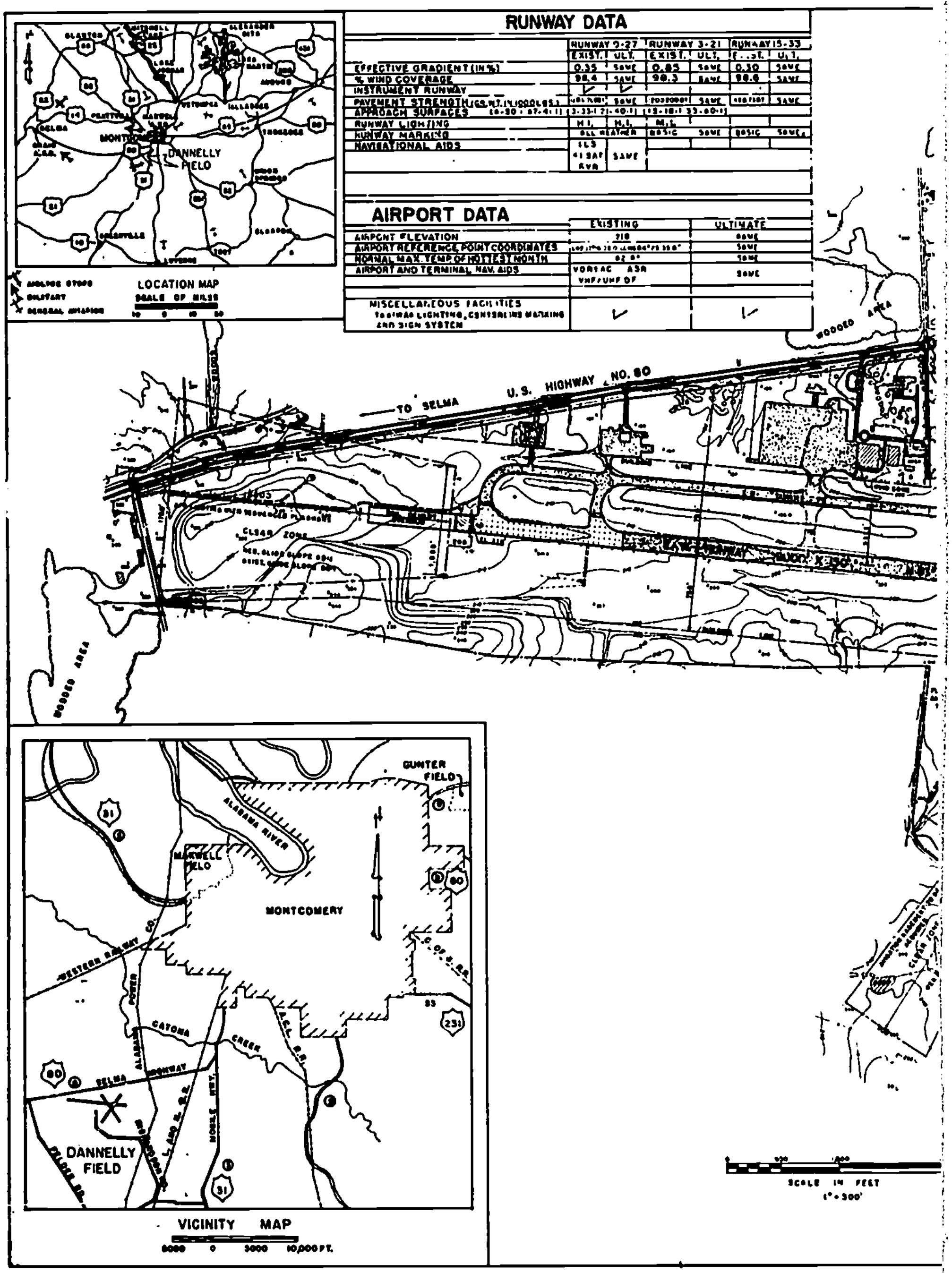
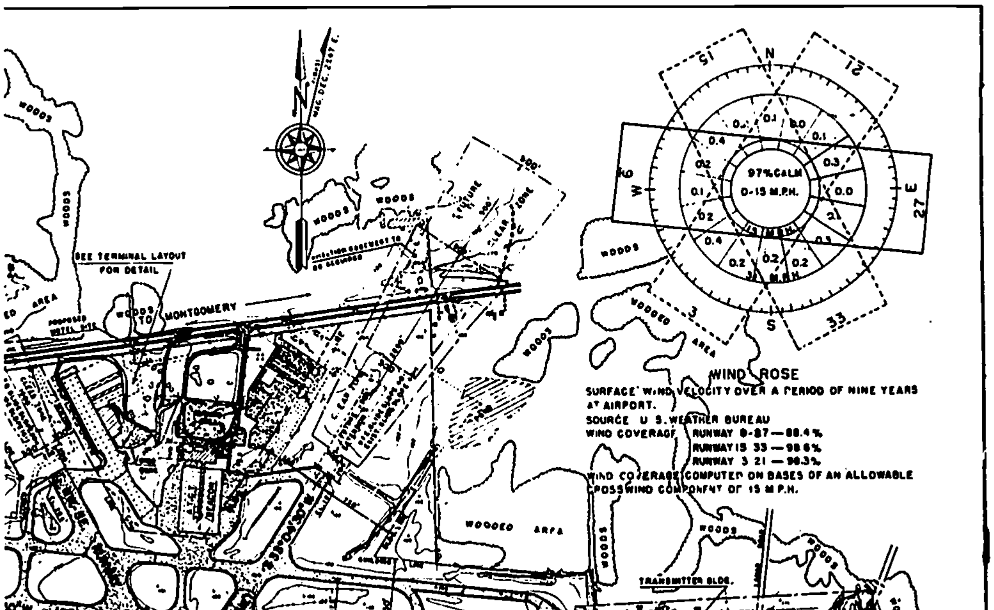


Figure 19. Montgomery's Dannelly Field. This airport layout map is included to give you a better idea of how many consideratio*s go into airport planning. Dannelly Field is not a very large airport, but you can see that even though it is not large, it is complex. Notice the detail on airport data as well as runway data. This information must



be complete and up to date if the airport is to provide adequate service to the community. Notice also that future growth is projected and planned far. This is to assure the airport's continued utility.

of power. In doing so, they speed up aircraft movements by clearing the runways for takeoffs or landings.

Taxiway patterns from the entrance to the apron area to the takeoff position should permit a smooth flow of traffic with no opposite direction paths and as few crossings as possible.

The size of the apron area is determined by the number of airport loading positions required. This number will vary a great deal from airport to airport. Whatever the number required, it is essential that adequate space be provided for the safe movement of aircraft to and from their loading positions with a minimum of sharp turns, stops, and opposing traffic.

Airport Lighting

Airports use various types and colors of lights to inform pilots. The familiar airport beacon is one of these. Green on the reverse side of the white beacon has long been the mark of an active civil airport. A split white beacon denotes a military airport.

When an airport rotating beacon is operating during daylight, it means that ground visibility in the control zone is less than 3 miles and/or the ceiling is less than 1000 feet and that a traffic clearance is required for landings, takeoffs, and flight in the traffic pattern.

Approach lighting systems are visual aids used during instrument conditions to supplement the guidance information of modern electronic aids. Lighting systems are intended to improve operational safety during the final approach and landing phase of flight.

Most runway and approach lighting systems allow the controller to adjust the lamp brightness for different visibility conditions, or at a pilot's request. The extreme brilliance of high intensity lights penetrates fog, smoke, precipitation, etc., but may cause excessive glare under some conditions.

Approach lighting has evolved from a simple line of lights that was aligned with the center line of the runway to variations such as the following:

- Lines of lights that extend beyond the approach end of the runway and are the same width as the runway. This enables the pilot to align his aircraft with the runway even though the runway is obscured by weather or darkness.
- These same lines of lights, in one variation, are made to flash sequentially. This not only accomplishes the above, but it points the direction of landing.

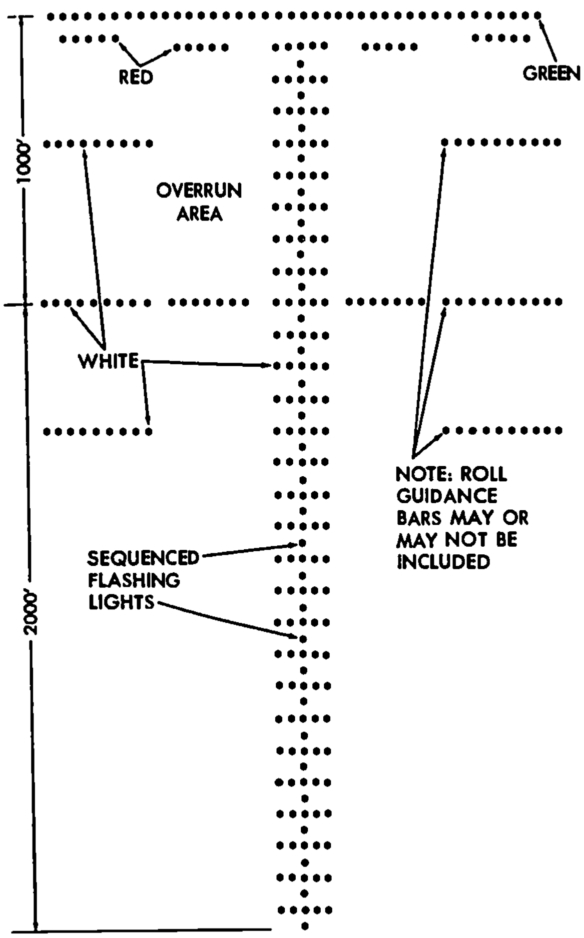


Figure 20. Approach Lighting.

- Approach lights that are tiered. The more distant lights from the approach end of the runway are mounted on a higher level than the nearer lights. This accomplishes all of the above, and, in addition, it indicates to the pilot the glide slope that is required in order to contact the approach end of the runway as near to the end as possible.

The *U.S. Standard* approach lighting has been adopted as the national standard for both military and civil airfields. It consists of 3,000 feet of high intensity, white centerline lighting leading to the runway threshold. Sequenced flashing (strobe) lights may be installed in the outer 2,000 feet. This lighting system may ultimately replace other systems now in use. (See Fig. 20)

Runway lights are white, slightly elevated from the ground and spaced 200 feet apart along each side of the runway. They can be turned on and off by individual controls operated from the control tower. Green threshold lights are placed across the end of runways. Blue lights guide pilots along taxiways at night.

Red obstruction lights mark all obstructions surrounding an airport. High obstructions, such as radio towers, which extend more than 70 feet above their surroundings, are marked at the top and at the one-third and two-third levels.

We will cover more on airport lighting in the last chapter of this booklet.

Control Towers

The airport control tower is easily spotted at a busy airport. It looks like the glass dome atop a tower, but why is it there? The glass tower gives control tower operators a clear view of the airport. The control tower operators are the only air traffic control (ATC) personnel with visual contact with the planes. It is their job to direct the traffic flow in the air as well as on the ground. Control operators work in sets, doing one job at a time.

But the glass tower is not the only part of the tower. In windowless rooms at the base of the structure are radar operators who direct traffic under instrument conditions by use of radar. The radar rooms are extremely important and should not be overlooked.

The entire complex is receiving more attention than it has in the past. For years, the control tower and ATC offices were built onto terminals. In 1961, Congress directed the FAA to finance and build it own control towers. The FAA desired a prototype that could be duplicated anywhere, one that would be beautiful as well as useful. Since only a few men actually have to see the field and the planes, their designer put the cab on top of the shaft. The rest of the men—mostly radar and radio operators—only need to see their instruments. The new design placed these men and their equipment in a building at the base of the tower that would be partially covered with earth. This would insulate against noise while rooting the tower into the landscape. These towers would be placed in a position away from the terminal that would allow them to see the runways more clearly making their job easier.

Terminals

The airport terminal building is essentially the service center for the transfer of passengers and their property between surface vehicles and aircraft. It may also contain the necessary Government facilities for the safe handling of air traffic, including flight service station, air traffic control tower, and Weather Bureau station. Other Government activities sometimes included are post office, airport mail facility, and, where there is international traffic, customs, immigration, public health, and Department of Agriculture stations.

The traveler expects to find, in the airport terminal building, comfortable seating, restrooms, and various concessions. At the same time, the terminal designer must consider safety, efficiency and convenience in his design.

Since its inauguration in this country in 1958 jet flying for the public has greatly increased the popularity of air travel. The larger volume of traffic is imposing unexpected demands upon recently built airports and necessitating expansion of those facilities directly serving the public, such as waiting rooms, newsstands, eating concessions, and parking areas.

The designer of an airport terminal building is faced with integrating the needs and requirements of the public, tenants, and owner into a scheme that operates efficiently and with a maximum degree of safety. Each must be considered from the standpoint of functional relationship to the others, with special emphasis being placed on planning for future demands.

Terminal buildings, particularly large ones, are civic business enterprises sponsored by local governments in response to air transportation needs. The problem confronting developers is one of providing suitable space for masses of travelers and adequate working space for airline and concessionaire tenants based on reasonable forecasts of passengers and customers. The past decade and a half has seen communities build terminal buildings that were considered, at the time of construction, to be larger than needed. Some were even criticized as being "white elephants." Many of these as well as surrounding building space and aircraft parking aprons have become so constricted that entirely new areas must be developed. The problem of expansion could become sufficiently critical to require consideration of a new airport site. This emphasizes the need for well-thought-out planning for the future.

A development should allow direct circulation for enplaning and deplaning passengers and for the handling of their baggage between the vehicular loading platform and the aircraft loading positions. Enplaning passengers should follow a self-revealing route to the passenger counter, through the waiting room, past concessions and other facilities to the aircraft loading gates. Deplaning passengers should follow a direct route to the baggage claim counter which, preferably, should be located adjacent to the vehicle platform. Baggage should follow as direct a route as possible from the passenger service counter to the airplanes and from the airplanes to the baggage claim counter. Figure 21 illustrates these basic circulatory requirements.

There are basically two concepts of terminal building operations at an airport—the centralized concept and the unit concept. A consolidation of these two concepts is sometimes possible. (The type of terminal used is determined by the amount of traffic it must carry.)

CENTRALIZED CONCEPT.—The centralized concept of building design refers to an operating arrangement wherein passenger, ticketing, and baggage facilities of all airlines are based in the same building. The passenger service and ticketing functions are usually in a unified area. Likewise, the centralized concept almost always employs a consolidated arrangement for baggage-handling facilities. The central waiting area and its surrounding concessions and other facilities serve passengers from all airlines, as well as visitors, using the terminal building. The layout of a building using this concept should be made flexible to allow for conversion to future needs.

