its large propellers, and though not a V/STOL, the fighter did signal the resurgence of the idea of the wing-deflected slipstream and its application to V/STOL.

To hover, a vertical flow of air must be established to provide the sustaining force on the aircraft. To hover efficiently—that is, without the expenditure of much energy—the diameter of the vertical airstream must be as large as practicable and its velocity very low. This the helicopter provides admirably with its large diameter rotor. Attempts to produce a sustaining force equal to that of a helicopter, but using a device that accelerates a smaller diameter airstream faster, use more energy than the helicopter uses.

It follows that unless space limitations are critical, the helicopter is the way to go. If rotor diameter is limited (the slipstream small and fast) a ring-shaped shroud can be put around the rotor and will help some (this is the "shrouded propeller" of the flying jeep). The ring can even be configured to look like a "saucer" but there is no aerodynamic advantage in doing so, though some needed stiffness of the shroud may be gained.

There are classes of V/STOL aircraft concepts which use shrouded propellers because of diameter limitations, but they do not resemble saucers because of the inefficiency of the round wing in forward flight.

As matters stand, none of the exotic aircraft in this group has found a commercial application. Although there is always room to say "but they might in the future" and always danger in saying "they never will," there is no present reason for thinking that the compromises and inefficiencies that have characterized them in the past will be overcome to an extent that will give them a place, relative to the successful types of aircraft, more important than they now occupy.

AIR SUPPORT FACILITIES

Introduction

The interface between ground and air is a landing facility which links the air and the surface transportation systems. This facility is commonly identified as an "airport" since most of the landing facilities fall into the category of serving primarily land airplanes as opposed to seaplanes, helicopters, airships, or balloons.

More than 50 years ago it was recommended that "flight stops" be placed along the highway. Such stops would be nothing more than a landing and take-off strip adjacent to a gasoline service station. This would combine motor car and airplane service to assure maximum and dependable service. Flight stops were to be a part of the national highway system.[13] A recommendation was made that

> No arterial motor highway should be built in the future without including adjacent flight stops every 30 to 50 miles for the personal flyer. Flight stops will mean a landing area for practically every town and hamlet located on such superhighways, thus providing those small communities with an additional means of transportation.[14]

This scheme, started in the late 1920's by the Richfield Oil Corporation, failed largely due to the fact that personal aircraft were still too expensive in both initial and maintenance costs. The depression of the 1930's also played its part in preventing the commercial success of the venture.

This section will discuss various types of landing facilities with particular emphasis on general aviation airports. The discussion will include airport classification, airport design and layout, airport administration and operation, and general aviation support facilities on the airport.

Airport Classification

Classification by Aircraft Type

The ground-air interface in the United States consists of a national network of landing facilities which can be categorized by the types of vehicles served as follows:[15]

Airports serving land airplanes	11,160
Seaplane bases serving seaplanes	472
Heliports	1,430
Total	13,067

Airports are designed around one or more landing areas called runways which may range from 50 feet wide and 1,500 feet long to 500 feet wide and 14,572 feet long.[16] Seaplane bases are primarily docking facilities adjacent to natural lakes, rivers, and ocean or bay areas which support seaplanes (land airplanes with pontoons) and flying boats (airplanes designed

[13] Froesch Charles and Prokosch Walter *Airport Planning*, 1st ed., (John Wiley and Sons 1946), p 165

[14] *Ibid*, p 74

[15] Federal Aviation Administration, January 1, 1975, Statistics released in news release 75-83, May 27, 1975

[16] John F Kennedy International Airport, New York

to land on the fuselage on water surfaces). Heliports are designated facilities for rotary-wing aircraft (helicopters) and many separate facilities are located adjacent to an airport. An area (such as those on top of buildings in metropolitan areas) designed to accommodate one, or a few vehicles, is identified as a helipad. A helistop is similar to a bus stop, allowing a helicopter to pick up and discharge passengers along pre-arranged routes, but without other support facilities.

Airport Ownership

Airports in the United States are also classified in terms of ownership as public or private—a classification scheme which determines eligibility for federal aid for development. Public airports are those whose ownership is by a public body such as a city, county, or state. Private airports are owned by individuals or companies and are ineligible for federal funds and, in most cases, state or local aid.

All public airports which have received federal aid are open to public (government), commercial, and private aircraft, within the operational limitations of both the aircraft and the airport. Access to private airports is determined by the owners and generally falls into one of three categories: (1) unrestricted (open to all aircraft), (2) restricted to airport owners and those with prior permission, and (3) restricted to airport owners.

A breakdown of airports in the United States by ownership is as follows:

Public	4,575
Private	8,487
	(5,599 closed to public)[17]

National Airport System

The Federal Aviation Administration (FAA) has developed a breakdown of the 3,040 airports in the National Airport System Plan (NASP) shown in Table I-IV.[18] This classification recognizes that all civil airports in the United States serve general aviation to some degree and measures any airport's functional role by two operational criteria: (1) number of enplaned passengers by certificated air carriers, and (2) number of annual operations.[19] As indicated in Table I-IV the number of passengers determine whether the airport falls into the primary, secondary, or feeder classification; and, the number of annual operations determines the density grouping within these three classifications.

