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A SunCam online continuing education course

Airport Engineering

Part I – Fundamentals

Madison, IN Municipal Airport

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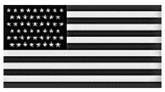
Airports – An Introduction

Airports are essential components of modern air travel. An airport is an area of land that is used or intended to be used for the landing and takeoff of aircraft, and includes its buildings and facilities, if any. This course series focuses on public civil airports from an engineering perspective, within the United States of America



that are under the authority of the Federal Aviation Administration (FAA). Project funding sources, airport ownership, and service level designations are not addressed in this course. Other planning-level aspects of airport design such as airport site determination, site studies, social and revenue considerations are also excluded. There are many airport features withheld from this course that are important to airports but are generally ignored in fundamental airport design and engineering. For example: security protocol, fueling vehicles, baggage handling, and air traffic control operations fall into this category.

As you read this course, recognize that airport design can be complex. Planning and construction of an airport is a multi-disciplinary effort that takes extensive development and effort. It is unrealistic to think that all aspects of airport design can be covered in this set of short courses. Instead, use this as instruction to guide and/or refresh you in this subject. There are many advisory circulars and other forms of literature published by aviation authorities that cover a multitude of subjects relating to airport design. These can (and should) be used by design professionals when working on any airport project.

Columbia Gorge Regional Airport (DLS)

This course introduces airports, their common features, and basic design considerations. Familiar acronyms will be presented, along with a description of the FAA's involvement in airport projects. Following courses will address runway and taxiway design, NAVAIDs, lighting, airport signs, apron design, and other topics.

Airports vary in size and accommodation; many have facilities to store and maintain aircraft as well as other features. Small airports, however, might only have one runway with few services. Technically, an airfield or airstrip refers to such a facility that has nothing more than a runway. Large airports may have air traffic control towers, multiple runways, emergency response departments, fleets of snow removal equipment, and extended terminals with passenger services such as restaurants and shopping. Some airports accommodate hundreds of aircraft, including shared facilities with military, cargo, or maintenance facilities. Needless to say, the larger the airport, the more involved the engineering becomes.

Aircraft

An aircraft is a heavier-than-air flying machine, which includes fixed and rotary wing vehicles: airplanes, helicopters, gliders, ultralights, gyrocopters, and unmanned aerial vehicles (UAV's). Lighter-than-air vehicles, such as balloons and airships, are also aircraft. Airports that are exclusively dedicated to helicopters, seaplanes, UAV's, and short take-off and landing aircraft are not included in this introduction. Of course, not all aircraft require airports to take off and land; UAV's, balloons, and ultralights are common examples of aircraft that can operate in alternate locations.

Common Airport Features

Runway

A runway is a defined rectangular surface on an airport suitable for the landing or takeoff of aircraft. A single airport may have multiple runways. Runways may be man-made (asphalt and/or concrete) or natural surfaces such as ice, turf, dirt, or sand.

Runway numbers indicate the magnetic azimuth of the runway's heading in decadegrees (e.x., the photo below shows Runway 35, indicating a heading of approximately 350°). Renumbering a runway is common since the Earth's magnetic field changes over time and markings may need to be occasionally adjusted. Parallel runways have letter suffixes to distinguish left and right on approach (such as RW 19L or 19R).

Prevailing wind is a leading factor when designing which direction a runway should be aligned, since fixed-wing aircraft have an advantage when taking off and landing into the wind. Runway length varies and may range from hundreds of feet to several miles (e.x., Denver International Airport RW 16R/34L is 16,000 ft long).

Taxilane

Taxilanes provide access from taxiways to aircraft parking positions and other terminal areas. Taxilanes are usually, but not always, located outside the movement area on an airport.

TAXIWAY

A taxiway is a defined path established for the taxiing of aircraft from one part of an airport to another. Taxiway design incorporates low speed and precise taxiing, integrating safety as the basis of design. Taxiways are generally hard surfaces, although some airports may use gravel or grass. Airport guidance signs provide directions and information to taxiing aircraft and airport vehicles.