UNIT OPERATION CONCEPT.—The unit (or decentralized) concept of terminal building operation is employed at several airports. Under this plan, each airline is housed in a separate building or in an area of an elongated or winged building with its own facilities for the handling of passengers, visitors, baggage, and cargo. This permits each airline to choose its equipment and furnishings, and to follow its pattern of operations and customer services without regard for compromise and cooperation demanded in centralized operations. Each airline can determine the degree of luxury it will use to attract customers. The traveler goes directly to the airline facilities

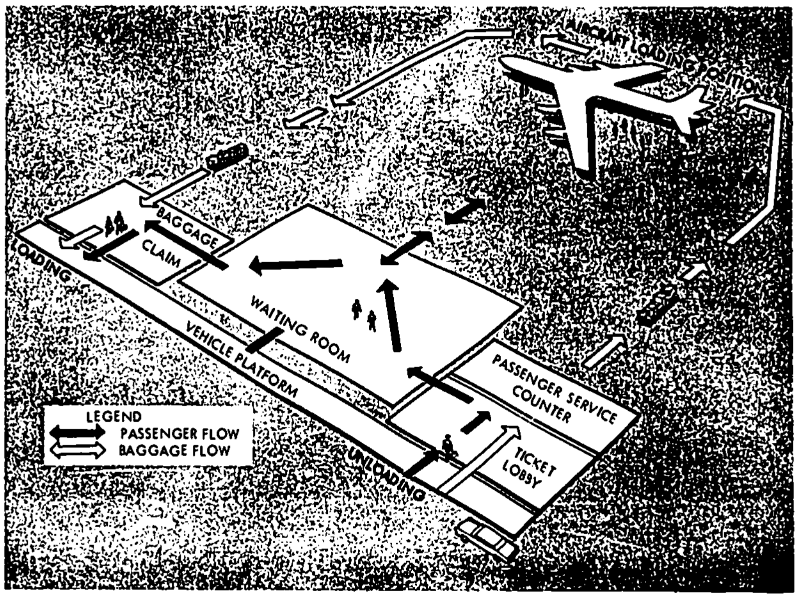


Figure 21. Passenger Baggage Flow.

he plans to use. In using the unit type of operation, duplication of public and concessionaire facilities results in higher capital investment for the airport owner and in less profit for concession operators because of the dispersal of customers.

The unit terminal building operation generally creates excessive walking distances for interchange passengers at transfer points. It may also cause excessive rolling distances for apron-service vehicles handling interchange baggage, mail, express, and cargo. Further, the concept is not adaptable to the efficient consolidation of airline servicing. The unit operation tends to cause confusion for casual travelers and airport visitors. Locating specific airline facilities in scattered buildings or units imposes inconvenience and hardship on passengers trying to arrange for flights.

CONSOLIDATION OF OPERATIONS.—Economy may be realized in space needed to accommodate ticketing and baggage services if a building can be planned for a consolidated operation. Space savings may be effected if one service organization could handle the operations involved in the transfer of passengers, baggage, mail, express,

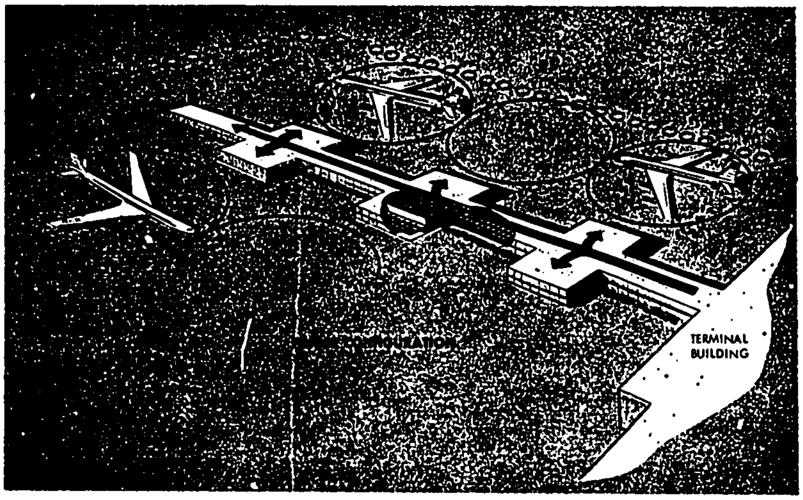


Figure 22. Aircraft Loading Positions — Finger Configuration.

and cargo to and from aircraft. A consolidated operation through the elimination of duplicated space, personnel, and equipment accomplishes this objective. The centralized concept is adaptable to consolidation of any one or all of the aforementioned activities.

AIRCRAFT LOADING POSITIONS.—The number and arrangement of aircraft loading positions at the terminal building has a profound effect on the configuration of the building. Airports with relatively low passenger volume, employing a one-level system, can usually operate most efficiently with a frontal scheme in which aircraft loading positions are parallel with the face of the building. Airports generating high passenger volume and a full flying schedule may effectively utilize a finger scheme for placement of the aircraft loading positions. Figures 22 and 23 illustrate the basic finger and frontal configurations of airport design.

A finger system concentrates a large number of loading positions in an area close to the center of activities in the terminal building. This cuts to a minimum walking distances for passengers and rolling distances for apron-service vehicles.

In a one-level system using either covered or fenced fingers, the passengers enplane and deplane on the apron level. Service trucks move along either side of the finger to aircraft loading positions. In a two-level system, trucks operate on the apron level and passengers move on the upper level. In either scheme, passenger and truck routes to the aircraft should not intersect unnecessarily.

The number of aircraft loading positions can be held to a minimum through effective monitoring and control of their use. Using the loading positions as much as possible produces three important and tangible results: (1) savings in original and costly construction of unneeded aircraft loading positions; (2) reduction in the length of passenger way or finger needed to reach the outermost positions; and (3) reduction of the time and distance required for passengers or apron-service vehicles to reach the far positions.

Remote loading positions are being introduced at airports that require more positions than can be supported by fingers. This helps to keep the maximum walking distances under 1,000 feet. The aircraft are parked at servicing points out on the apron, and passengers are transported to the aircraft from the terminal by mobile lounge. The passengers board the lounge from the main concourse of the terminal building without walking up or down stairs. In the mobile lounge they are taken to the remote loading position where they

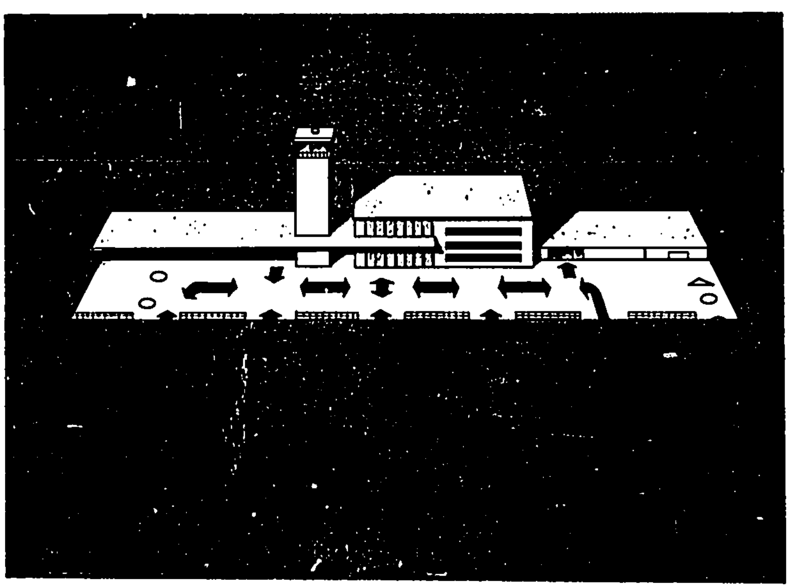


Figure 23. Aircraft Loading Positions — Frontal Configuration.

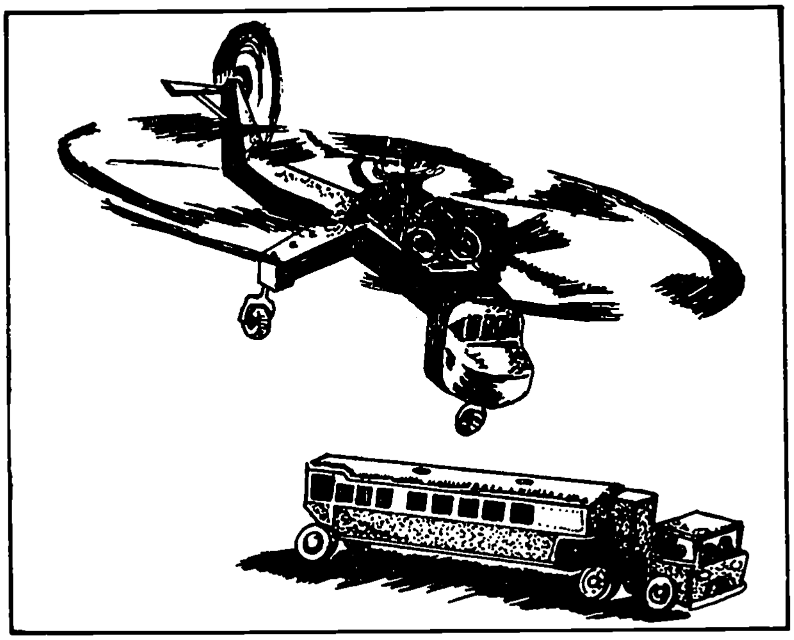


Figure 24. Artist's Conception of Mobile Lounge.

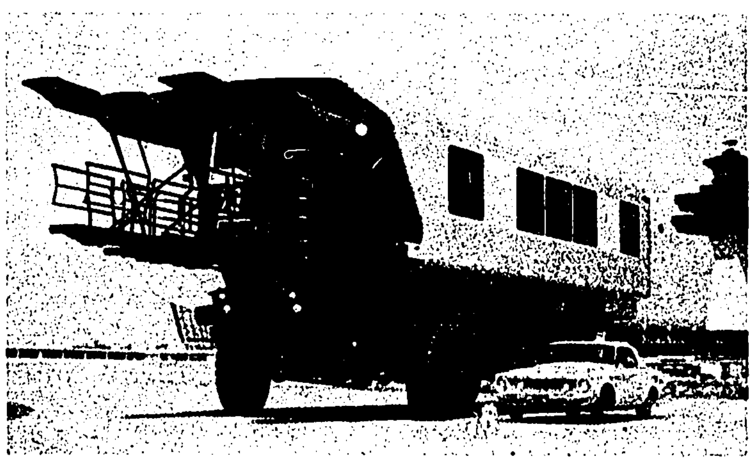


Figure 25. Mobile Lounge Used at Dulles International Airport.

enter the aircraft directly from the lounge. This practice is currently being used at Dulles International Airport outside of Washington, D.C. Dulles is one of the rare airports with capacity ready for future needs. Designed specifically to handle jet transports, it is used for long-range flights from across the country and overseas, while Washington National Airport remains the captial's terminal for shorter flights.

The mobile lounge in use at Dulles International Airport is an efficient, new concept of getting air travelers from the terminal to their waiting aircraft. Because this traveling waiting room does away with the need for "fingers" extending from the terminal, the aircraft passenger walks about 150 feet from the time he enters the main building until the time he is seated in the air-conditioned lounge and is ready to be carried to his waiting jetliner.

Each of the 20 mobile lounges in service at Dulles will carry up to 90 passengers in complete comfort. The present terminal has positions for 24 mobile lounges, but 56 lounge positions are programmed for 1975, when traffic growth is expected to dictate expansion of the terminal building from its present 600 feet to 1200 feet.

The mobile lounge fits tightly against the terminal building so that passengers can enter without going up or down any stairs. To facilitate loading, each mobile lounge has two entrances. Passengers can smoke and listen to music as they are carried out to their jets, protected from weather, jet noise, and blast. On arrival at the airline operations apron, telescoping ramps fit against the door to the jetliner and passengers enter their aircraft—again without climbing or descending steps.

Passengers flying into Dulles are met by a mobile lounge and driven to the terminal building. The lounge itself is driven from either end and both engines can be utilized if additional forward power is required.

NOISE CONTROL AND SAFETY FACTORS.—Airport planners devote a great deal of consideration to problems of noise control and safety. Both of these are vitally important. Airport noise control and safety consciousness are mandatory if the airport is to fit into the community. Planes produce a great deal of noise when they pass at low altitudes when landing or taking off. Jet planes emit higher frequency sounds which are far more annoying than the lower frequency sounds produced by propeller-driven aircraft. This noise is an irritation not only to airport neighbors but also to people in the immediate vicinity of terminal buildings and maintenance facilities. Therefore, terminal planners provide noise deflecting barriers. Some terminals allow passengers to remain entirely indoors by providing movable, covered ramps, connecting the aircraft and terminal building, or mobile lounges traveling between the aircraft and the terminal, like those at Dulles International Airport.

To complaints of disturbing noise lodged by residents of communities near airports, no fully satisfactory answers have yet been found. A partial solution is found in altering airport flight patterns and aircraft takeoff procedures. An initial rapid climb at full thrust to about 1200 feet, followed by a reduced rate of climb at reduced thrust to cruising altitude cuts the number of complaints, but it represents a compromise between the safest and most efficient combination of engine power and aircraft speed and those combinations which result in the least annoying noise levels.

It is also possible to reduce complaints by directing low-flying aircraft over less densely inhabited areas, although at many airports such changes in flight patterns may not be effected without undesirable sacrifices, especially as regards prevailing wind directions. A more satisfactory solution involves the development of devices to suppress jet engine sound at the source without too seriously affecting weight, drag, or power output.

Another serious noise problem is the so-called sonic boom produced by airplanes traveling at speeds greater than mach 1, the speed of sound. The sonic boom is caused by the shock wave generated by the aircraft, traveling at the same speed as the aircraft. It is a sudden pressure change audible as a thunderclap or an explosion which can be heard on the ground but not in the plane that produces it. This shock wave follows the aircraft throughout the flight so that sonic boom is a continuing phenomenon. When supersonic aircraft fly at low altitudes the boom may be of sufficient intensity to cause glass breakage and other damage. The shock of the sonic boom varies with the size of the aircraft, and the damage created by the boom varies with the value of the real estate that lies in its wake.

Despite the strides in aviation safety made over the years, the goal must be ever higher levels. These 10 areas are considered the most important areas for further action in aviation research and practice:

1. **Airport & Navigational Aids.** Improve navigational and landing aids at inadequately equipped airports including maintenance, testing, and trained personnel.
2. **Loss of Control/Turbulence.** Continue studies on turbulence, including training, instrumentation, meteorological factors, especially methods for detection.
3. **Emergency Evacuation.** Review evacuation procedures to accommodate larger passenger loads and for new types of structures. Reappraise current techniques.
4. **Economics of Safety.** Develop parameters for cost effectiveness of safety equipment vs. losses from accidents.
5. **Crash Fire Protection.** Provide "on-board" fire protection thru suppression of ignition sources, containment of fuel, and rapid evacuation facilities.
6. **Weather Information.** Improve adequacy and dissemination of information, particularly on weather hazards, including thunderstorms, fog, icing, turbulence.
7. **V/STOL Development.** Conduct operational suitability testing, with emphasis on safety factors.
8. **General Aviation.** Improve training programs, expand methods for disseminating forecasts and weather data in "plain language" form, provide inherent stability and crashworthiness in private aircraft.
9. **Collision Avoidance.** Accelerate development of proximity warning devices in light of new technology, to anticipate increased congestion.
10. **Component Reliability.** Use quality control, system monitoring, and reliability analysis, as an important part of engineering design and operational planning to reduce malfunctions.

The ultimate aim of safety consciousness is to help make flying the safest form of transportation. The same improvements that make passenger terminals safer also work for cargo terminals.