Communities, as distinguished from airports, are also classified in the National Airport System. The cities, or Standard Metropolitan Statistical Areas(SMSAs), fall into one of four types determined by the area's share of the national total number of passengers enplaned on domestic certificated carriers. The four types are as follows:

Hub Type	Percent of Total Enplaned Passengers
Large Hub	1% or more
Medium Hub	.25 to .99%
Small Hub	.05 to .24%
Non-hub	Less than .05%[20]

There are approximately 150 communities in the United States classified as hub, based upon the .05 percent or more of the annual 202 million total passengers or 101,000 enplanements.[21] Richmond, as an example, with 503,000 passengers and 190,000 operations annually, would be classified as a small hub community, and the airport, Byrd Field, would be classified as a secondary, medium density class airport in the National Airport System.[22] Airports with only general aviation activity usually fall into the Non-hub category, even if a large number of passengers are transported in general aviation aircraft.

Airport Operational Role

Airport system planners use another classification system based primarily on the maximum size of the aircraft served by the airport. This scheme divides airports into four categories:[23]

(1) **BASIC UTILITY (BU):** (Previous distinctions between Stages 1 and 2 have been eliminated.) This type of development theoretically accommodates about 95 percent of the general aviation propeller fleet under 12,500 pounds (maxium gross weight). There is no special activity criterion required for this type of airport.

(2) **GENERAL UTILITY (GU):** This type of airport accommodates substantially all general aviation propeller aircraft under 12,500 pounds. At least 500 annual itinerant operations of aircraft between 8,000 - 12,000 pounds are required.

(3) **BASIC TRANSPORT (BT):** These airports accommodate all general aviation aircraft

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[17] *op cit*, FAA, January 1, 1975

[18] *Ibid*

[19] An operation is defined by the FAA as a takeoff or a landing

[20] *1972 National Airport System Plan*, Volume AEA Eastern Region, Federal Aviation Administration 1972

[21] Air Transport Association of America, *Air Transport 1974*, Washington D C 1974, p 3

[22] *op cit*, 1972, National Airport System Plan updated by Computer Printout to February 1975

[23] Sources BU and GU from FAA AC 150-5300-4A, 11-68, BT and GT from FAA AC 150-5300-6, 7-69

TABLE I-IV

NATIONAL AIRPORT CLASSIFICATION SYSTEM

Airport Category	Annual Passenger Enplanements	Annual Operations
Primary System	More than 1,000,000	
High Density		More than 350,000
Medium Density		250,000 to 350,000
Low Density		Less than 250,000
Secondary System	50,000 to 1,000,000	
High Density		More than 250,000
Medium Density		100,000 to 250,000
Low Density		Less than 100,000
Feeder System	Less than 50,000	
High Density		More than 100,000
Medium Density		20,000 to 100,000
Low Density		Less than 20,000

Note:

Airports classified as above are those within FAA's "National System of Airports." The United States airport network also includes those classified as "local interest airports" and "military airports." The latter two groups are those public, private, and military facilities not deemed necessary by FAA for the country's "National System of Airports."

Source: FAA AC 150-5090-2, June 25, 1971.

up to 60,000 pounds MGW including propeller transports and business or executive jets. A BT airport must indicate at least 500 (existing or forecast) annual itinerant operations by aircraft between 12,500 and 60,000 pounds MGW.

(4) **GENERAL TRANSPORT (GT):** These airports generally accommodate transport category aircraft up to 175,000 pounds MGW The minimum requirement for this type of airport is at least 10 existing or forecast itinerant DEPARTURES per week (or 1,040 itinerant operations per year or season) by either the critical type aircraft or ONE of the appropriate families of aircraft. This classification level is sometimes referred to as Scheduled Transports (ST) or Air Carrier (AC).

The system described above relates runway length and bearing capacity to aircraft size in terms of maximum takeoff weight and annual operations. Some planners may develop finer breakdowns based upon reduced loads, e.g., BT 100/60, a basic transport runway which accommodates 100 percent of the transport fleet at 60 percent of maximum load. This classification system excludes or mandates the upgrading of general aviation airports below the BU level, i.e., those unable to accommodate 95 percent of general aviation propeller aircraft.

Airport Functions

Identification of an airport on the basis of a major or specialized function that it performs is often convenient. The most common such designations are as follows:

(1) Air carrier
(2) Joint use
(3) General aviation
(4) Local interest
(5) Reliever
(6) Industrial
(7) Recreational

Air carrier airports are those with certificated scheduled air carrier service. Joint use airports are jointly used and/or owned by military and civil users. The general aviation airports are those which serve general aviation exclusively, i.e., the airports without either certificated air carrier service or military operations.

Local interest airports usually are those which are not part of the federal or state system of airports. These can be either privately or publicly owned fields with limited capacity for operations and future development. Limitations may be due to nearby obstructions, unfavorable

terrain, remote access, or other factors such as population trends which would restrict either the size or number of aircraft using the facility.