APRON

An apron is a surface (usually paved) that is employed for various purposes, including aircraft tiedowns, short and long-term parking, fueling, washing, or maintenance. Aprons are typically located in the non-movement area of an airport near or adjacent to the terminal area. Aircraft boarding may occur on an apron, depending on airport accomodations. Well-designed aprons minimize runway incursions and expedite aircraft services. Tiedown design on an apron should maximize the number of spots while providing required wingtip and taxilane clearances. Wash pads or de-icing areas on an apron are dedicated areas for these purposes; the pavement is sloped to collect runoff fluids into a treatment system differing from storm water collection.

Hangar

Hangars are buildings used to maintain and store aircraft for security and protection against wind and other adverse weather conditions. Hangars vary in size and shape; box hangars can size larger and multiple aircraft, while T-hangars maximize the number of aircraft per apron area. Corporate hangars may have small offices and other amenities. Standard hangar design includes safety measures such as proper clearances, hazard mitigation (fuel spills, fume accumulation, etc.), and security considerations.

Terminal Building

The terminal building is where passengers enter and exit the airport facility. The terminal usually contains check-in services, baggage handling, security checkpoints, and gates that convey passengers to board and deplane an aircraft. At small airports, a single terminal building serves all functions of a terminal and concourse, while large airports may have multiple concourses linked by tunnels, walkways, or bridges. Satellite terminals allow aircraft to park around the entire circumference of the building.

Washington Dulles International Airport (IAD)

Air Traffic Control Facilities

Electronic equipment and buildings (i.e. a tower) aid air traffic control (ATC) in communication and surveillance of aircraft, including weather detection and advisory systems. The FAA owns and maintains ATC equipment. An air traffic control tower (ATCT) must be located near active runways to give controllers visibility of runways and movement areas.

LAX Control Tower and Terminals

Navigation Aids (NAVAIDs)

NAVAIDs include electric and visual air navigation equipment, lights, signs, and associated supporting facilities. NAVAID systems are both visual and instrument based that assist in guiding pilots during aircraft operations. The FAA owns and maintains NAVAID equipment. A VHF Omnidirectional Range (VOR) station is shown below; however, there are many different forms of NAVAIDs such as localizers (LOC), precision approach path indicators (PAPI), and instrument landing systems (ILS), as will be discussed in a subsequent course.

Weather & Communication Facilities

Segmented circles, wind cones, and weather cameras provide data to pilots of current weather and surface conditions at an airport. Automated Surface Observing System (ASOS) and Automated Weather Observing System (AWOS) are automatic recording instruments to measure air and weather conditions.

Snow Removal Equipment

Snow removal is critical to safe and continuous airport operation. Adequate equipment is necessary to clear snow from movement and non-movement areas. Depending on airport size, snow removal equipment (SRE) may vary from a single machine to a fleet of vehicles and personnel.

Airport Acronyms

Acronyms are essential in aviation. Here are some common terms you may encounter as an airport design engineer:

A/C — Aircraft
AAA – Airport Airspace Analysis
AAC – Aircraft Approach Category
AC — Advisory Circular, Asphaltic Concrete
ADG — Airport Design Group
ADO – Airports District Office
AGL – Above Ground Level
AIM – Aeronautical Information Manual
AIP — Airport Improvement Plan
ALP — Airport Layout Plan
ALS — Approach Lighting System
APRC – Approach Reference Code
ARC — Airport Reference Code
ARFF — Aircraft Rescue and Fire Fighting
ARP – Airport Reference Point
ASDA – Accelerate Stop Distance Available
ASOS — Automatic Surface Observation System
ASRS – Aviation Safety Reporting System
ASTM – American Society of Testing and Materials Intl.
ATC — Air Traffic Control
ATCT – Air Traffic Control Tower
ATIS — Automated Terminal Information Service
AWOS — Automated Weather Observation System
BMP – Best Management Practice
CFR — Code of Federal Regulations
CIP — Capital Improvement Plan
CL – Centerline
CMG – Cockpit to Main Gear Distance
CTAF — Common Traffic Advisory Frequency
CWY – Clearway
DBE — Disadvantaged Business Enterprise
DER – Departure End of Runway
DME — Distance Measuring Equipment
EA — Environmental Assessment
EAT – End-Around Taxiway
EPA — Environmental Protection Agency
FAA — Federal Aviation Administration
FAR — Federal Aviation Regulation