Cargo Terminals

Cargo terminals are constructed on a different plan from passenger terminals. The terminal is constructed just for handling freight and is often an interline effort. It may or may not be built adjacent to the passenger terminal although such a location facilitates the loading and unloading of freight carried on passenger flights. Increasing amounts of freight are being carried in this way which necessitates interline cooperation as few airlines have comprehensive route coverage.

The air terminal designers consider the entire shipment and distribution cycle when they plan to construct a new terminal or enlarge one already in use. They must consider the market and the volume of trade already done.

They must plan for spaces for trucks to pull up to when dropping their loads; they must consider the speed and efficiency required to

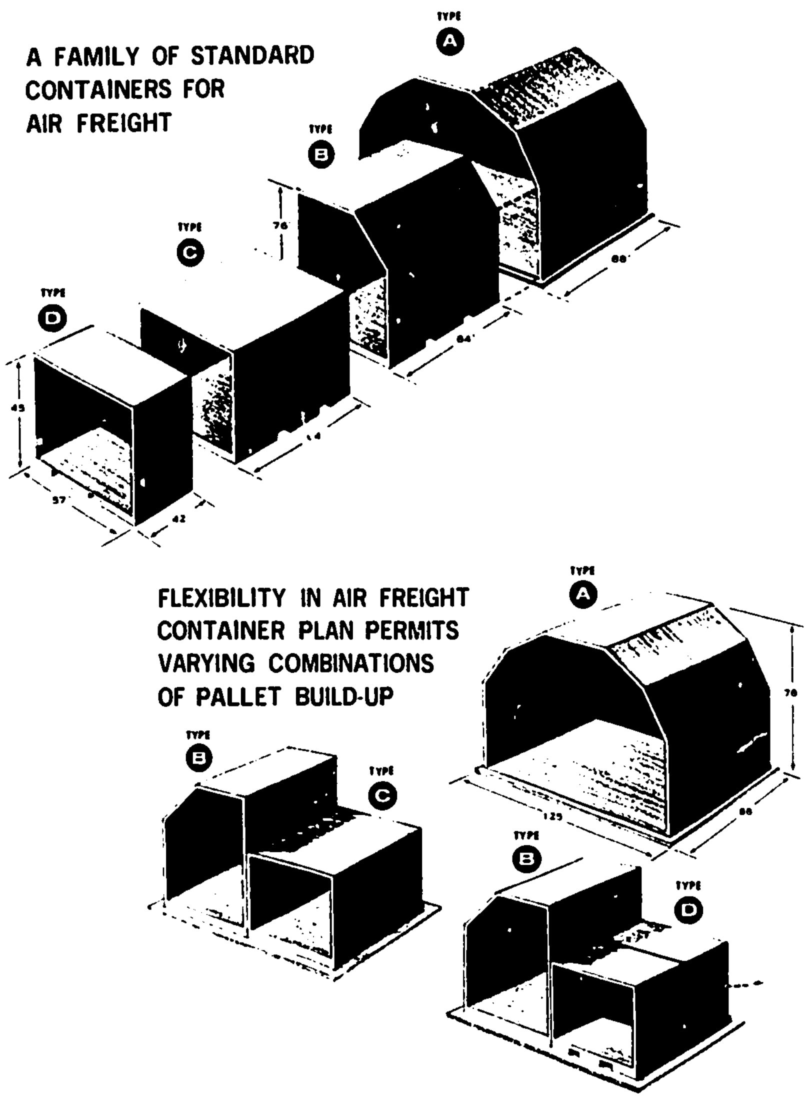


Figure 26. Air Freight Containers.

process this freight for shipping; and they must provide for loading planes quickly and efficiently. At the other end of the line the process is reversed. Provision must be made to unload, outprocess, and load onto trucks the freight to be delivered. Throughout this entire process time is money, and needless delays can cost millions of dollars.

The computer has had a very definite impact on the air cargo industry. Because it can analyze cost distribution and discover weaknesses in the present system, it is being used daily. Some of the solutions to present problems suggested by the computer are being tried and tested and are sure to change the picture of the entire industry.

Two big advances have been tried and will be perfected in the future. The first of these is the use of container packaging which saves time, packaging, and documentation costs. Figure 26 shows the basic family of air freight containers.

The second big advance has been the increasing use of automation. The experts look to automation as the possible solution to the choking effect of increased air cargo traffic on ground facilities. As traffic grows, more and more air carriers develop plans to automate their cargo terminals.

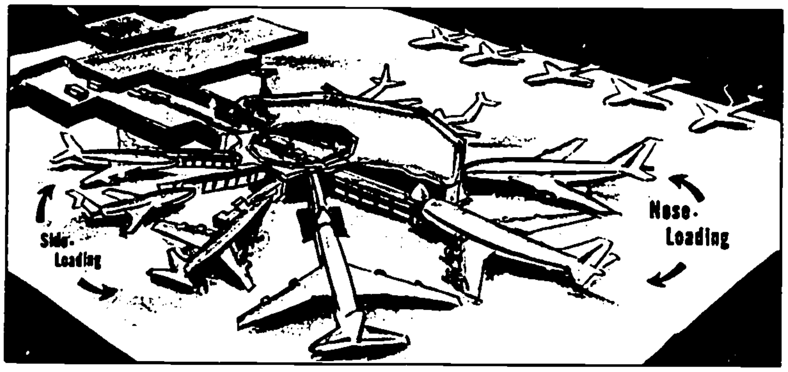
Automation in the handling of air freight is already easing congestion at the larger hubs, but it will have to prove its worth when the Boeing 747 hits the market. This giant has a cavernous hold—214,000 pound cargo capacity—which can accommodate 2½ times the traffic at present. To fill this aircraft by hand would be as useless as counting the pebbles at the beach. Shippers, therefore, must develop a system of inventory loading and unloading that can match this fantastic capacity, for efficiency on the ground must match the 747's flying effectiveness, if profit is to be made.

Automation seems to be the answer. The following illustrations show some of the planned terminals and the ways they are approaching the problem of increased traffic and the 747.

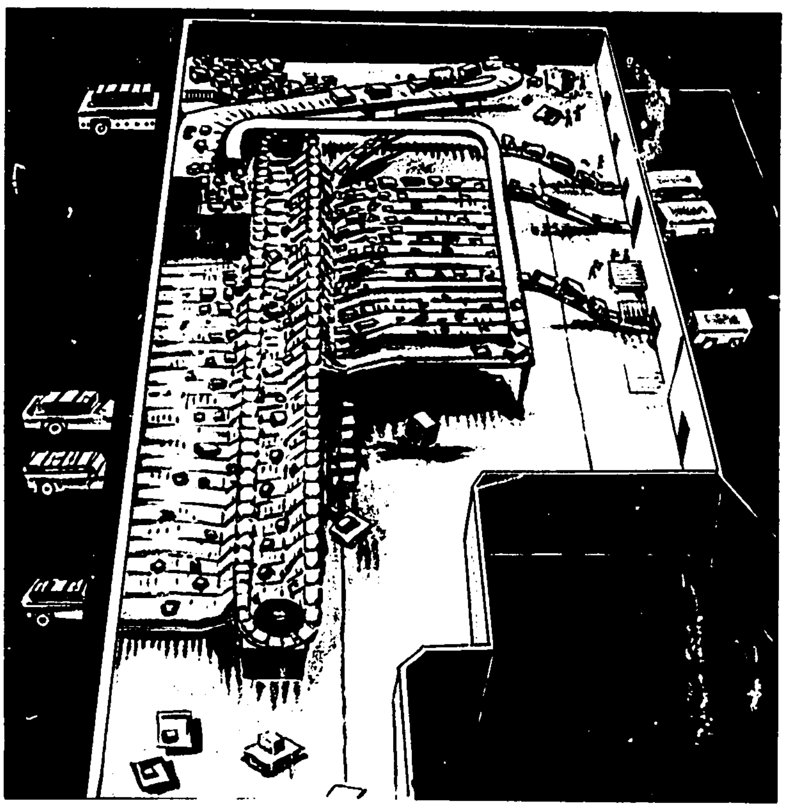
AIRPORT PROBLEMS

Terminal designers have a great many activities and problems to consider. This book will not even try to cover them all, but only discuss a few to give a feeling for the problem.

When a prospective passenger comes to the airport for the first time, he is faced with one of the air traveler's biggest problems—



ONE SUGGESTED TERMINAL DESIGN

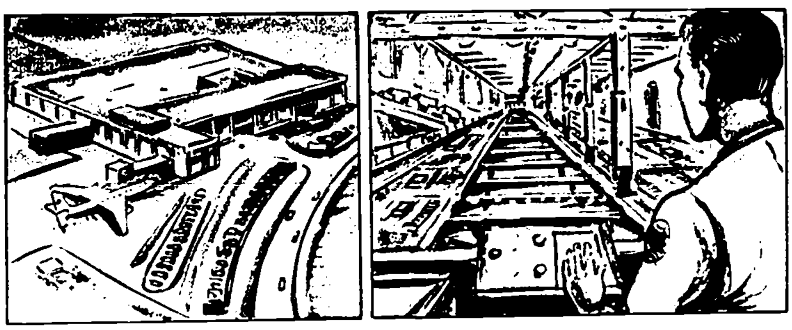


SYSTEM FOR PROCESSING AND REDIRECTING CARGO

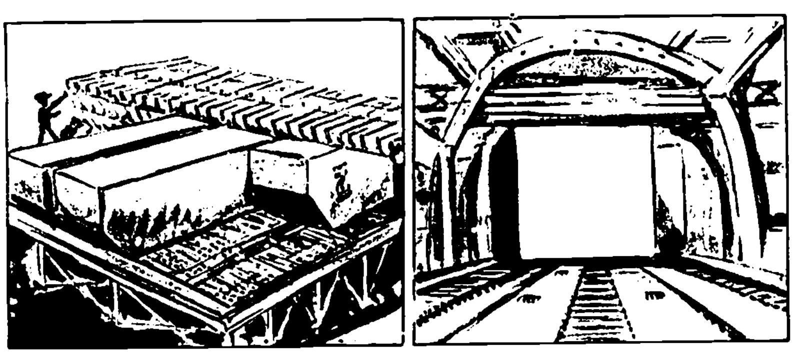
Figure 27. Future Plans.

AIRPORTS

AUTOMATIC CARGO FACILITY NECESSARY FOR THE FUTURE



NEW CARGO FACILITY AT KENNEDY INTERNATIONAL



CONTAINERIZATION MUST BE PERFECTED FOR 747

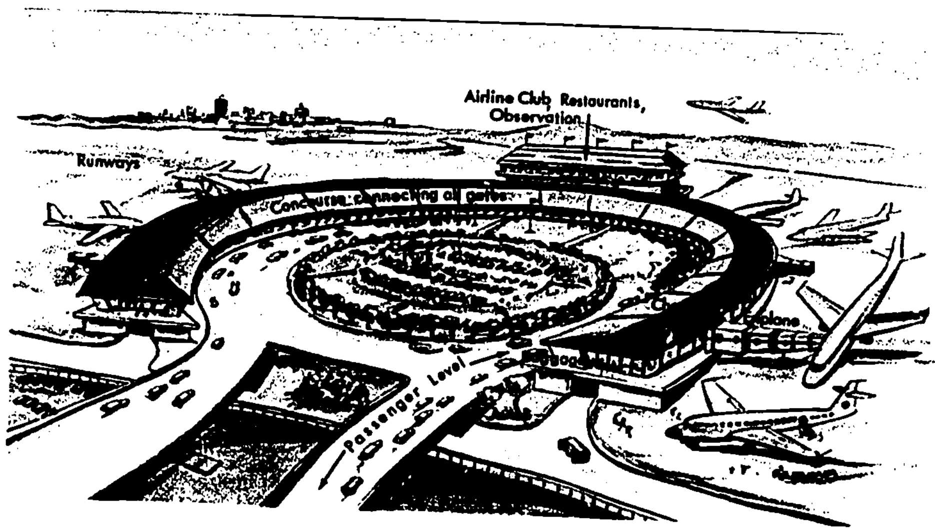


Figure 28. Airports of the Future: Kansas City's Plan.

where to park his car. Parking spaces are limited, and traffic to and from the airport is becoming so congested that in many areas it takes a traveler longer to get to the airport than it does to fly to his destination.

Once he finds a parking space, he enters the terminal to see congestion of another type. There are too few public telephones, too few restrooms, too few chairs in the waiting rooms, too few helpers at concession counters, too few places to eat, too many people everywhere, too many lines to wait in, too many crowds, and too much confusion. He goes over to the ticket counter to check in and see what time his flight leaves. He immediately finds out why they say to be there an hour before takeoff—it takes him 25 minutes to make it to the counter. Once he gets there, he gets his ticket, checks his baggage, is told what gate to go to, and is wished a happy trip. Now he has 15 minutes to find gate number 16 on the Northeast Concourse—wherever that is. On his way there he stops at a machine and buys an insurance policy in the hope that he might get off the ground today. After wandering around aimlessly for about five minutes he sees a sign that says Northeast Concourse. Gaily he rushes toward the sign and down the corridor to gate 16. It is a long way to gate 16—it seems like 16 miles. Finally he makes it with a few minutes to spare. He looks around at the small waiting room and hopes this is the right one because he would never have time to go back to the lobby and check. Luckily, it is the right gate and the announcer calls his flight number and says passengers may board. He gets out his ticket, presents it to the hostess, boards the plane, and sits down to relax at last.

Although this illustration is done in jest, it does portray the big problem at airports—a problem which has attracted quite a bit of attention lately.

Today's big aviation problem is in the air above airports (where some planes have to fly holding patterns for at least 8 minutes, occasionally an hour or more) and on the ground. Air travel time has dropped as much as 50 percent since 1948, but ground travel time to and from the cities' airports has increased 50 percent. Ground travel time is bad and growing worse daily because of highway congestion. Unless a faster way is found to get passengers to and from airports, airlines stand to lose a major part of their short-haul traffic—800 miles or less—to competing forms of transportation.

Airports need to expand to meet the needs of an ever-growing flying public. For every 1,000 passengers now using U.S. airports, FAA estimates that 2,000 passengers will be using them in 1972 and that 3,500 will be using them in 1977.

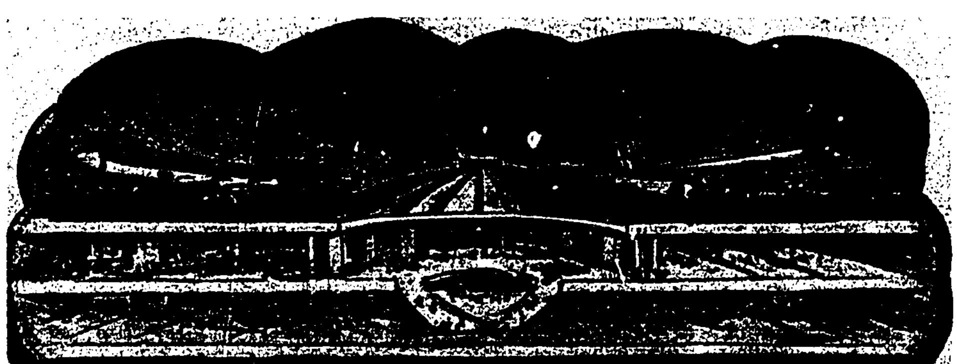


Figure 29. Underground Terminal Planned for Los Angeles with Parking at Lower Levels.