The reliever airport is one designated by FAA to serve as a reliever for an air carrier airport in a metropolitan area. In effect, reliever airports are intended to reduce traffic and congestion at the air carrier airport by diverting general aviation activity.

The industrial airport is an airport designed around an industrial park enabling companies with their own airplanes, and/or doing business with companies or clients with aircraft to have convenient air access. This concept is valid from a land use standpoint in that much of the land required around an airport to protect clear zones and approaches can be utilized by industry which is less bothered by noise than residential users.

The recreational airport is one serving a resort or other recreational area by providing a convenient air access facility allowing pilots who fly in to park and walk or be transported to the recreational facilities. Some resort owners view aircraft owners as a legitimate higher income market best served with an airport designed and located as an integral part of the resort facility.

Airport Design and Layout

Airport Design

There are at least 10 factors which should be considered in analyzing new sites and in planning and designing new airports. They are:

(1) Convenience to users
(2) Availability to land and land costs
(3) Design and layout of the airport
(4) Airspace obstructions
(5) Engineering factors
(6) Social Factors
(7) Availability of utilities
(8) Atmospheric conditions
(9) Hazards due to birds
(10) Coordination with other airports. [24]

High priority should be given to the first factor, covenience to users. If the airport is not convenient to those who wish to use it, the project is unlikely to be successful.

Runways

Although most general aviation airports do not have two runways, or runways over 5,000 feet in length, layout of a general aviation airport recommended by the FAA is shown in Figure 1-6. [25] The layout is a plan of an airport with a summary of the basic data required for planning and development.

Included in the plan is a Basic Data Table which provides airport information such as its elevation in feet above sea level, its geographic coordinates (a point near the center of the airport is used as a geographic reference point), its navigational aids, and its mean temperature of the hottest month.

Basic runway data include the slope of the runway (effective runway gradient), the wind coverage, the navigation and lighting aids serving the runway, and the runway load bearing capacity for various aircraft.

The airport is designed around one or more runways. The single runway's design is very common for general aviation since it requires a minimum amount of land. Each airport layout is planned around the direction and velocity of the prevailing winds for the geographic area. The wind rose in Figure 1-6, developed from official weather data shows the percent of coverage of each runway under crosswind conditions. Such a table would indicate the requirement for an additional runway if one runway cannot provide 95 percent coverage under velocities of 15 mph. Most general aviation aircraft can be operated with up to a 15 knot (18 mph) crosswind component (a wind equivalent to 18 mph at 90° to the runway.) [26]

When a second crosswind runway is utilized, it can be arranged with the first runway as a crossing runway as in Figure 1-6, or as a separate or connecting runway with the arrangement determined by such factors as number of runways, surface (hard surface or grass), length, land available, obstructions, and extent and location of facilities.

The use of parallel or non-intersecting angled runways serves to alleviate traffic for airports with high density of operations or to separate traffic or incompatible mix such as air carrier and general aviation or conventional general aviation and STOL or VTOL. [27]

The runway surfaces may be hard surface, blacktop (bituminous), concrete, or grass/turf. While most general aviation aircraft can be

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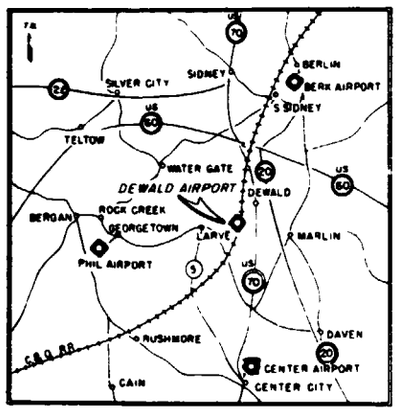
[24] Paquette Radnor Ashford Norman and Wright Paul *Transportation Engineering Planning and Design*, (New York The Ronald Press Co), 1972 p 732