FBO — Fixed Base Operator
FCC — Federal Communications Commission
FOD – Foreign Object Debris
FSDO — Flight Standards District Office
GA — General Aviation
GIS — Geographic Information System
GPA – Glide Path Angle
GSE — Ground Support Equipment
HAA – Height Above Airport
HATh – Height above Threshold
HIRL – High Intensity Runway Lights
ICAO — International Civil Aviation Organization
IFR — Instrument Flight Rules
ILS — Instrument Landing System
LDA – Landing Distance Available
LOC — Localizer
LORAN — Long Range Aid to Navigation
LOS – Line of Sight
MALS — Medium Intensity Approach Lighting System
MALSR — MALS with Runway Alignment Indicator Lights
MIRL – Medium Intensity Runway Lights
MSL — Mean Sea Level
NAVAID — Navigational Aid
NDB — Non-Directional Radio Homing Beacon
NEPA — National Environmental Policy Act
NGS – National Geodetic Survey
NOTAM — Notice to Airmen
NPA – Non-Precision Approach
NPIAS — National Plan of Integrated Airport Systems
NTSB — National Transportation Safety Board
OCS – Obstacle Clearance Surface
OFA – Object Free Area
OFZ — Obstacle Free Zone
PA – Precision Approach
PAPI — Precision Approach Path Indicator
PCC — Portland Cement Concrete
POFZ – Precision Obstacle Free Zone
RAIL — Runway Alignment Indicator Lights
RDC – Runway Design Code
REIL — Runway End Identification Lights
RF — Radio Frequency
RNAV — Area Navigation
ROFA – Runway Object Free Area
ROFZ – Runway Obstacle Free Zone

RPZ — Runway Protection Zone
RSA — Runway Safety Area
RW — Runway
STOL — Short Takeoff and Landing
SVFR — Special Visual Flight Rules
SWY – Stopway
TACAN — Tactical Aircraft Control and Navigation
TCH – Threshold Crossing Height
TDG — Taxiway Design Group
TERPS — Terminal Instrument Procedures
TESM – Taxiway Edge Safety Margin
TH - Threshold
TL — Taxilane
TODA — Takeoff Distance Available
TOFA — Taxiway Object Free Area
TORA — Take-off Run Available
TSA — Taxiway Safety Area
TW — Taxiway
TWR — Tower
UHF – Ultra-High Frequency
VASI — Visual Approach Slope Indicator
VFR — Visual Flight Rules
VHF – Very High Frequency
VMC — Visual Meteorological Conditions
VOR — VHF Omnidirectional Range
VOR/DME — VHF Omnidirectional Range/Distance Measuring Equipment
WCAM – Weather Camera
WHA — Wildlife Hazard Assessment
WHMP — Wildlife Hazard Management Plan
WX — Weather

Federal Aviation Administration (FAA)

Per Title 49 United States Code, the FAA is instructed to regulate air commerce, promote safety, and encourage development of aviation and its associated technology. Emphasis is strictly directed at safety of airports and airway systems including airport construction and improvement projects. Federal standards should be met, passenger and cargo accommodation should be promoted, and delays decreased.

The mission statement of the FAA is to "provide the safest, most efficient aerospace system in the world". Although the FAA has offices to regulate aviation safety, air traffic, commercial space transportation, and other things, the airport organization provides leadership in planning and developing a safe and efficient national airport system. The office has responsibility for all programs related to airport safety, inspections, and standards for airport design, construction, and operation. Each year, the office awards billions of dollars in airport grants and approves passenger facility charge collections. The office also is responsible for national airport planning, environmental and social requirements, and establishes policies related to airport rates and charges, compliance with grant assurances, and airport privatization.

Existing airports should be brought up to current standards, although this may not always be feasible. Non-standard conditions exist and alternative means can be considered. Facility layout, passenger accommodation, cargo handling, maintenance facilities, traffic flow, and other criteria may be incorporated into the planning of airport improvements before engineers become involved in the project. Regardless, improving an existing airport should demand the same level of scrutiny and evaluation as a new airport design. It is essential that engineers working on an airport project prioritize public safety and aircraft operations to the highest degree. FAA oversight during a project demands a frequent channel of communication to ensure the project meets the necessary standards. Engineers commonly interact with FAA personnel to provide progress reports, schedule inspections, and convey questions or problems as construction occurs. It is noteworthy that aircraft operations cannot be prevented, regulated, or controlled simply because the airport or runway does not meet the design standards for a particular aircraft type.