This means much needs to be done. The President called a task group together to study the problem and report their findings. The task force is headed by the Secretary of Transportation, Alan S. Boyd, and Charles S. Murphy, Chairman of the Civil Aeronautics Board. Their findings were not yet complete at the time this booklet was prepared, but, when complete, should shed some new light on the problem.

Every traveler who has ever been caught in an airport jam-up knows that airports need to grow as the traffic they serve grows, but who will finance this growth? Federal funds are not available for construction of terminal facilities, and state and local spending proposals often fail to pass. Everyone wants the improvements, but no one is willing to pay for them, so while each waits for the other to put in the cash, the problem gets worse. It has been suggested that difficulties in getting local aid for airfield and terminal improvements make necessary a major new Federal aid program comparable to the Federal highway program.

Some airport operators say their planning is hampered by lack of information from the commercial airline industry. Therefore, they have urged the Federal Government to set up a National Aviation Planning Commission to meet the combined challenge of traffic growth and the superjets through coordinated planning.

The commission would tackle such questions as how to speed people to and from airports, how to design more efficient terminal buildings, how to cut down on aircraft noise, and how to improve procedures for ticketing, handling baggage, and checking in passengers.

Solutions now are in the line of dreams. Some foresee the day when air passengers will check in at downtown terminals and be flown by helicopter in giant pods to outlying airports where the pods would be set down next to jet planes. Others envision forms of rapid transit to speed passengers to and from the cities to the airports. Cleveland's new rapid transit extension, for example, should alleviate much of the terminal congestion. VTOL/STOL aircraft are seen by others as the remedy to many of the airport's problems, for they could not only speed passengers to the airports but could also carry much of the short-haul traffic.

These solutions are still in the experimental stage; however, many people hope that they and other possibilities uncovered in working with these ideas will help reduce the problem and enable aviation to realize its full potential.

New ideas are being tried with terminal design too. The latest concept, under development at Houston and Tampa, is to have one or more terminal units, either with roof-top parking for autos or with parking in a center structure connected to the terminal units by "people mover" vehicles.

All these and other approaches are being tried to cope with the costly and still-growing problems of jet-age and supersonic air transportation.

REVIEW QUESTIONS

1. **The Federal Airport Act set up a substantial aid program. What can the money be used for?**
2. **Why are airports necessary?**
3. **Why are most airports located at a distance from the cities they serve?**
4. **Review the basic facilities at an airport.**
5. **Describe a mobile lounge.**

THINGS TO DO

This chapter can lead to several interesting projects. The most obvious project, of course, is to visit an airport. However, simply going to an airport and looking around is not going to show you what you read about in this chapter. The part of the airport which you see as a traveler is the part which is designed for the public. Your trip to an airport should be arranged in advance with either one of the commercial airlines at the airport or with the airport management. See if you can arrange to see the "backstage" operations: scheduling, air freight movement, etc. You can also follow up on the problem areas discussed in this chapter: the airport noise problem, the cargo loading problem, the passenger movement problem, etc.

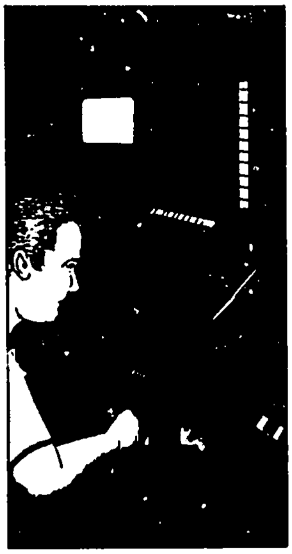
SUGGESTIONS FOR FURTHER READING

BERNARDO, JAMES V. *Aviation in the Modern World*. New York: E. P. Dutton & Co., Inc., 1960.

BURKHARDT, ROBERT. *The Federal Aviation Administration*. New York: Praeger, 1967.

Federal Aviation Agency. *Eighth Annual Report* . . . . Washington, D.C.: U.S. Government Printing Office, 1967.

Chapter 5



Air Traffic Control

THIS CHAPTER deals with the increasingly important science of controlling aircraft in the air. You will read about the early history and gradual development of air traffic control as a science. You will then take a simulated flight which will demonstrate how today's air traffic control devices and procedures work. During this "flight," you will see how modern navigational aids are a part of the air traffic control operation. Finally, you will read about some problem areas and some future developments in air traffic control.

After you have studied this chapter, you should be able to do the following: (1) outline the development of air traffic control and show how this development parallels that of the airlines; (2) discuss how today's air traffic control guides planes from one airport to another; and (3) list some problems and potential solutions involving air traffic control.

UP TO THIS POINT, the text has concentrated on aspects of civil aviation and facilities which today's air traveler can see and with which he is to some degree familiar. This chapter will discuss an aspect of civil aviation which the air traveler does not usually see: air traffic control. It will center on air traffic control both enroute and at the points of departure and destination: what it is, how did it start, how did it develop, how does it work today, and how will it work tomorrow?

Just as it is important to regulate and control train, bus, and auto traffic operating on this Nation's highways, it is even more important to regulate and control traffic operating in the skies. Although invisible highways called airways provide a path for planes to follow through the air, these airways are three-dimensional: they have height, as well as length and width. This three-dimensional aspect of airplane flight makes the problem of air traffic control far more difficult than that of surface traffic control. Most aircraft cannot stop on these aerial highways to look around and get their bearings. Even when airplanes slow down, their pilots have to keep them above a certain minimum speed (the stalling speed). Air traffic, then, is traffic continually in motion: aircraft are always moving from one place to another, with nowhere to stop.

Control of this vital air traffic is a service of the Federal Government. The Federal Aviation Administration (FAA) is charged with controlling air traffic in the United States. To insure that air traffic moves safely and efficiently from point to point, the FAA maintains several different kinds of air traffic control (ATC)* facilities. Some of these facilities "just grew"; others are relatively recent additions to ATC.

DEVELOPMENT OF ATC

The present intricate air traffic control system had its beginning and grew up concurrently with the airmail service. It can be traced back to the post World War I "barnstorming" era. Between 1918 and 1926, the U.S. Post Office Department secured, maintained, and operated a number of aircraft to provide airmail service. Between 1918 and 1920, airmail service was inaugurated between New York, Washington, Chicago, St. Louis, Minneapolis, and San Francisco.

This service was nothing like today's regular overnight airmail service. A pilot flew "by the seat of his pants" from point to point, and the mail got through. Navigating the early mail planes depended on the pilot's being able to see the ground and to figure out where he was by means of visual landmarks. If the weather was bad, the pilot could not see where he was. Navigational aids, however, came to the rescue of the airmail service and provided the beginning of today's highly sophisticated air traffic control system.

* ATC, unfortunately, stands for two things: Air Training Command and Air Traffic Control. In this chapter, ATC will mean Air Traffic Control.

A chain of radio stations, built between 1920 and 1921, was the first major aid to these early airmail pilots. Used primarily for weather information, these ground-based radio-telegraph stations provided pilots with advance weather information for subsequent legs of their flights. Since weather information is such an important part of air traffic control, these early radio aids were really the first step in the complicated communications network which forms a substantial portion of today's air traffic control.

These early mail flights took place during the day. The Post Office Department, however, naturally sought ways to enable pilots to fly the mails during the hours of darkness, as well. By 1926, a system of light beacons had been built, extending from the Atlantic to the Pacific. These lights enabled pilots to fly, theoretically, around the clock, from New York to San Francisco. This light line was the second long step forward, elementary as it seems to us today, in the development of a country-wide air traffic control system.

A major problem in these early attempts to assist pilots was that pilots could not always see the lights! The Post Office Department, the Army, the Navy, and the National Bureau of Standards had been at work, devising new and better ways of using radio equipment to guide the pilots and their planes. Up to this point, the use of radio had been confined to radio-telegraph (Morse code) sending and receiving equipment installed in only a small number of airplanes on an experimental basis.

The new system involved the use of low and medium frequency radio ranges and the establishment of four electronically derived courses which enabled the pilot to determine his directions and to navigate across the country by listening to the radio signals. The booklet on navigation covers the low frequency radio system in more detail; the point here is that it was another major step in the evolution of the concept of air traffic control.

One extremely significant result of the establishment of the low frequency radio ranges was the establishment of *airways*. Airways are designated paths through the airspace; actually, airways are *air highways*. It is important to understand that the airways are defined by radio aids to navigation. Airways grew as air traffic grew, just as railroad lines grew connecting population centers. These early airways were designed by color and number. Red, green, blue, and amber airways crisscrossed the country.

The first semblance of an airways system was established with these color designated airways. It served as a valuable transitional device from visual navigation to electronic navigation. However, the pilot still had to listen to the radio signals which defined the airways, and he had only four defined airways to follow. The concept of airways will figure importantly in subsequent sections of this discussion.

A new problem presented itself as the number of airplanes using the airways increased. The movement of traffic over the airways under conditions of good visibility, when airplanes could "see and be seen," was a simple problem.

The demand for other than just fair weather flying raised a more complex problem. Its answer, accurate and safe instrument flight, brought with it the need for specific air traffic control. The devices which airports had used to help airplanes land, including flags, flares, lights, and ground signals, were no longer sufficient. Expediting the movement of aircraft and preventing collision between aircraft flying under limited visibility conditions were becoming a serious problem. This was especially true around the major airline terminals when aircraft on the same or converging airways were flying "on instruments."

As a result, the airlines requested and obtained the approval of the Bureau of Air Commerce to establish their own traffic control offices at the important airports. Each of these air traffic control offices was organized as an independent operation controlled by the airline manager at the airport chosen. Newark, Chicago, and Cleveland were the sites of the first traffic control offices.

This traffic service was designed for airline use in the interest of increasing the safety of their own operation. The service was made available without charge to all private, military, and other Government aircraft using the airways. In this way, the airlines were able to keep track of the proximity (closeness) and movement of other aircraft in the area.

As longer non-stop flights began and air traffic in general increased, congestion began to occur along the airways farther from the airports. Formerly, the only part of the airways which had been crowded were the sections near airports; now, the volume of traffic had increased so much that the airways were becoming congested farther from the airports. Traffic to and from other airports along the airways had to be fitted in with that leaving from and arriving at the main terminals. It became apparent that a need for control extended farther out along the airways than the airline offices were prepared to handle. A unified nation-wide control of air traffic could provide the answer to this growing problem.

The rapidly increasing number of flights other than those of the airlines along the airways pointed up the interstate nature of air traffic control. The responsibility no longer belonged to the airlines; now, it belonged to the only agency that had the proper authority to handle it, the Federal Government.

The Federal Government met the challenge well. In 1936, the Bureau of Air Commerce took over control of air traffic along the airways. The Bureau arranged to take over the three airline traffic control offices then in operation. This was the nucleus of our present system of air traffic control and aids to navigation under the direction of the Federal Government.

The passage in 1938 of the Civil Aeronautics Act marked the start of a new era in civil aviation. This piece of legislation consolidated the various Government agencies which dealt with the expanding aviation industry, among them the Bureau of Air Commerce. Under the new Government structure, the fast-growing air traffic control operation was handled by the Civil Aeronautics Authority. This Government body expanded the jurisdiction of the three original airline traffic control offices outward to control larger areas. Additional offices were created as the need dictated and funds became available.

A reorganization plan of 1940 transferred the air traffic control function to the newly-created Civil Aeronautics Administration under the Department of Commerce. The entry of the United States into World War II slowed down the application of new technology to air traffic control in civilian aviation, but the war accelerated military applications of these new ideas, especially radar. After the war, radar became the chief tool of the air traffic controller, especially at heavily used airports and heavily congested airways.

Many new navigational aids have taken the place of the early, simple "clock-and-compass" navigational aids used by pre-World War II pilots. At the same time, the Federal Government has kept pace with the growing complexities involved in controlling the ever-increasing volume of air traffic. Passage in 1958 of the Federal Aviation Act incorporated the functions of the Civil Aeronautics Administration into the Federal Aviation Agency, including air traffic control. Greatly increased air traffic has spurred ingenious and almost amazing advancement of air traffic control as an art and as a science. The Federal Aviation Agency maintains centers for research and development in this fast-growing science. The swift progress of aviation has created requirements that are far in advance of existing facilities for navigation and control. Several high-level government task forces, the most recent of which is Project Beacon, have closely examined the present state of air traffic control and have made recommendations for the future development of this significant aid to aircraft movement.

Airport traffic control, an increasingly important part of air traffic control in general, was left to the owners and operators of the various airports until World War II. The need gradually emerged for centralized control and regulation of airport traffic, and the Federal Government took over control of airport traffic in order to centralize its regulation in a single agency which would follow a single set of procedures. Today's Federally controlled airport traffic control forms a highly important segment of overall air traffic control.

Military and civilian aviation work together to improve the safety and speed of today's increased volume of air traffic. Advanced aircraft demand advanced control; since both military and civilian aviation share the airways, it is in the best interest of both military and civilian authorities to cooperate to the fullest possible extent in sharing present control systems and in developing new systems.

Air traffic control, then, began with the airmail service; it grew up with increasingly better navigational aids; and it is reaching its maturity today with far-reaching advanced technology. How does today's air traffic control help guide airplanes safely and rapidly from takeoff to landing? Perhaps the best way to understand all the aspects of air traffic control is to "take a flight" and examine just exactly what goes into controlling an aircraft. Parts of this flight have already been covered in the booklet on navigation, so some of what follows will be familiar. However, today's air traffic control is bound up closely with advances in navigation.

ATC IN ACTION

The flight we have planned is from Oklahoma City's Wiley Post Airport to Love Field in Dallas. For this trip, we are going to use an airplane with a complete set of navigational equipment, and we will use almost every facility the Federal Aviation Administration

AIR TRAFFIC CONTROL

In this booklet, we have used only a few of the common abbreviations which form a large part of the air traffic controller's vocabulary. You may encounter many of these abbreviations in your own reading on air traffic control. The following list of air traffic control terms includes their usual abbreviations, and the terms themselves are explained in the text of this booklet.

Airport Surveillance Radar (ASR)

Air Route Surveillance Radar (ARSR)

Air Route Traffic Control Center (ARTCC)

Air Traffic Control Radar Beacon Interrogator (ATCRBI)

Automatic Data Interchange System (ADIS)

Flight Service Station (FSS)

Instrument Flight Rules (IFR); Visual Flight Rules (VFR)

Instrument Landing System (ILS)

Pilot Weather Reports (PIREPS)

Precision Approach Radar (PAR)

Radar Approach Control (RAPCON)

Radar Bright Display Equipment (RBDE)

Radar Microwave Link (RML)

Remote Center Air Ground (RCAG)

Remote Transmitter and/or Receiver Site (RTR)

Tactical Air Navigation (TACAN)

Ultra High Frequency (UHF)

Very High Frequency (VHF)

Very High Frequency Direction Finder (VHF/DF)

Very High Frequency Omni Directional Range (VOR)

Figure 30. Air Traffic Control Terms.

(FAA) provides for our use. This is somewhat unusual, but we are really giving you an overall view: we want you to see all the facilities the Government offers the pilot.