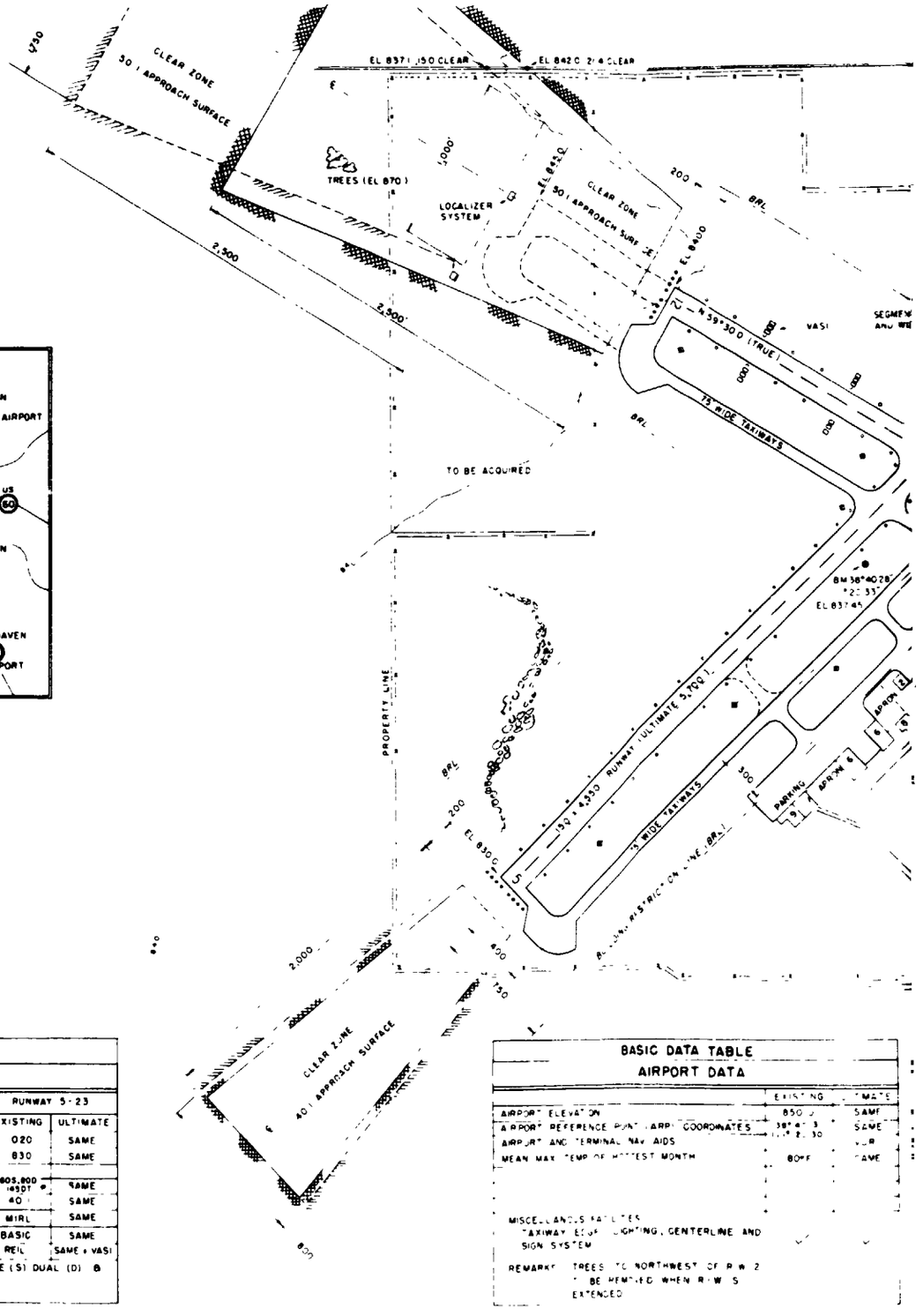
[25] Abstracted from *Airport Master Plans* AC 150 5070-6, Federal Aviation Administration February, 1971 p 41

[26] *Utility Airports* AC 150 5300-4A, Federal Aviation Administration, November, 1968 pp 89-93