Chart Supplements

Airport diagrams and information are found in the FAA's Chart Supplements. Although they are primarily intended for pilots, engineers may find it is useful to obtain a copy pertaining to their region when working on airport improvement projects. Such a resource provides supplemental information about airport organization and operations. This information can be particularly important when designing construction and safety phasing plans to understand the flow of traffic on an airport since aircraft operations must not be impeded by construction projects. Chart supplements include runway and taxiway configurations, lighting systems, radio frequencies, topographical features, airport services, NAVAIDs, "hot spots" (an area on an airport with a history or potential risk of collision or runway incursion indicated by HS 1, HS 2, etc. on airport diagrams), and other material. See Appendix A for examples.

New & Existing Airports

New airports must meet long-term aviation demands in a manner that is consistent with national standards. Safety is the highest priority. The airport engineer is required to identify the design elements that maintain safety and efficiency in accordance with FAA policies. Airport planning should consider both present and future aviation needs and demands associated with the airport. Coordination with the FAA and airport authorities will assist in determining the short-term and long-range characteristics that will best satisfy the needs of the community and traveling public.

JFK Control Tower & Terminal

Existing airports, as previously mentioned, should be brought up to current standards where possible. It may not be feasible to meet all requirements at an existing airport, and funding of improvements will have to be identified and addressed during the design process. For non-standard conditions, the FAA may consider alternative means of ensuring an acceptable level of safety. Provisions for an improvement project should be made far in advance and must conform to project funding and planning requirements.

Pre-Design Requirements

Before formal design takes place, airport designers should investigate what is required by federal, state, and local governments.

Financial aid in the form of the FAA grant program is available for qualifying public-use airports via local FAA Airports District Office (ADO). Acceptance of federal funding demands that airports agree to certain obligations, enforced by the Airport Compliance Program. Environmental conditions must be met during and after airport construction in accordance with NEPA. State government standards and/or construction materials may, but do not have to be, accepted by the FAA. Local governments have regulations that may affect airports. Examples of these are fire regulations, zoning ordinances, building permits, and water rights.

Airport projects also require notification be given to the FAA when construction or an alteration occurs on or near an airport. CFR Part 77 Airspace Analysis allows the FAA to evaluate potential impact on air navigation. An updated ALP is generally the best method to convey plan information. An Airport Development Plan (ALP) is a scaled drawing of existing and proposed land and facilities necessary for the operations and development of the airport. Any airport will benefit from a carefully developed plan that reflects current FAA standards and planning criteria. New FAA revisions should be incorporated into ALP's and implemented into new developments. ALP's present aeronautical requirements, relevant clearances and dimensional data, as well as airside and landside feature configurations (see Appendix B). Plans on file in the form of a master record at the FAA ensures airport owners have full consideration for development.

Another aspect that should be considered during pre-design is land use and airspace protection. Even though adjacent landowners may not be associated with the airport, their infrastructure can have negative impacts on airspace by violating land uses or creating obstacle conflicts with approach and departure surfaces. Land acquisition to protect all possible airspace intrusion is generally not feasible, and is usually supplemented by local zoning, easements, or other means. For new runways, land should be acquired to include Object Free Areas (OFAs) and Runway Protection Zones (RPZs). The ALP should clearly address land use and methods to accommodate airport requirements.

Airport Design Considerations

DRAINAGE

Proper drainage is a principal requisite on an airport. The objective of drainage design is to provide for safe passage of vehicles or operation of the airport facility during a storm event. AC 150/5320-5 provides detailed guidance on storm system design. Since drainage design is frequently an item on an airport engineer's to-do list, a synopsis of general guidelines is provided.