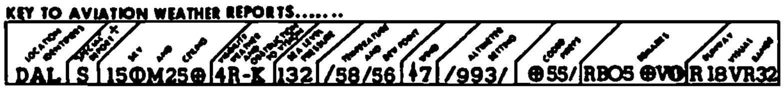
Planning Our Flight

Here we are at the airport and ready to leave. We still need two things: we have to obtain a weather briefing, and we have to file a flight plan. Weather conditions along our path of flight are extremely important and may even determine whether or not we fly at all. Literally hundreds of FAA and *Weather Bureau facilities* make weather observations periodically and provide these observations and resultant forecasts to all interested points. Collection and distribution of this data requires an extensive and complex network of *Teletypewriter* systems connected by telephone wires.

The basic teletypewriter operates at 100 words per minute which is fast enough for local or area operations but which becomes too slow to handle national weather traffic. A faster system called the *Automatic Data Interchange System* collects data from the basic Teletype circuit, and speeds it throughout the Nation. These faster systems may be programmed to print out any desired weather information at the basic Teletype speed when the information comes through on the high speed line.

Since we are interested in weather at Dallas, the operator could have programmed the system to print out the Dallas weather conditions in the following format:

KEY TO AVIATION WEATHER REPORTS.......



DECODED REPORT

DALLAS: SPECIAL OBSERVATION, 1500 FEET SCATTERED CLOUDS, MEASURED CEILING 2500 FEET OVERCAST, VISIBILITY 4 MILES, LIGHT RAIN, SMOKE, SEA LEVEL PRESSURE 1013.2 MILLIBARS, TEMPERATURE 58°F, DEWPOINT 56°F, WIND SOUTH 7 KNOTS, ALTIMETER SETTING 29.93 INCHES, PILOT REPORTS TOP OF OVERCAST 5500 MSL, RAIN BEGAN 5 MINUTES PAST THE HOUR, OVERCAST OCCASIONALLY BROKEN, RUNWAY 18 VISUAL RANGE 3200 FEET.

+ S INDICATES THAT REPORT CONTAINS IMPORTANT CHANGE

Typical Teletypewriter Message Showing Weather Conditions. The Bottom Part Shows The Key to Interpreting the Message.

Figure 31. Teletype Weather Message.

Although weather conditions around Dallas do not look very favorable, there does not appear to be any turbulence which would endanger the aircraft. It may be necessary to fly a part of the route on instruments due to low ceilings and limited visibility, but we are completely prepared for this possibility.

FILING OUR FLIGHT PLAN.—The next step is filing the flight plan. A flight plan is important because it alerts Flight Service Stations (FSS) all along our route of flight that we are coming their way. Each Flight Service Station will also provide us with additional

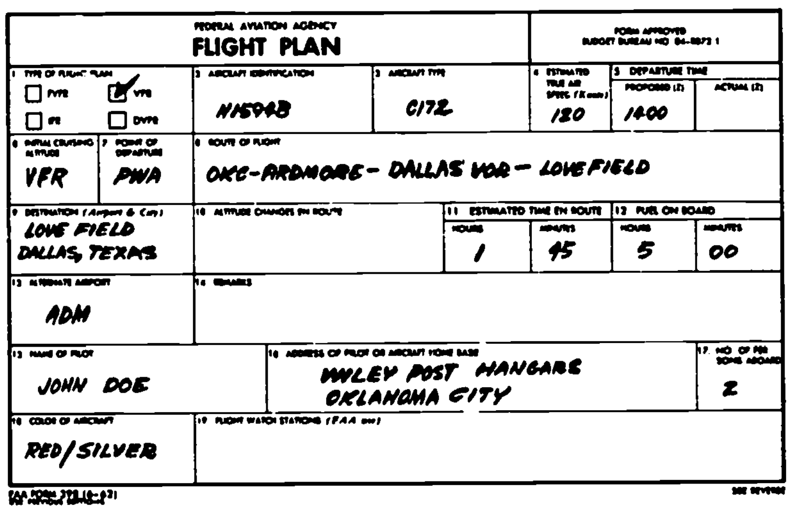

FEDERAL AVIATION AGENCY
FLIGHT PLAN
FORM APPROVED
BUDGET BUREAU NO. 04-R072.1
1 TYPE OF FLIGHT PLAN: FVFR / VFR (checked) / IFR / DVFR
2 AIRCRAFT IDENTIFICATION: N1594B
3 AIRCRAFT TYPE: C172
4 ESTIMATED TRUE AIR SPEED (Knots): 120
5 DEPARTURE TIME — PROPOSED (Z): 1400; ACTUAL (Z):
6 INITIAL CRUISING ALTITUDE: VFR
7 POINT OF DEPARTURE: PWA
8 ROUTE OF FLIGHT: OKC-ARDMORE- DALLAS VOR - LOVE FIELD
9 DESTINATION (Airport & City): LOVE FIELD DALLAS, TEXAS
10 ALTITUDE CHANGES EN ROUTE:
11 ESTIMATED TIME EN ROUTE — HOURS: 1; MINUTES: 45
12 FUEL ON BOARD — HOURS: 5; MINUTES: 00
13 ALTERNATE AIRPORT: ADM
14 REMARKS:
15 NAME OF PILOT: JOHN DOE
16 ADDRESS OF PILOT OR AIRCRAFT HOME BASE: WILEY POST HANGARS OKLAHOMA CITY
17 NO. OF PERSONS ABOARD: 2
18 COLOR OF AIRCRAFT: RED/SILVER
19 FLIGHT WATCH STATIONS (FAA use):
FAA FORM 398 (6-62)
SEE REVERSE

Figure 32. Flight Plan.

weather information, barometric pressure settings for our altimeter, and notify other stations of our progress. It is important to call each FSS, since this facility may initiate search and rescue activities if we are more than one hour overdue. We contact the local FSS and file this flight plan.

Now watch what happens. A Flight Specialist is entering information from our flight plan into a Teletype Network very similar to the one which handled weather data. From here it will proceed to Flight Service Stations all along our route and be printed out at 100 WPM.

They know we are coming and approximately what time to expect us; the rest is up to us now.

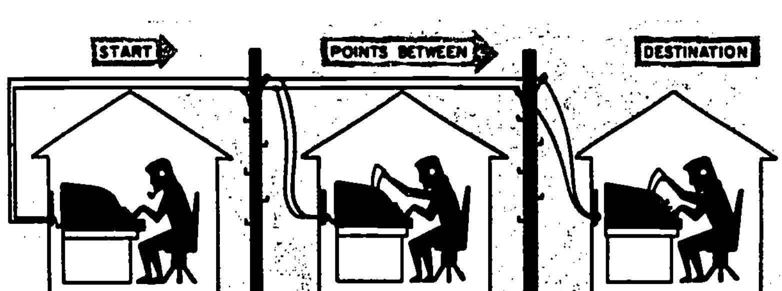


Figure 33. Teletype Network.

PREPARING FOR FLIGHT.—Now we perform the pre-flight inspection and get into the airplane. We are ready to taxi for takeoff, but first we tune our radio to 121.7 Mc (Ground Control) and ask for taxi instructions.

Aircraft: WILEY POST GROUND CONTROL THIS IS CESSNA ONE FIVE NINER FOUR BRAVO AT HANGAR 4 READY TO TAXI. VFR FLIGHT PLAN TO DALLAS LOVE FIELD. OVER.

FAA Ground Control: CESSNA ONE FIVE NINER FOUR BRAVO, WILEY POST GROUND CONTROL, RUNWAY ONE SEVEN. WIND ONE EIGHT ZERO AT ONE ZERO. ALTIMETER TWO NINER NINER EIGHT. TIME ONE FOUR ZERO ZERO ZEBRA. TAXI NORTH ON RAMP. HOLD SHORT RUNWAY ONE SEVEN.

Aircraft: CESSNA ONE FIVE NINER FOUR BRAVO. ROGER.

We have our instructions and taxi to the warm-up area adjacent to the runway. At this point a check is made of the engine and controls to assure proper operation. After this checkout the transmitter and receiver are changed to 119.7 Mc (Tower frequency) to request takeoff instructions.

Aircraft: WILEY POST TOWER, CESSNA ONE FIVE NINER FOUR BRAVO READY FOR TAKEOFF.

FAA Control Tower: CESSNA ONE FIVE NINER FOUR BRAVO CLEARED FOR IMMEDIATE TAKEOFF.

Aircraft: WILEY POST TOWER CESSNA ONE FIVE NINER FOUR BRAVO. ROGER.

The controller and aircraft are communicating through a transmitting and receiving site something like this:

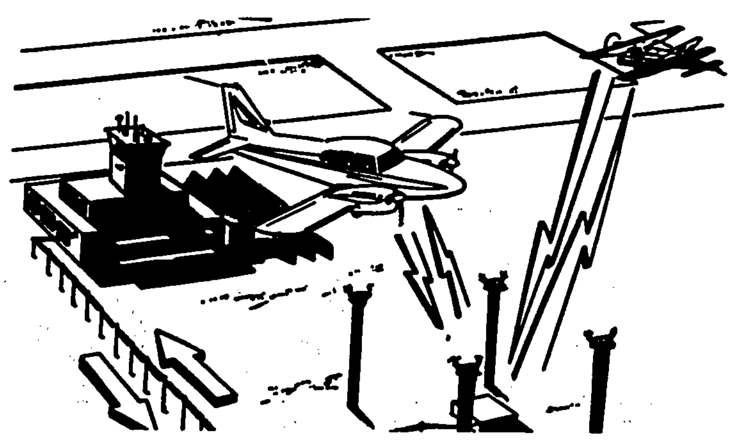


Figure 34. Communications Transmitting and Receiving Site.

From the tower, voice goes over phone lines to the transmitter and from the antenna to the airplane receiver; the pilot replies; his reply is picked up by the receiver antenna; and the voice goes back to the control tower over the phone line. Several frequencies are usually available to permit more than one controller and pilot to converse simultaneously. This site is called the *Remote Transmitter* and/or *Receiver Site*. In addition to the *Very High Frequencies* (VHF) we are using, *Ultra High Frequencies* (UHF) are also available. The VHF transmitters usually have a power output of 50 watts and the UHF transmitters produce 100 watts.

It would be well to make a list of the frequencies we may be using during our trip for communications and navigation. The exact frequency to use at each place is shown on the Sectional Chart or, preferably, in the Airman's Guide.

The Flight

During the course of our flight, we will be using almost all the navigational and ATC facilities in general use today. While this is a bit unusual, we think it will give you a better idea of all that can be done to guide and direct an aircraft in the air today.

VOR NAVIGATION.—We are now in the air, and we climb to the altitude at which we intend to fly. We are leaving the airport traffic area, which extends to a radius of five miles around the airport. Now we tune in the Oklahoma City *Very High Frequency Omni Directional Range* (VOR) to get onto the course we intend to fly. VORs

Figure 35. VOR Setting.

are electronic facilities which transmit radio waves that may be received by an aircraft VOR receiver. The receiver can translate the radio waves into direction *(azimuth)* information for the pilot to use in navigation. By using VOR a pilot can select courses at 1° intervals providing 360 flyable VOR radials *(courses).*

The first step is to tune the VOR frequency, in this case to 115 Mc. It is a good practice to listen to the identification to be sure we have selected the proper station. Most VORs send out the identification in code each six seconds, but some have a recorded voice giving the station identification. The identification for Oklahoma City is OKC, or as we would hear it: — — —, — . —, — . — . in code.

At this time, we tune the VHF transmitter to 122.1 Mc and call the Oklahoma City Flight Service Station to report the actual time of takeoff.

Aircraft: OKLAHOMA CITY RADIO. THIS IS CESSNA ONE FIVE NINER FOUR BRAVO OFF AT ZERO FIVE, VFR FLIGHT PLAN FROM OKLAHOMA CITY TO DALLAS. OVER

FAA Flight Service Station: CESSNA ONE FIVE NINER FOUR BRAVO, ROGER, OUT.

The next step is to tune the course selector to the desired course to take us over the VOR facility. To visualize the proper course, look at the layout of magnetic directions around the VOR as shown on the Sectional Chart.

To get to the VOR, we must fly a magnetic course of 218° to the facility. The bearing selector should now be tuned to a course of 218°.

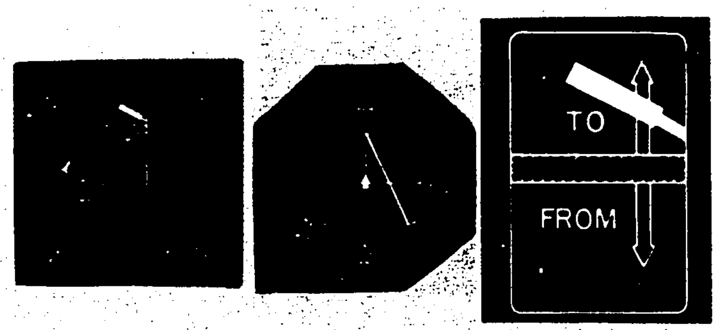


Figure 36. Course Setting.

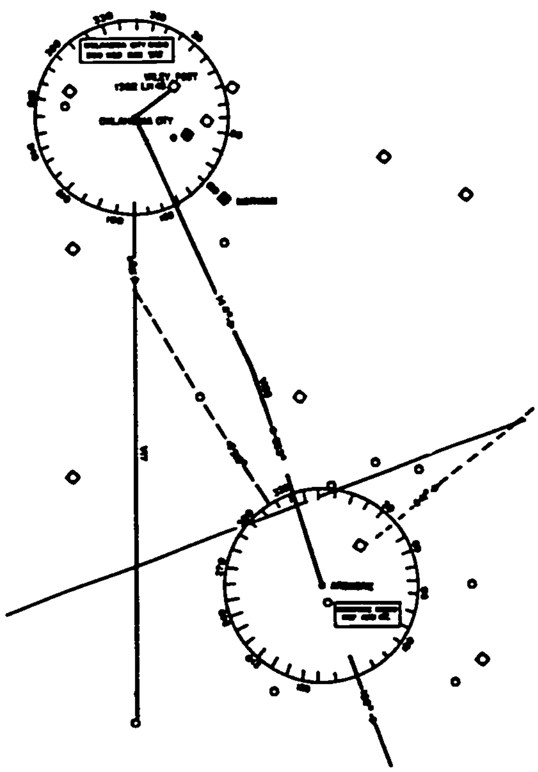


Figure 37. VOR's on Sectional Chart.

Notice that we now have an indication on the deviation indicator. The needle is deflected to the right, and since we fly the needle, we correct our heading to the right to intercept the 218° radial. When the needle is centered, we are on course. If we overcorrect, the needle will point left, indicating *fly left*.

At the same time that the deviation indicator began working, another instrument called the ambiguity or TO-FROM indicator showed an indication of TO. This means that our course is taking us nearer the station.

As we follow this course, the needle begins to move and finally moves to FROM, an indication that we have just passed over or by the station and are moving FROM it. The rectangle in the center is called a *flag*. When the needle is in this area, the signal strength from the VOR is usually too low to use, and deviation indications should be disregarded.

Now we turn the Bearing Selector to 144° and make a left turn to intercept this radial. Remember, the deflection indicator needle points the direction to fly: left deflection means fly left, right deflection indicates fly right, and in the center means on course. Notice that 144° is a Victor Airway labeled with the designation V163. There are approximately 300,000 miles of Victor Airways created by a network of VOR facilities located 50 to 100 miles apart.

Although there are many ways of using VOR indications, this simple explanation is adequate as long as the compass heading of the aircraft agrees within several degrees of the desired VOR radial to be flown.