[27] STOL - Short Takeoff and Landing VTOL - Vertical Takeoff and Landing



LOCATION MAP

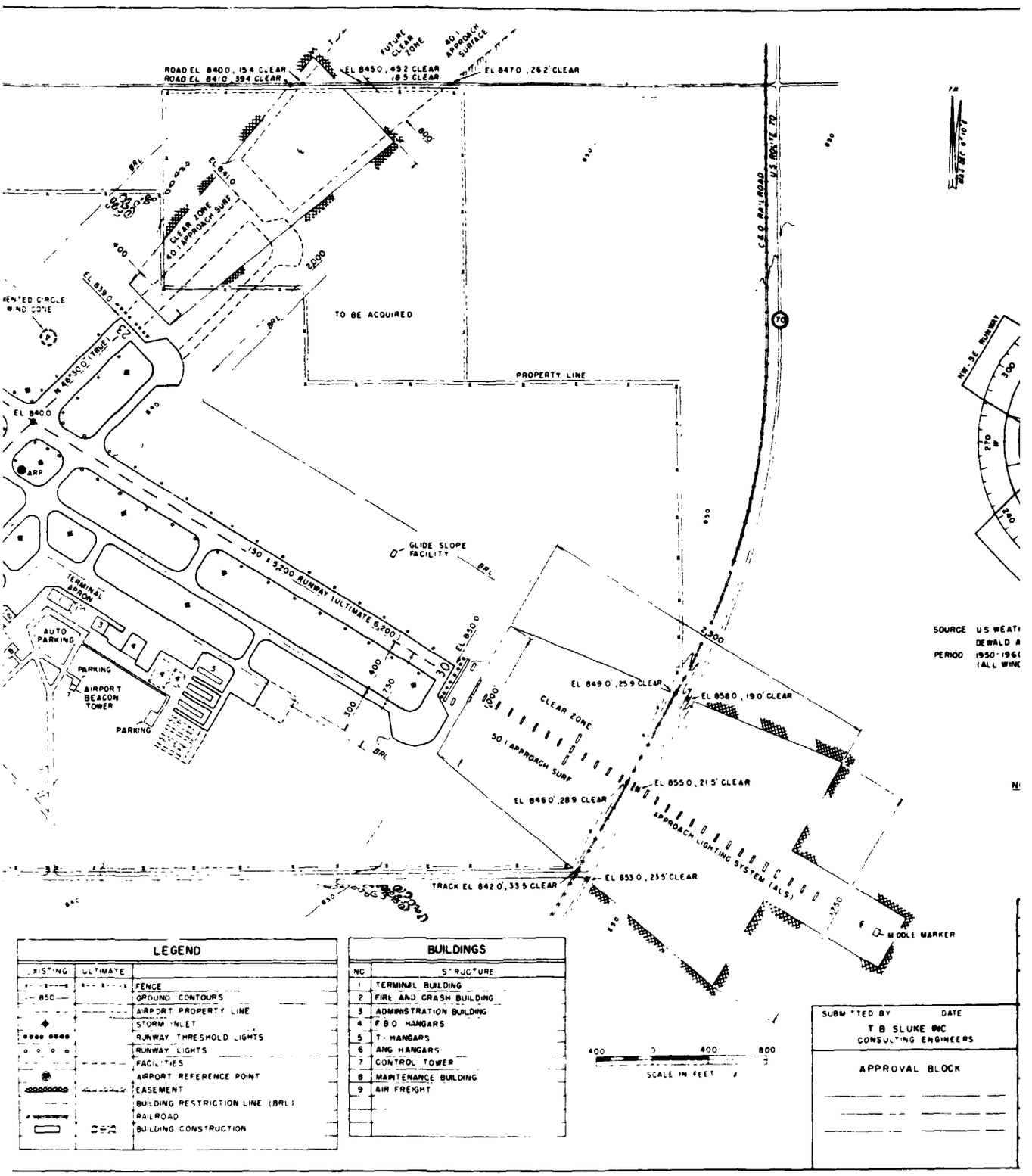


BASIC DATA TABLE RUNWAY DATA				
	RUNWAY 12-30		RUNWAY 5-23	
	EXISTING	ULTIMATE	EXISTING	ULTIMATE
EFFECTIVE RUNWAY GRADIENT (IN %)	0.19	SAME	0.20	SAME
% WIND COVERAGE	91.6	SAME	83.0	SAME
INSTRUMENT RUNWAY	✓	✓		
PAVEMENT STRENGTH	60,800 lbs DT * 45,000 lbs S	SAME	60,800 lbs DT * 45,000 lbs S	SAME
APPROACH SLOPES & CLEAR ZONES	50:1	SAME	40:1	SAME
LIGHTING	MIRL	SAME	MIRL	SAME
MARKING	ALL WEATHER	SAME	BASIC	SAME
NAVIGATIONAL AIDS	ILS, ALS, VASI	SAME	REIL	SAME + VASI

*VALUES GIVEN ARE GROSS AIRCRAFT WEIGHT IN 1,000# FOR SINGLE (S) DUAL (D) & DUAL TANDEM (DT) GEAR AIRCRAFT

BASIC DATA TABLE AIRPORT DATA		
	EXISTING	ULTIMATE
AIRPORT ELEVATION	850.0	SAME
AIRPORT REFERENCE POINT (ARP) COORDINATES	38°40'3 [illegible] 2.30	SAME
AIRPORT AND TERMINAL NAV AIDS		VOR
MEAN MAX TEMP OF HOTTEST MONTH	80°F	SAME
MISCELLANEOUS FACILITIES	TAXIWAY EDGE LIGHTING, CENTERLINE AND SIGN SYSTEM	
REMARKS	TREES TO NORTHWEST OF R/W 23 TO BE REMOVED WHEN R/W 5 EXTENDED	

AIRPORT LAYOUT PLAN
FIGURE 1-6



LEGEND

EXISTING	ULTIMATE	
		FENCE
850		GROUND CONTOURS
		AIRPORT PROPERTY LINE
		STORM INLET
		RUNWAY THRESHOLD LIGHTS
		RUNWAY LIGHTS
		FACILITIES
		APPORT REFERENCE POINT
		EASEMENT
		BUILDING RESTRICTION LINE (BRL)
		RAILROAD
		BUILDING CONSTRUCTION

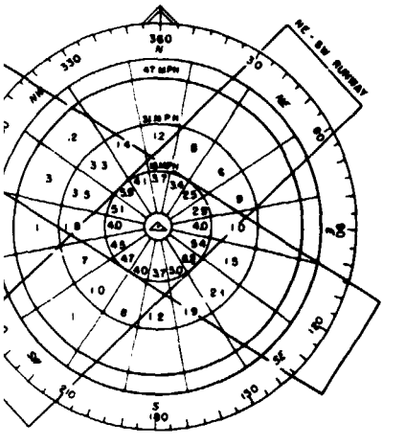
BUILDINGS

NO	STRUCTURE
1	TERMINAL BUILDING
2	FIRE AND CRASH BUILDING
3	ADMINISTRATION BUILDING
4	F B O HANGARS
5	T - HANGARS
6	ANG HANGARS
7	CONTROL TOWER
8	MAINTENANCE BUILDING
9	AIR FREIGHT