For a look at what the VOR and the electronic technician do for you, let's compare this to flying a compass heading. No wind drift calculation is required, magnetic deviation and variation are of no concern and the accuracy of each radial of the VOR is within 1°. In general the VOR makes for more effortless, more accurate, and safer flying. It allows us the miracle of precise navigation over ground we may not even see.

The VOR operates in the frequency range of 108-118 Mc on a nominal power output of approximately 180 watts. Dual equipments are installed at each location and are constantly electronically monitored. If a transmitter develops a defect, the monitor changes to the standby transmitter and places it in operation. If the standby equipment fails, the monitor will shut the entire facility down and sound an alarm at some control point. A technician then must proceed to repair the equipment as rapidly as possible, put it back on the air, and certify it as a usable facility. This is where training pays dividends in the technician's speed, accuracy, and in his ability to know and to certify that the facility is safe and dependable.

TACAN.—Now that we are outbound from the first VOR, a check on our position may be made using *Tactical Air Navigation* (TACAN). Our airborne equipment, called an interrogator, will ask the ground station what our distance is from it and will also indicate the direction of the ground station from us. VOR and TACAN are usually installed in the same building and called VORTAC. The VOR station we are using also has TACAN, so we may now select the proper channel, 97 in this case.

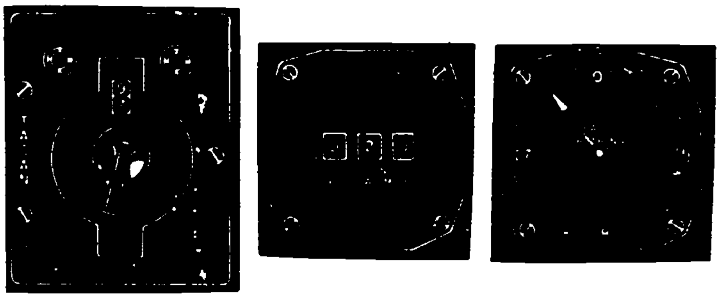


Figure 38. TACAN Instruments.

The interrogator dials begin to rotate as they search for the reply from the ground station. When the reply is received, the red flag disappears, and the dials begin to track. The distance from our plane to the TACAN is shown as 20 nautical miles.

The other instrument is indicating 324°, which is the azimuth of the ground station from us.

These readings confirm that we are on a course of 144° FROM the VORTAC or, in other words, that it is at 324°, 20 miles behind us. Electronics is at work again, and it is to the credit of an FAA electronic technician that these facilities are available and dependable when we need them.

OUR NEXT VOR.—Ardmore VOR is ahead of us, and it is time to retune our VOR receiver to 116.7 Mcs. The Bearing Selector should be changed to 153° which will take us to the VOR; and as the TO-FROM indicator switches to FROM change to 150°. VORs are spaced about 50 to 100 miles apart and provide a reception distance up to approximately 180 miles, depending upon the altitude of the aircraft. The altitude we are flying would provide us with a range of from 50 to 100 miles.

Now that you are familiar with navigation by VOR, it is time to look at another VOR feature, that of voice. At 15 minutes past the hour and 15 minutes before the hour, weather reports are broadcast over the voice channel of the VOR.

It's time now—let's listen.

THIS IS ARDMORE AREA RADIO, TIME FOUR-FIVE, AVIATION WEATHER, ARDMORE: CEILING—5,000; BROKEN: VISIBILITY, 4; LIGHT DRIZZLE, FOG: TEMPERATURE 58, DEW POINT 57, WIND 170 DEGREES, 6 KNOTS, ALTIMETER TWO NINER NINER TWO: THIS IS ARDMORE AREA RADIO.

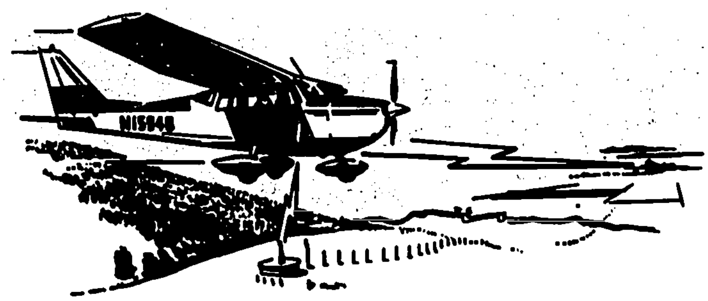


Figure 39. VOR Aircraft — FSS Communications.

Ceilings are lowering, and visibility is decreasing. We will probably be doing instrument flying before long.

The VOR is below us now, and it is time to report to the local Flight Service Station. Tune the transmitter to 122.1 Mc, and call the FSS. To avoid the necessity of our retuning the VHF receiver which will usually be in use on the VOR frequency for navigation, the FSS may transmit to us over the VOR. This allows the pilot to retain VOR and listen at the same time. 122.1 Mc is commonly used by light aircraft to transmit to a FAA, and, if desired, the pilot may request a reply on 122.2 Mc from the transmitters located at the FSS.

Aircraft: ARDMORE RADIO THIS IS CESSNA ONE FIVE NINER FOUR BRAVO, OVER.

FAA Flight Service Station: CESSNA ONE FIVE NINER FOUR BRAVO THIS IS ARDMORE RADIO, GO AHEAD.

Aircraft: CESSNA ONE FIVE NINER FOUR BRAVO OVER ARDMORE VOR, 3,500, VFR FLIGHT PLAN FROM OKLAHOMA CITY TO DALLAS, OVER.

FAA Flight Service Station: CESSNA ONE FIVE NINER FOUR BRAVO, OVER ARDMORE RADIO, 3,500, ARDMORE ALTIMETER TWO NINER NINER TWO, ARDMORE OUT.

Communications has again played an important role in the safety of our flight. The Flight Specialist can send our position report over the Teletype Net to our next reporting point in a matter of seconds; in fact, the electronic message travels at the speed of light, 186,000 miles per second.

IFR.—Weather is definitely closing in on us, and we will have to continue on Instrument Flight Rules (IFR). Again, we call Ardmore Radio and request a change in flight plan from VFR to IFR.

Ardmore has been broadcasting *Special Aviation Weather Reports* and *Pilot Weather Reports* which indicate mild turbulence and near zero visibility. Ardmore Radio also advises us of the frequency to use to communicate directly with the *Air Route Traffic Control Center* (ARTCC) in Fort Worth which monitors and advises aircraft under IFR conditions.

Even though the Fort Worth ARTCC is out of our radio range we may still communicate with them over the *Remote Center Air Ground* Communication Sites which act as extended voices and ears for the Center. The voice from the controller is carried over telephone lines to RCAG sites where it is transmitted to us; our transmission is received by the RCAG and relayed to the controller over telephone lines.

The ARTCC is connected to many of these remote sites providing full coverage of the control area. This means that for the duration of our flight we can maintain effective communications although we may be many miles from the center itself. The site we are using now is located on a mountain near Ardmore and is kept in dependable operation by electronic technicians from Ardmore.

The frequencies in use at each of these sites may be *paired;* for example, each communications channel includes one VHF transmitter and receiver and one UHF transmitter and receiver, both of these having standby equipments to assume operation in case of failure or malfunction of the main equipment. Among the associated equipments are *Tone Control Systems* to provide control functions from the center and automatic standby power generating equipment to assure continued operation in case of commercial power failure.

Standby Engine Generators are also installed with many other navigational aids. This is especially important since usually the same elements which wreck utility power lines occur during the time when the aircraft needs assistance the most. These units are capable of sensing a power failure, starting the engine, and assuming the full load in about seven seconds. The larger units of the type used at the ARTCC produce 550,000 watts each: enough to supply a medium size town with all their power requirements.

RADAR—THE ALL-SEEING EYE.—The controller in the center will constantly observe our progress on his radar indicator. During the flight it is his responsibility to advise us of other aircraft which may be in our area and to reroute any aircraft which may be in danger of conflict. Radar is going to be very important to us for the dura-

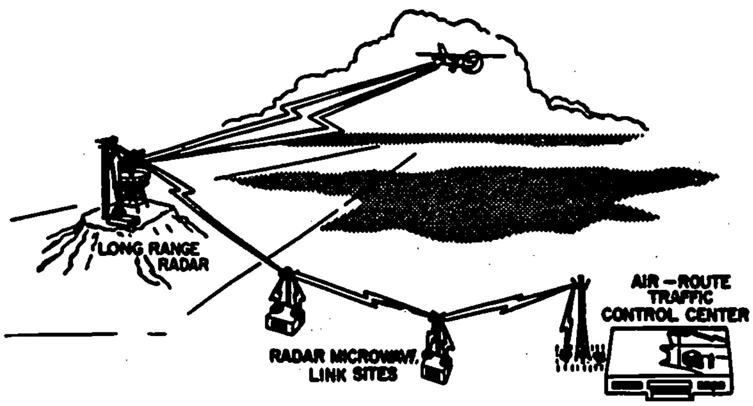


Figure 40. Enroute ATC Radar.

tion of the trip, since we will not be able to see other aircraft and must depend on radar being our eyes. The long range radar the controller is using is called *Air Route Surveillance Radar* and has a range of up to 200 miles. This means that either the radar at Oklahoma City or the one just north of Fort Worth could be watching us.

This radar produces a peak power output of over four million watts to assure a dependable long range operation. Even though we are in rain clouds, this radar can still see us because of a feature called *circular polarization.* This feature eliminates most of the heavy rain so the controller can watch only the aircraft. The weather bureau radar is different since they are interested in the rain clouds. Another nice feature of this radar is the ability to respond only to targets which are moving. This prevents the radar display from being cluttered and simplifies the controller's duties.

It could be a very lonesome feeling up here if we were not being *monitored* by radar. The chance of radar failure is very slight, since each site has two complete radar systems; in case of a malfunction in one, the other takes over. Added to this is a crew of competently trained technicians who are ready and capable of correcting any trouble.

Here is a little problem. If we are being scanned by radar in Oklahoma City, how does the controller in the Fort Worth ARTCC see us? This calls for a system to move the radar intelligence from Oklahoma City to Forth Worth: a *Radar Microwave Link* is used.

Actually this system is a number of receiver-transmitter sites, located about 25 miles apart, which receive, amplify, and transmit the signal to the next site. The signal strikes a reflector, is deflected downward to a parabolic antenna, is amplified, the frequency shifted to avoid input signal and output signal interference, sent to another parabolic antenna where it is beamed to a reflector and deflected on its way to the next site.

Remote Control Equipment allows the technician to change equipment and to perform many control functions from either terminal end of the link. The technician who has the responsibility for repeaters in the link may not be associated with either end terminal but must know which equipment needs his attention. Much of the diagnosis is done from the terminal ends, since it is impractical to have a technician drive from site to site to find defective equipment.

When the radar signal arrives at the ARTCC, it is converted to a television type display which allows the controller to view the presentation with a fairly high level of surrounding light. The equipment which performs this conversion is called *Radar Bright Display Equipment*. The radar signal is applied to one side of a conversion tube and a TV picture is obtained from the other side.

The displayed presentation shows the controller the present location of the aircraft as well as a trail indicating several minutes of past history.

ELECTRONIC AIRCRAFT IDENTIFICATION.—Increasing air traffic has made it difficult for the controller to identify or distinguish various aircraft being monitored. To help solve this problem, a secondary radar system called *Air Traffic Control Radar Beacon Interrogator* has been developed. The controller can assign our aircraft a code number such as 01 or any one of many more. Then, when the ground equipment *interrogates* our airborne transponder, it will reply with our assigned code.

Two methods may be used to obtain a beacon identification. On the regular radar presentation a *light gun* is held over the aircraft target to be identified and the trigger squeezed. In Radar Bright Display the controller positions a little circle or symbol over the target with a control stick.

The code which is assigned to the aircraft will be immediately displayed on little tubes called *nixie tubes* for the controller's use. This is especially important in congested areas where many aircraft are in the air and identification is difficult. Eventually the aircraft beacon transponder will also report the aircraft altitude. The Radar Beacon

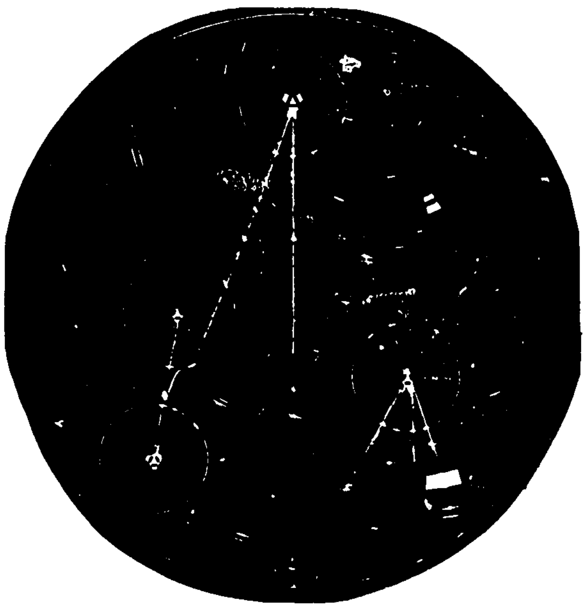


Figure 41. Electronic Aircraft Identification on Radar Scope.

antenna is installed on the regular radar antenna which assures that the two are scanning the same targets.

The controller may select all aircraft on a particular code or ask the aircraft to push the identification button to identify itself. Beacon targets are easily identified from other targets by the addition of slashes or a "bloom" to the target. Radar Beacon also has an advantage in that the aircraft Beacon Transponder replies to the ground station rather than depending on the conventional echo return. This feature assures a greater dependability of return than conventional radar.

Future plans call for a combination of Radar, Beacon, and Bright Display equipments to provide a continuous description of identity, altitude, and flight plan which will follow the aircraft target as it moves across the presentation. A computer will constantly analyze information and keep the controller informed of important data about each flight.

VHF/UHF DIRECTION FINDING.—Although it means diverging slightly from our planned flight, let's look at another situation that could exist. Suppose we were without the electronic navigation equipment in our aircraft and had only a communications transmitter and receiver along with a compass. Add to this the fact that we may be lost or unsure of our location. We may ask for assistance from a facility called *Very High Frequency Direction Finder* (VHF/DF). The Flight Information Manual shows one at Dallas—let's call them on one of their assigned frequencies.

Aircraft: LOVE FIELD. THIS IS CESSNA ONE FIVE NINER FOUR BRAVO, REQUEST HOMING, OVER.

FAA: CESSNA ONE FIVE NINER FOUR BRAVO, THIS IS LOVE FIELD, TRANSMIT FOR HOMING, OVER.

Aircraft: LOVE FIELD, THIS IS CESSNA ONE FIVE NINER FOUR BRAVO (transmit a constant voice tone for 10 to 20 seconds), OVER.

FAA: CESSNA ONE FIVE NINER FOUR BRAVO, THIS IS LOVE FIELD. COURSE WITH ZERO WIND, 180, OVER.

Aircraft: LOVE FIELD THIS IS CESSNA ONE FIVE NINER FOUR BRAVO. COURSE 180, OUT.