SUBMITTED BY DATE
T B SLUKE INC
CONSULTING ENGINEERS

APPROVAL BLOCK

FOLDOUT FRAME 2



...HER BUREAU STATION	15 MPH CROSSWIND COVERAGE R/W 18/30	• 91.4 %
AIRPORT	15 MPH CROSSWIND COVERAGE R/W 5/23	• 83.0 %
50	15 MPH CROSSWIND COVERAGE ALL RUNWAYS	• 96.6 %
NDS VFR & IFR)	△ • 6.3 % CALMS, 0-3 MPH	
	% OF VFR WEATHER • 90.0	
	% OF IFR WEATHER • 10.0	

WIND ROSE

NOTE
THESE PLANS SHOULD NOT BE USED AS STANDARDS FOR PLANNING OR DESIGN

NO	REVISIONS	BY	APP	DATE

DEWALD CITY AIRPORT COMMISSION

DEWALD AIRPORT
ANYWHERE, U S A

AIRPORT LAYOUT PLAN

T B SLUKE INC
CONSULTING ENGINEERS

DESIGNED BY _____ DATE ____	TRACED BY _____ DATE ____
DRAWN BY _____ DATE ____	CHECKED BY _____ DATE ____
DRAWING NO 23754-A	SCALE AS SHOWN SHEET 1 OF 1

FOLDOUT FRAME 3

operated from grass surfaces, hard surfaces are desirable due to reduced friction, smoother ride, and lower probability of aircraft damage by stones and foreign objects.

Taxiways

Supporting the runway system are access routes called taxiways which connect the runways with the ramp and parking areas. Taxiways separate ground traffic from the active runway, thereby increasing the capacity of the airport. Taxiways may be limited to one primary runway or may encompass all runways with connectors or turnoffs to facilitate exit and entrance at various points.

Airport Airspace

Airspace around the airport is protected from obstructions by the legal designation of clear zones or corridors. The lower boundary of the clear zone is sloped upwards and away from the end of the runway on a required slope criterion which is determined by runway use and the operational role of an airport. The slope varies from 20 to 1 for a basic utility (BU) airport to a 50 to 1 slope for a runway with a precision instrument approach system at a general transport (GT) airport. [28]

The airspace to the side of the runway is also legally protected by buffer zones from any buildings or structures (see Building Restriction Line in Figure 1-6), and terrain or other obstructions through side clear zones with generally a 7 to 1 slope.

Airport Facilities

Connecting the taxiways with the aircraft storage and parking facilities are connectors and aprons which may also serve as temporary parking for aircraft. Long-term parking is accommodated by tie-down areas for aircraft stored outside.

Ground access to the airport is through one or more roads which connect with perimeter roads and driveways leading to administration buildings, facilities, hangars, and aircraft parking areas.

Other facilities on the airport fall into four broad categories:

(1) **Administrative and support facilities** are those utilized by the airport owners or authorities for offices and the storage and maintenance of vehicles and ground support equipment. Depending upon the airport, the facility may range from a small, steel-type structure combining office and storage space to a larger office building and separate storage/maintenance structures. Airports with fire and crash equipment will locate such facilities centrally so as to be close to the runways and taxiways as in Figure 1-6.

(2) Approximately 25 to 33 percent of the resident aircraft owners desire **inside storage** to protect aircraft from the elements and provide security. Storage is accomplished either by a single unit type hangar containing 5 to 20 aircraft, or individual stalls commonly called "T hangars." The latter are usually connected in a series and located in rows adjacent to taxiways as shown in Figure 1-6.

(3) **Air traffic control tower facilities** are likely to be found on top of the administration or terminal building in the case of older facilities. In new facilities these are contained in a separate high-rise structure, located to provide an unobstructed view of all aircraft operating areas on the airport. Some **navigational aids** are contained in a small frame building adjacent to the runways that they serve. Airports with an instrument landing system require approach lights near the end of the runway, and off airport aids such as lights and radio beacons called markers.

Figure 1-6 shows navigational aids serving runway 30/12 which consist of the following:

1. VASI. A **v**isual **a**pproach **s**lope **i**ndicator to provide optical/visual descent guidance to Runway 12
2. LOC. A **loc**alizer system to provide directional guidance for Runways 30 and 10.
3. Glide slope for electronic vertical descent guidance to Runway 30.
4. Approach lighting system for visual reference transition on Runway 30.
5. Markers to identify position on the Runway 30 approach. An outer marker, not shown in Figure 1-6, is located 5-7 miles from the airport on the center-line of Runway 30. [29]

(4) General aviation services are provided utilizing a variety of terminal and operational facilities which support the particular operation. The terminal building is a facility designed to service air carrier passengers and is not normally found on a general aviation airport unless left over from earlier use of the facility for air carrier operations.

Most operations are conducted in facilities erected or leased by the general aviation fixed

[28] *Utility Airports, op cit*, p 20

[29] *Airman's Information Manual Part 1*, Federal Aviation Administration, Washington, D C , May 1975, pp 10, 18, 19

base operators commonly called FBOs. FBO facilities range from a small hangar/office/lounge combination facility to an extensive layout with several hangars, maintenance shops, and a large office/lounge classroom building. In addition to the FBO facilities there may be several specialized facilities which provide specific general aviation services, operating out of hangars, hangar/office facilities or even mobile structures.

Administration and Operation

Amininistrative Organization

To a certain extent administrative procedures of a general aviation airport are a function of ownership. Most of the privately owned fields in the United States are landing strips on the owner's land which accommodate only a few private aircraft. Privately owned airports are administered as the owners choose.

Public airports are administered by the public body (commission or authority) which represents the units owning the facility. There are several types of administrative structures with the particular type primarily dependent on the size and activity of the airport. For example, airports may be administered by the mayor of the city as just another unit within his jurisdiction. This method is appropriate for small, low activity airports where the administrative demand does not require the expertise and/or time of a full-time airport manager. Another frequently used method is to lease the entire airport to a general aviation base operator with responsibility for airport maintenance and operations assumed by the operator. Other airports may have a full-time or part-time airport manager designated with one or more additional staff.

Administrative Functions

In considering the actual administration of an airport one must distinguish between the airport and general aviation operations on the airport. The airport owner is responsible for the design, construction, and maintenance of the physical facilities used by the public and by tenants of the airport. Operations on the airport relate to the operation of aircraft and general aviation services provided for such operation. Flight operation on the airport is the responsibility of the owners or operators of the particular aircraft. Services are the responsibility of those providing them. In some cases, the airport owner provides one or more services such as aircraft fueling, aircraft storage, and parking.

The major administrative responsibilities of the general aviation airport manager are planning, development, maintenance, and operations. An airport master plan presents the planner's conception of the ultimate development of a specific airport. Master plans are applied to the modernization and expansion of existing airports and to the construction of new airports, regardless of their size or functional role. Master plans disclose anticipated amounts and types of air and ground traffic for proposed or existing landing facilities. Theoretically a master plan program will (1) cause the persons responsible for organizing the local endeavor to come to agreement as to just what should be planned and built and, (2) become an instrument which permits those charged with the actual planning and construction of the building to proceed with their work in a progressive and orderly fashion.

The FAA emphasizes and encourages long range planning for airports and administers the Planning Grant Program (PGP) which provides funds for up to 66 percent of the cost of developing a 20-year master plan for a public airport. A plan is developed using the combined efforts of a consultant, the FAA, and the sponsor (the airport authority or commission).

The master plan as prescribed by the FAA is usually divided into four phases:

(1) Airport Requirements

This includes an inventory of existing facilities, airspace, airports, land use laws and ordinances, financial resources, and socio-economic factors.

The demand for aviation services for 5,10, and 20 year time-frames is forecast.

A demand/capacity analysis is made to include cost versus benefits, and facility requirements are developed from this analysis.

(2) Site Selection

For new airports or the relocation of existing airports, a site selection or evaluation is conducted of all possible sites within a 30-minute drive of the community population center.

(3) Airport Plans

The airport layout (Figure 1-6), land use, terminal area, and airport access are shown as planning drawings.

(4) Financial Plan

The schedules, cost estimate, economic feasibility, and proposed plan for financing are considered for all proposed development.[30]

Airport development is the process of execution of the master plan. The FAA also participates in this phase through the Airport Development Aid Program (ADAP). The FAA will participate in most non-revenue producing development projects such as land acquisition, runways, taxiways, and aprons. The FAA share ranges from 50 to 100 percent depending upon the particular project. As the need for a project is identified, the airport authority prepares a project plan and applies to the FAA for approval and funding. Once granted, the airport authority proceeds with the project, which is usually contracted through competitive bids. As the community requirements for aviation services and facilities change so does the dynamic airport planning and development process. The FAA recommends updating of the master plan at one-year intervals if indicated by changes in aeronautical demand.

Maintenance and upkeep of the airport involves many functions common to industrial, highway, and agricultural facilities. The unique characteristic of an airport is the requirement for close surveillance and action on items which may affect safety in flight operations; approach paths, runways, and taxiways must be kept free of all obstructions and foreign objects which may be a hazard to approaching and landing aircraft or cause costly damage to propellers and/or engines. An object ingested by a jet engine from a ramp may result in thousands of dollars in damage.

Small tire size in relation to weight of aircraft dictates runway and taxiway bearing capacities in excess of comparable paved highway surfaces for many general aviation airports. The need is dictated for a smooth, well-maintained surface for all aircraft operating areas. Grass areas of the airport which are used by aircraft for runways, taxiways, and parking must be kept mowed to a low height in order to reduce friction and eliminate unseen hazards. Some airports have turned unused areas between and adjacent to runways into crops which provide limited revenue on unused land. A common practice is a contract with a local farmer to mow all the grass areas in exchange for use of certain areas for farming.