The DF course to Love is 180°. This confirms our location since we are on a course of 150° to the Dallas VOR, northeast of Love Field. If we had been lost, we would now have a definite course to

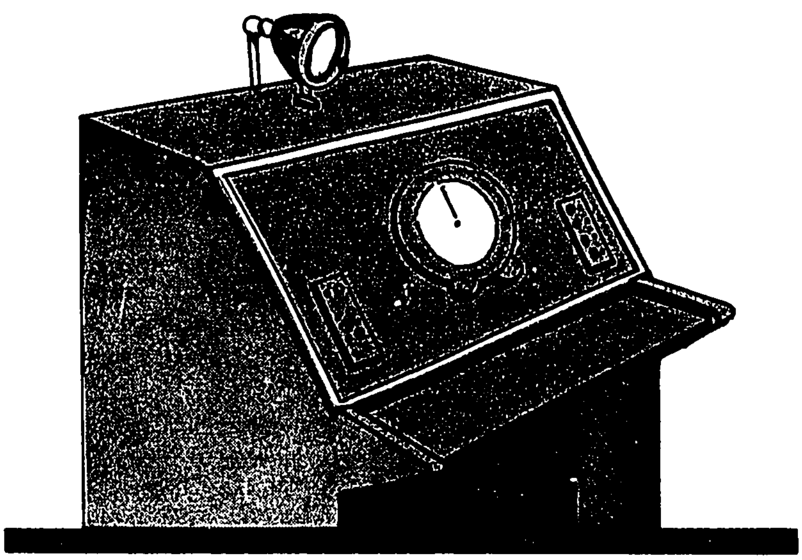


Figure 42. VHF Direction Finder.

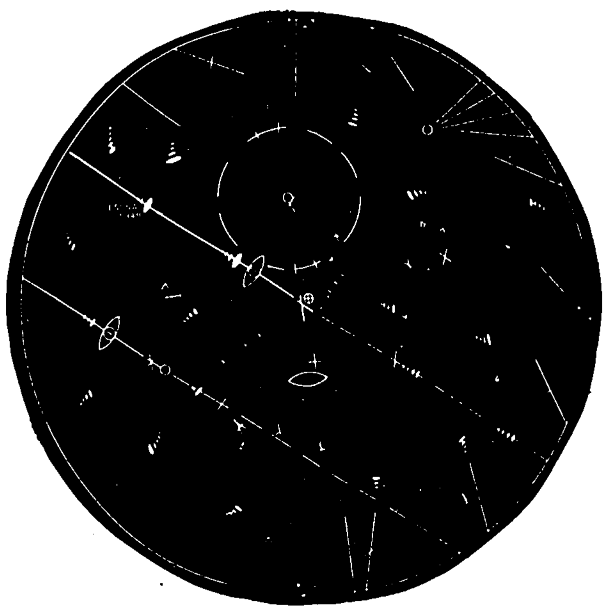


Figure 43. Airport Surveillance Radar Scope.

fly. This indication was read out by the DF operator on an instrument which responded to the direction from which our transmission came. At the same time, at some facilities, it develops a line on radar from the center of the display through the plane. From this both azimuth and distance are available.

Landing

Now we are getting ready to begin the procedures involved with landing our plane at Love Field. Notice in this section how we are constantly under the control and direction of at least one controller at all times.

HANDOFF TO APPROACH CONTROL.—The controller at the ARTCC has just informed us that we are being *handed off* to *Radar Approach Control* at our destination airport, and we make appropriate communications frequency changes. We are now being monitored by *Airport Surveillance Radar* which has a range of about 60 miles. This radar will be used to vector us to the point where we may intercept the *Instrument Landing System* (ILS) for the descent to landing.

Airport Surveillance Radar has a peak power output of over 400,000 watts and also has the ability to display only those targets which move. This feature eliminates displaying buildings around the airport which could obscure the aircraft targets. Fortunately, dependable operation assures us that it is almost impossible for this radar to lose us at this very critical time as we begin our descent.

Superimposed directly on the radar presentation is a map which shows the controller our exact location with respect to the desired course, and allows him to follow our progress throughout each phase of the approach.

Visibility is still near zero, and we are entirely dependent on radar to advise us of proximity of other aircraft and provide a safe course to avoid collision. No need to be concerned: we are still safer here than we would be in the family automobile on the freeway.

MAKING AN INSTRUMENT LANDING SYSTEM APPROACH.—Radar has guided us into position to intercept the ILS. The first contact we will make with the ILS will be with the *Localizer* which radiates radio signals defining the center line of the runway. The localizer receiver converts these signals into a needle indication giving *fly right, fly left,* or *on course.* The indications are the same as those of the VOR; in fact, many aircraft use the same instrument for both.

Localizer equipment operates in a range of frequencies from 108

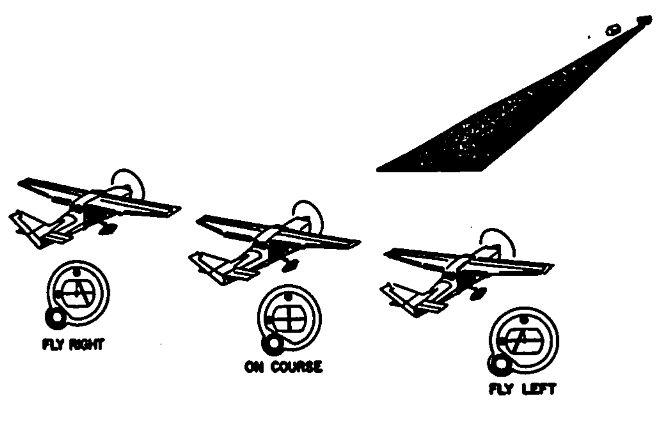


Figure 44. Airport Localizer.

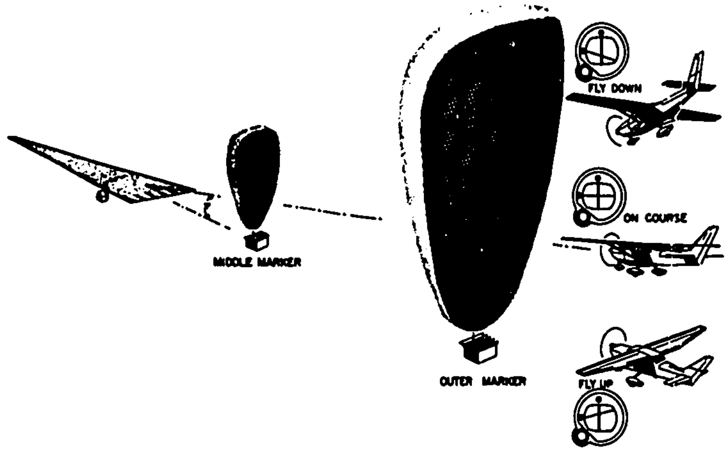


Figure 45. Aircraft Glide Scope.

Mc to 112 Mc with a transmitter power of approximately 200 watts. This provides a reception distance up to 25 miles from the localizer. The antenna is located at the opposite end of the runway from the approach end and projects a center line signal down the runway and out to us. The localizer also has a voice channel which will allow us to receive the Control Tower even though the receiver is tuned to the localizer.

ESTABLISHING THE ANGLE OF DESCENT.—Now that we are on the localizer course, the *Glide Slope* indicator is observed to establish the angle of descent we will use on approach to touchdown. Needle indications point the direction to fly except here it is *fly up, fly down*, or *on path*. The two ILS needles are ordinarily located on the same instrument with the vertical needle used for localizer and the horizontal needle used for glide slope. There is also a *flag alarm* for each signal. When a flag is in view, signal strength is insufficient, and readings may not be accurate. The flags will disappear when signal strength becomes sufficient.

The Glide Angle makes an angle of about 3° with the runway and extends out for approximately 15 miles from the runway. The Glide Slope transmitter is located near the approach end of the runway and about 600 feet to the side of the runway centerline.

Indications as received by an aircraft on a Glide Slope approach are shown in Figure 45.

INSTRUMENT LANDING SYSTEM MARKERS.—The ILS course is usually intercepted just before a facility called the *Outer Marker* is reached. This facility is located from 4 to 7 miles from the end of the runway and operates on a frequency of 75 megacycles. It radiates a narrow pattern vertically above it which does two things as the aircraft passes through the pattern: first, the aircraft may have a purple light on the dash which will light; second, the signal may be heard from the marker receiver in the form of code, two dashes per second for the outer marker. An aircraft may have either or both of these indications.

The marker is primarily a distance fixing device to provide an indication of distance from the runway. Now is also a good time to check our altimeter which shows 1200 feet above ground. Everything looks good, and we should be descending at about 475 feet per minute at a speed of 90 knots. Still no visual contact with anything on the ground. Our entire trust is in the electronic facilities and

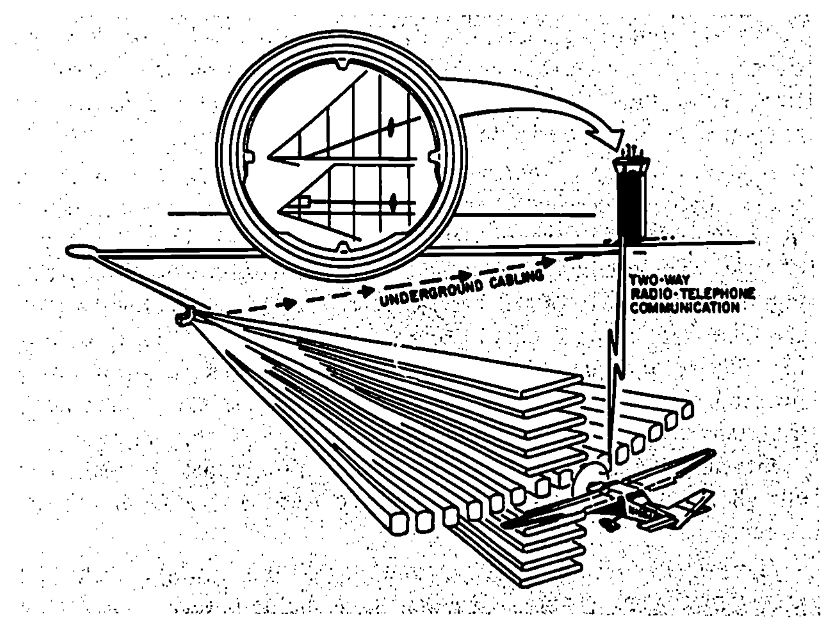


Figure 46. Precision Approach Radar.

our instrument indications. No need to even turn on the windshield wipers—nothing to see.

As a precautionary measure it would be a good idea to ask to be monitored by *Precision Approach Radar*. This radar monitors our approach on both localizer and glide slope. Since we have ILS equipment, this is merely an added safety measure. This type of radar uses a *height finding* radar with an antenna which scans vertically and displays the aircraft position with respect to the desired glide angle.

The other antenna scans *horizontally* and displays the aircraft location relative to the centerline of the runway.

The controller then advises the pilot of any corrections to make to get on course. A particularly important aspect of this type of radar is that all an aircraft would need in the way of equipment to use it would be radio communications. Both antennas are combined in one building to provide a precision approach radar system which becomes very valuable in low visibility conditions.

Still no visual contact with the ground, but we are on glide path, still lined up with the localizer course. Now we get an *amber* light on the control panel which indicates we are over the *Middle Marker*. At the same time we hear an audible indication of alternate dots and dashes. This tells us that we are about 3500 feet from the end of the runway. A glance at the altimeter shows 200 feet; radar monitoring reassures us that we are on course; and everything looks good.

VISUAL CONTACT.—Now we combine navigational, instrument, air traffic control, and visual procedures to complete our landing. Earlier in this booklet, you learned why runways are built with certain types of lights in a specified arrangement. Now we will see how these lighting systems aid our pilot. The Approach Lights are below us with the Flashing Strobe Lights creating a running ball of light pointing the way to the runway. From here on into touchdown we may proceed visually. The 1000 foot wing bar is just ahead, indicating that this distance is 1000 feet from the end of the runway.

Green lights indicate the runway threshold so that we may plan our glide to touch down just beyond them and be sure we are on the runway.

ESTABLISHING THE GLIDE ANGLE WITH THE VISUAL APPROACH SLOPE INDICATOR (VASI).—Another set of lights is very evident here and allows us to maintain a proper glide angle even though we are not flying the glide slope. These lights are called Visual Approach

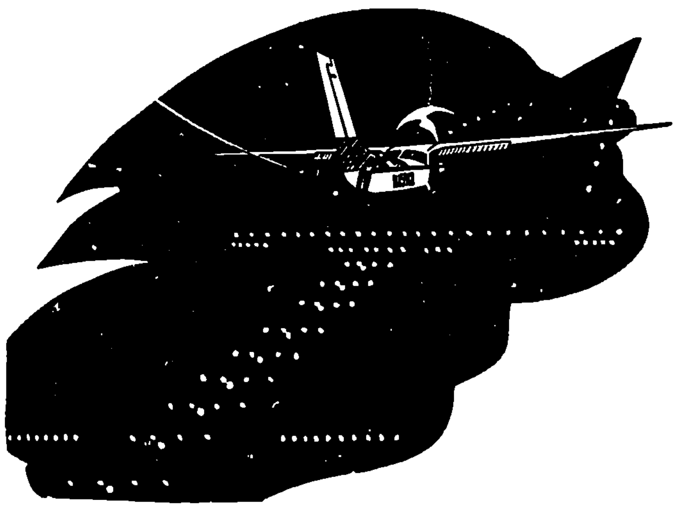


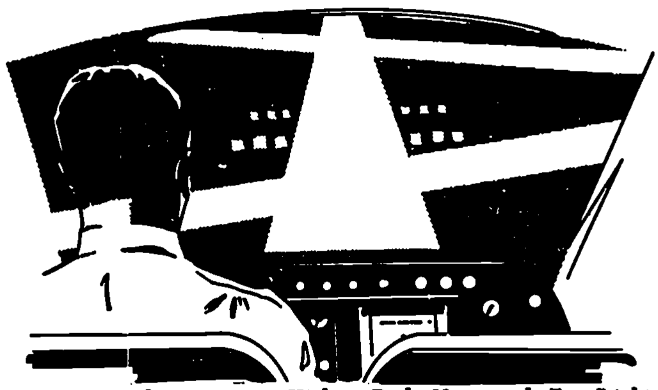
Figure 47. Approach Lights.

Slope Indicator. Some airports have these located on the back course of the localizer to provide a flyable glide angle indicator on each end, while other airports, such as this one, have these lights located on the front course of the localizer. Figure 48 is what a plane would see on this type of approach.

From this you see that we have the proper glide angle when the set of lights closest to us is *white* and the far set is *red*.

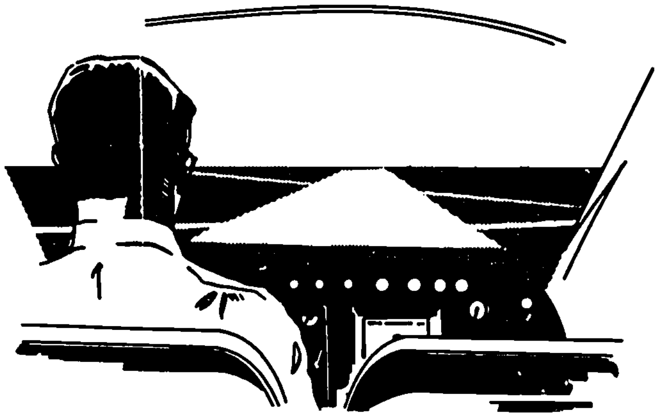
On the runway we have just made a good landing, and now we move to a parking area. The tower has just requested us to change to Ground Control frequency where we will receive taxi instructions to the hangar area. Suppose fog or snow prohibited Ground Control from seeing us. This is a problem at high density airports where it may be about a mile to either end of the runway from the tower. A device which does not depend on optics but produces a presentation comparable to that produced by an optical camera is needed. The answer to this is a radar called *Airport Surface Detection Equipment*. This radar continually scans the airport, sending a radiated beam through fog, snow, and rain the eye can't penetrate, and provides a presentation of all airport traffic. With a little practice, you can even tell which type of aircraft each one is.

Before you turn off the master switch to the electrical equipment,



VASI Indication, *too High*: *Both Near* and *Far* Lights—*WHITE*

VASI Indication, *on Course*: *Far* Lights — *RED*
Close lights — *WHITE*



VASI *Indication, Below Course*: Both *Near* and *Far* — *RED*

Figure 48. Visual Approach Slope Indicator (VASI).

stop and think a minute. Think of all the electronic equipment and facilities which helped to make this a safe and routine flight. Think of the absolute dependence on this equipment when we were in a black void and knew other aircraft were out there—somewhere.

From this we gain an appreciation for the skill of a pilot as well as the services of the FAA controllers and flight specialists which were made possible by the electronic facilities, maintained in a safe, accurate, and dependable condition by the well trained, competent, FAA electronic engineers and technicians.

ATC Facilities Used in Flight

Our flight from Kansas City to Dallas involved both complex navigational aids on our airplane and ATC facilities on the ground. A review of the ATC functions seems in order here.

After we filed our flight plan and got our weather briefing, the information on the flight plan was sent out over the Teletype circuits to the several air traffic controllers who would monitor and guide us. This information was put in the form of *Flight Strips* which were then displayed on a *Flight Progress Board* near each controller. These strips and boards formed the basis of the information which the controllers used to guide our airplane. Radar information, too, aided the controllers in "seeing" just where our airplane was at any given time.

The pilot then called FAA Ground Control for his takeoff clearance. The tower passed the clearance on to us. The tower radar monitored our takeoff, and then the pilot tuned in the proper course. Because we were flying VFR, we could get onto our course whenever we wanted. Had we been flying IFR, however, the ARTCC would have told us exactly when we should be flying the course. This procedure is understandable, of course: the ARTCC controller would have routed us around any other traffic in the area.

Our flight went along pretty smoothly, until we ran into some bad weather. We then called the Fort Worth ARTCC, and it picked us up on its radar. The remote communications site enabled us to talk directly with the controllers in the Fort Worth ARTCC.

Because we changed our flight plan from VFR to IFR, our pilot had to perform certain additional checks and keep the Fort Worth ARTCC informed of his position, heading, speed, etc. Electronic devices do much of this for today's pilot. Automatic lights on his instrument panel, for example, light up when he passes over a particular check point.

When our airplane got close enough to Dallas Love Field, the ARTCC controller told our pilot that we were being "handed off" to Dallas RAPCON. This simply meant that we were now being monitored and directed by radar at Love Field, rather than the Fort Worth ARTCC. This procedure is also understandable: the ARTCC controllers are concerned with airplanes flying on the airways between major points, rather than with airplanes which are flying close to major airports.

We were able to make a "straight in" landing. Suppose, though, that Love Field had had a great deal of air traffic before we got there. The RAPCON would have advised our pilot to go into a *Holding Pattern*. This set series of procedure turns would enable the traffic around the airport to land or take off and keep us out of their way! We would have been monitored by a *Holding Facility*, simply another radar system, until we were "handed off" to Radar Approach Control.

When we were cleared to land, the tower's radar room would follow us all the way in. The controller there would tell us whether we were above, below, or on the glide path by following our airplane on his radar scope face.

All of these techniques help make today's flying extremely safe. The electronic facilities are usually duplicated at most ATC facilities: in case one system fails, another system can be activated. The FAA maintains some 63 aircraft which fly more than 50,000 miles annually, simply to check the efficiency and accuracy of air traffic control operations, procedures, and facilities. The more than 18,000 air traffic control specialists have a minimum of two years' training in weather, navigational aids, FAA regulations, flight assistance, and radio communications. A period of apprenticeship precedes their advanced training. This advanced training is followed by "on-the-job" training (OJT). In addition, continuous advanced training in the latest techniques and equipment insures that today's air traffic control specialist keeps up with his field.

THE FUTURE

What does the future hold for the air traffic controller? What are the present and projected developments of the science of air traffic control? To answer these and similar questions, we must build on the material already covered in this booklet. The preceding chapters have examined, to a degree, the future of aircraft, airlines, and airports. The future of air traffic control naturally depends upon advances in these other areas.

A modern scientist will tell you that air traffic control is only one part of a total *system*—and the *Air Force Aerospace Glossary* defines a system as "any organized arrangement in which each component part acts, reacts, or interacts in accordance with an overall design that inheres in the arrangement." This lengthy definition can be boiled down to this: In a large and complex operation, such as today's aircraft-airport-passenger operation, all the parts work together and react with one another. This booklet will conclude with an assessment of the air transportation system, element by element, in order to give you some perspective on developments to come.

Aircraft

The airlines have planned for the enormous increase in airline traffic in the 1970's by their multi-billion dollar investment in new flight equipment. Conservative estimates see a three-fold increase in airline traffic by 1975, as compared with today's traffic, and some experts anticipate a quadrupling of the level of traffic by 1980. The airlines currently have more than $7 billion invested in aircraft, and they have on order some 1,055 additional aircraft for delivery through the 1970's. This figure includes almost 100 supersonic transport SST aircraft, each of which is valued at an average of $30 million or so. These figures all add up to more people, more aircraft, and more air traffic.

Another aspect of aircraft is air freight traffic, which will greatly increase when the newest large cargo aircraft come into general service.

Airports

The total number of airports served by commercial air carriers has remained about the same for the past five years. The lead time for constructing a major airport complex is some 7 to 10 years. At present there are only a handful of new major airports under construction or in the planning stage: Kansas City, Dallas/Fort Worth, Houston, Jacksonville, Miami, and Las Vegas. Because the number of new airports being constructed falls short of anticipated requirements, existing airports must be expanded and improved to handle the air traffic of the 1970's.

The scheduled airlines have already embarked upon an improvement program for their facilities. In 1967, for example, some $120 million was spent in expanding their facilities. Through 1971, the airlines expect to spend another $1.6 billion in new terminal facilities: hold rooms, baggage retrieval systems, and other services.

Passengers

This is probably the most difficult area for predictions. The FAA sees a three-fold increase in passenger traffic by 1977. Major factors behind this increase, according to the FAA, center on a favorable economic climate, including a high gross national product, high disposable income, virtually full employment, and a declining overall average fare structure. This simply means that more people will have more money to spend on more leisure time activities and will have to pay less for them. In addition, increasingly faster aircraft with larger volume capacity should increase the number of passengers.

Air Traffic Control

Air traffic control, as you have no doubt gathered, must follow developments in these areas. More money leads to more passengers, which leads to more aircraft, which leads to more air traffic—which requires more money! It is difficult to track down exact figures, but the acting administrator of the FAA recently stated that "we need to invest $4 to $5 billion over the next five years for new and improved airports in this country; and perhaps $2 billion to further update the airways system. . . . Also included [in this estimate] is further automation to the en route and terminal traffic control systems, and the hiring and training of additional air traffic controllers."

Congress, too, is involved. The Chairman of the Subcommittee on Transportation of the Senate Appropriations Committee has stated: ". . . we must either increase and improve our control capability or restrict and heavily regulate all types of flights. The cold, hard fact is that, unless we provide more money for more air traffic control personnel, equipment and research now, beginning in 1970 and for at least two to four years thereafter, the flights of both the airlines and general aviation will have to be heavily restricted and regulated."

The FAA, almost needless to say, is very much concerned about the current air traffic congestion. The FAA has stated that " . . . the best solution [to ATC problems] is not restrictions, but *more ground space* and *more efficient* use of the *air space*." The ground space problem can be solved by more airports, including both specific jetports and "congestion reliever" airports, and also by improvements to existing airports. The issue of "more efficient use of the air space," however, is not as easily summed up.

Delays in the operation of scheduled flights are a source of growing concern to the average air traveler. It is perhaps interesting to note that on the basis of a national average, the average delay is only about 90 seconds. Of course, this "average delay" includes the great majority of flights, which depart or arrive on time, and the flights which are late in either departing or arriving, sometimes by as much as one or two hours.

Bad weather is a significant factor in causing delays in scheduled takeoffs and landings. Bad weather means that air traffic controllers must direct aircraft around the storm centers. This extra work naturally tends to slow down the flow of air traffic along the airways. Bad weather can also tend to disrupt the normally smooth operation of radar and the other electrical equipment used in controlling air traffic. When this happens, controllers have procedures to follow which insure safety on the airways but which also are slower than the procedures they can use when they have all their equipment in order.

All-weather landing systems will change the nature of air traffic control around our major hubs (large airports). Today, when one of our major airports is "socked in" (closed because of low visibility), air traffic scheduling becomes extremely difficult, and air traffic control becomes a real art. As aircraft increase in size and speed, the problem of bad-weather landings and take-offs will also increase greatly. Today, several commercial airlines have been cleared by the FAA for semi-automatic landings: the airplanes are guided to within an altitude of 100 feet over the runway, and then the pilot completes the landing of the craft, if he can see the runway visual aids. If he cannot see the lights and markings, he climbs away, full throttle, and then he either tries again or goes on to an alternate airport.

Another system which the FAA is currently studying involves the projection of microwave radio signals to the aircraft from checkpoints on the ground. These signals form an image of the runway on a display panel for the pilot to "see" the runway.

The real advance is in computer-controlled landings. In this sort of operation, a computer activates the control surfaces and throttle of the aircraft all the way to the ground. These landings are still very much in the experimental stage; however, one day you may fasten your seat belt and hear a voice say: "Good afternoon. This is your computer speaking . . . ."

Other future developments center on radar and improved navigational devices. Today's radar scope looks a great deal different from yesterday's. Improvements in radar are permitting what are called radar bright displays, mentioned earlier in our "flight" from Oklahoma City to Dallas. These displays on a radar scope face are bright enough to be seen easily in relatively bright light. A new system currently being tested in key air traffic control centers is called an alpha-numeric radar display system. This rather forbidding-looking term simply describes a new way to indicate on the radar scope face vital information about the aircraft which appear as "blips." "Alpha-numeric" means consisting of letters and numbers, and this display system is connected to a computer. The computer-radar scope combination tracks the aircraft and then prints out automatically on the scope face all the essential information the air traffic controller needs to know about the aircraft. Tomorrow's radar scope face might even be in full color. Experimental radar displays have shown arrivals in one color, departures in another, and "over traffic" (non-landing or -departing air traffic) in a third color.

We also mentioned ATC's radar beacon interrogator system earlier. This system is currently being improved, as well. The system is being expanded to use more than 4,000 individual codes, which will greatly improve the efficiency of air traffic control by displaying both the altitude and identity of each aircraft equipped with this system next to its target on the controller's scope.

Another device which should be of help to aircraft pilots is called a collision avoidance system (CAS). A device that will alert the pilot to a potential collision and tell him what avoidance maneuver to make, and when to make it, has long been sought by the airlines. When, in 1965, such a device finally appeared to be technologically practical, the airlines mounted a major effort to turn this promise into hardware that could be used on airline aircraft. During 1967, an airline group working with manufacturers came up with a technical description of a CAS that would meet airline requirements. This group then developed a plan for testing and proving out equipment built to this system description. The airlines are currently in the process of arranging for tests of this device. One prototype involves a beeping sound that the pilot hears in his earphones, signalling him to glance at his instrument panel, where the device indicates the direction the pilot should fly to avoid collision. Cost of the equipment is not yet known, but estimates put it around $60,000 per aircraft.

Warm fog dispersal tests are also of interest here. Fog accounts for the majority of the flight cancellations and diversions caused by bad weather. Cold fog (water droplets below 32° F) accounts for only a small percentage of bad weather fog conditions, but it is easiest to disperse. A cold fog dispersal program started by one airline recently grew in only five years to include 21 airports and 10 airlines. Warm fog, which accounts for 95% of all fog, has eluded attempts to find a practical and economical dispersal technique until very recently, when the airlines began a test of new chemicals for dispersing warm fog at Sacramento, California. Midway through the tests, the airlines reported they were "cautiously optimistic" about the results of their $100,000 test program. When such a system is fully tested and installed, it should substantially increase the number of bad-weather take-offs and landings.

Voice TACAN is another possibility for the future. Using present TACAN radio links, the pilot of the future may have another ground-to-air communications network. Radar altimeters of the future may be able to recognize changes as small as three inches up to a height of 80 feet.

The future of air traffic control is as wide as the mind of man. From its humble beginnings in the early 1920's, it has developed into a highly sophisticated art, performed by well-trained specialists and advanced by ever-changing technology. Changes in navigational equipment are almost inextricably bound up with changes in air traffic control equipment. Similarly, other factors, including size and quantity of airplanes and volume of passenger and freight traffic, also figure into the total air traffic control picture. The future holds in store for us more airplanes in the air, more people flying in these planes, and more airplanes flying faster and faster. Airports will be designed to accommodate these new airplanes, and air traffic control will have to keep pace with all these changes. The airplane passenger will probably not know much about the ways in which these behind-the-scenes changes are affecting his flight, but we hope that you now will know something more about this complex business of civil aviation and facilities.

REVIEW QUESTIONS

1. Trace the development of air traffic control. How has the Federal Government helped develop today's sophisticated air traffic control system?

2. Discuss the functions of flight service stations, air route traffic control centers, and approach control. How does each of these air traffic control functions help today's pilot?

3. How does radar help the air traffic controller?

4. What devices will aid the air traffic controller of the future? How will these devices also aid the pilot?

THINGS TO DO

1. You might arrange a visit to your local airport and get permission to observe the air traffic controllers at work. If this is not possible, you might investigate the possibility of inviting an air traffic controller to speak to the class on the duties, responsibilities, and problems of his job.

2. From the relatively brief account given in the text, combined with information gathered from additional reading, work up a script for a simulated ATC handling of takeoffs and landings at a busy airport. Assign various roles to members of the class and present the simulated exercise to the class.

3. An excellent portrayal of the problems involved in running a modern large airport can be found in the novel *Airport* by Arthur Hailey. Mr. Hailey says of this book that "before beginning any new novel, I spend at least a year investigating the background. It worked that way with *Airport.* I traveled from airport to airport, talking . . . with airport and airline officials, pilots, stewardesses, maintenance men, air traffic controllers." You might read this novel with a "factual background" and give a book review of it to the class.

SUGGESTIONS FOR FURTHER READING

BURKHARDT, ROBERT. *The Federal Aviation Administration.* New York: Praeger, 1967.

Federal Aviation Agency. *Eighth Annual Report* . . . . Washington, D.C.: U.S. Government Printing Office, 1967.

GILBERT, GLEN A. *Air Traffic Control.* Chicago: Ziff-Davis Publishing Company, 1945.

SMITH, ROBERT T. *Guide to Air Traffic Control.* New York: Sports Car Press, 1963.

Other sources: As in previous chapters, current periodicals will have the latest developments in the growing art of air traffic control.

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