Maintenance of lights and navigational aids may be shared with FAA personnel for those facilities which are installed by the FAA and/or used as approach navigational aids. The maintenance of leased facilities is determined by the terms of the lease. Snow removal is a major effort for airports in the northern climates. Since salt cannot be used on runways and taxiways due to its corrosive effect on aluminum, surfaces must be kept free of snow to avoid accumulation and packing. Because snow and ice account for more closed airports in certain regions than fog, the airport must be equipped to deal with them.

The extent of an airport authority's involvement in operations varies from nil to full responsibility as both airport owner and operator. Most airports restrict their involvement in fuel roles on the premise that it is more practical to consolidate fuel sales through one agency than for each operator on the airport to attempt to negotiate a fuel contract on a lower volume potential.

Airports with certificated air carrier service must be certificated as airports under FAR Part 139.[31] This regulation spells out requirements for such airports in the area of safety and operations as related to air carriers. While not applicable to general aviation airports, certain provisions of this regulation may be adopted on a voluntary basis. An example would be the provision for fire/crash rescue capability on the airport.

General Aviation Operators

General Aviation Services on an airport are generally provided by one or more FBOs. The FBO operates under a lease agreement with the airport authority under which the airport provides facilities and/or land with the authority to provide services to general aviation users. These services may include any one or a combination of the following, listed in general order of importance and/or frequency:

(1) Aircraft storage and parking.

(2) Fuel sales to locally based and itinerant general aviation aircraft.

(3) Aircraft, engine, and accessory maintenance and repair.

(4) Flight and ground instruction

(5) Aircraft rental.

[30] *Airport Master Plan*, Federal Aviation Administration, AC 150/5070-6, United States Government Printing Office, February, 1971

[31] *Federal Aviation Regulations Part 139, Certification and Operations Land Airports Serving CAB Certificated Scheduled Carriers Operating Large Aircraft* Federal Aviation Administration, U S G P O , December 1974

(6) Air taxi, charter service.

(7) Aircraft sales—new and/or used.

(8) Aircraft parts and accessory sales.

(9) Other specialized services such as air ambulance, aerial photography, banner towing, aerial application (crop dusting).

The extent and quality of services provided is determined by the size and activity level of the airport, the type of users and aircraft, the number of operators, and the airport's compliance standards and lease terms.

Small airports with a low level of activity and few based aircraft (12 or less) might offer only aircraft storage and parking since this service requires no personnel on duty. Twelve to 25 based aircraft is generally considered a minimum number to support an FBO offering the first three services listed above. As the number of based aircraft and related aviation activity increases, additional services can be justified. As a general rule, only the medium to large activity airports offer the full range of general aviation services.

An important decision for the airport manager is one of determining if, and when, a second or additional general aviation operator is justified. The Federal Aviation Act of 1958 prohibits the granting of exclusive rights on a federally funded airport. As a result, the airport authority cannot arbitrarily limit the number of operators on an airport. The airport authority can establish reasonable compliance standards for any new operation.

The development of the compliance standards must be done in recognition of the nonexclusive rights provision of the Federal Aviation Act; of the need to maintain a level of quality and safety in new operations equal to or better than existing operations; and, the need to provide reasonable protection for the investment of an existing operator or operators. The latter can only be accomplished by the development of minimum levels of activity necessary to justify additional services or operations. When these levels have been passed, a new operation can be established on the airport provided that operation meets the compliance standards.

The compliance standards identify the minimum standards for facilities and services to be provided and serve as the framework under which the lease is developed. The compliance standards and lease terms vary widely from airport to airport, but a few provisions generally are recognized as desirable:

(1) A lease term of at least 10 years and preferably 20 years or longer with renewal options.

(2) The right to provide desired services and conduct operations in accordance with reasonable standards.

(3) The right to construct facilities for such operations.

(4) Reasonable rental charges based upon the land and facilities provided by the airport or the gross sales volume or a combination thereof. A typical schedule of lease charges by the airport might be as follows:

2 percent of gross sales excluding fuel and aircraft sales
2 cents-4 cents per gallon of fuel sold
6 cents-12 cents per square foot of unimproved land
15 cents-20 cents per square foot of improved land (paved aprons, ramps, etc.)
$3.00-$7.00 per square foot of hangar and office space (if such facilities are provided by airports).

The lease is a compromise between the interests of the airport authority which desires to obtain maximum revenue in exchange for the land and facilities used, and the FBO who desires the lowest cost lease in order to maximize his profit and return on investment. Since a major portion of many lease charges is fixed and unrelated to business volume, the operator often blames the lease as the cause of his financial failure.

There are frequent instances, unfortunately, of lease agreements developed by an airport without consideration to the limited profit potential and low return on investment, characteristic of most general aviation operations. There are cases on record of airports which have experienced numerous failures of general aviation operators where sufficient activity existed to support an operator. The fundamental cause was often found to be the lease which, if modified to terms more favorable to the operator would make possible a sound, financially healthy operation and more revenue for the airport in the long run.

AIRWAYS AND AVIONICS

Introduction

This section will deal primarily with both