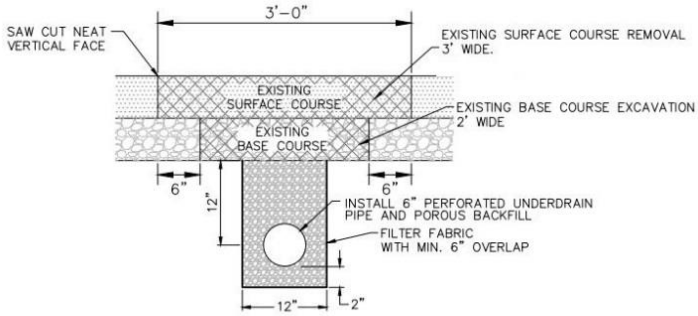
Drainage systems should be designed to:

1. Rapidly remove storm water from the airfield pavement
2. Efficiently collect airfield flow and convey it to discharge points
3. Protect pavements from damage during and after large storms
4. Provide safe operations for air and ground vehicles
5. Maintain water quality standards in accordance with local/state/federal codes
6. Account for future expansion and grading requirements

Unfortunately, airports by nature are relatively flat, making the above tasks more difficult. Each site must be carefully assessed for soil conditions, topography, facility size, vegetation, ponding, and local storm characteristics frequency. Airport expansion often turns pervious surfaces to impervious (i.e. grass to pavement) which causes increased runoff. Storm water detention ponds are commonly required which may increase wildlife attraction, an undesirable consequence (see AC 150/5200-33). Avoidance of ponding and erosion of slopes that could compromise pavement foundations is essential. Best management practices (BMP's) should be employed to mitigate the adverse impacts of development activities.

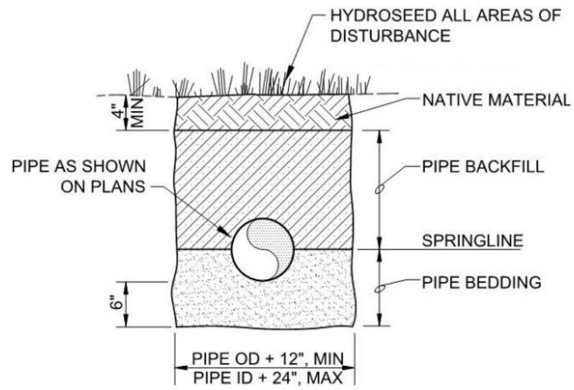
Storm drain design should remove storm runoff during or following storms to avoid interruption to aircraft operations and prevent damage to subgrades. Drainage systems vary on each site and should function with minimum maintenance.

The following images show sample drainage details and plan:

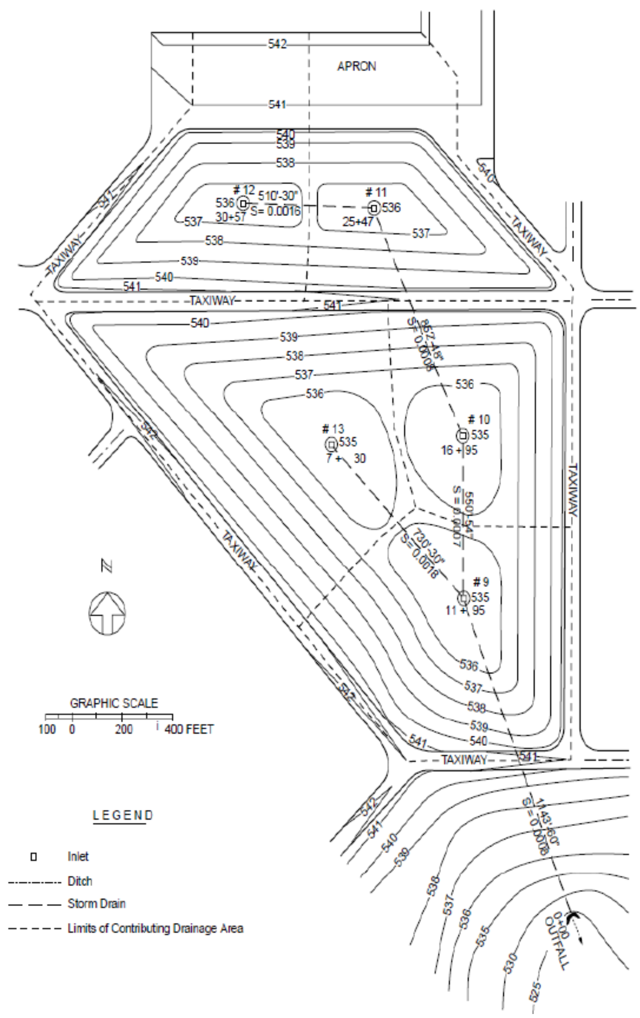


PAVEMENT UNDERDRAIN DETAIL

NOT TO SCALE



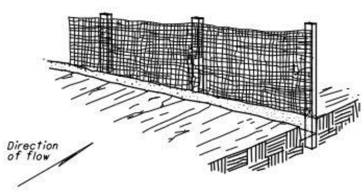
NON-PAVED



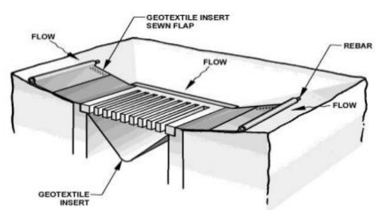
EROSION, STORMWATER, & SEDIMENT CONTROL

Erosion, stormwater, and sediment control techniques are worthy of a standalone course due to the impact they have on an airport project. Poor planning of control measures may result in unstable soil, increased flood hazards, destroyed ecosystems, or disturbed water supplies. Good planning incorporates prudent methods to retain sediment, prevent stormwater pollution and/or flooding, and minimize accelerated erosion. Design engineers should be very familiar with the requirements a project demands to responsibly maintain a construction site during the work and after it is complete.

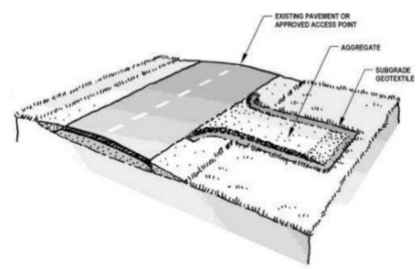
Erosion control is the non-structural practice that involves strategic management of a construction site to minimize the disturbed area and amount of time the site is exposed to runoff. Sediment control is accomplished through structural practices that intercept loose sediments to prevent their transport off-site. Effective erosion control greatly reduces the necessary amount of sediment control. The FAA has specifications for airport project construction, and best management practices (BMP) should be incorporated into designs, as necessary. Since erosion and sediment control is not exclusive to airports, there are many resources to aid on design available from departments of transportation, natural resource agencies, and other government authorities. Proper erosion & sediment control plans (ESCP) and stormwater pollution prevention plans (SWPPP) are critical.



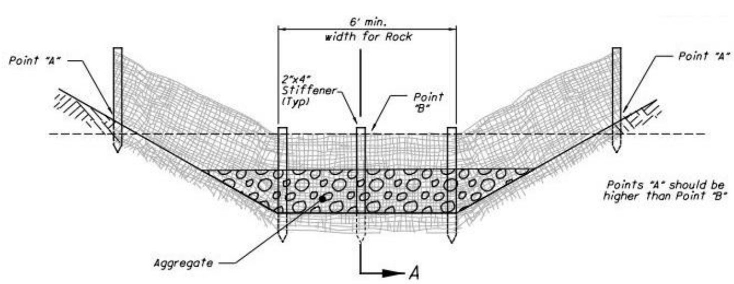
Silt Fence Installation
Source: Ohio DOT



Inlet Protection
Source: ODOT Erosion & Sediment Control Manual



Construction Entrance
Source: ODOT Erosion & Sediment Control Manual



CROSS-SECTIONAL VIEW OF FLAT BOTTOM DITCH
Source: Ohio DOT

WILDLIFE HAZARDS

Wildlife in the vicinity of an airport is a serious hazard to operating aircraft. Design engineers should take this into account on any project in the area of active operations. Birds and other wildlife may be particularly attracted to airports due to their large open areas or storm water ponds, for example. Or, an airport may be geographically located near places that naturally attract wildlife, such as a landfill, wildlife sanctuary, or an ocean. Wildlife control prevention should be integrated into airport designs where possible to minimize such hazards.

SECURITY

Airport security measures are intended to prevent unauthorized access to restricted areas and protect people, aircraft, and property. The Transportation Security Administration (TSA) has specific requirements for post-9/11 airport security. Engineers may be expected to conform to current standards in the design of an airport project.

ENVIRONMENTAL FACTORS

Studies should be taken that consider the impact of creating or expanding airport facilities. These studies might include noise analysis, air and water quality effects, historical features, archeological examinations, and evidence of endangered or protected species. Also, it is important to review the effect an airport project has on adjacent or nearby residents.

TOPOGRAPHY

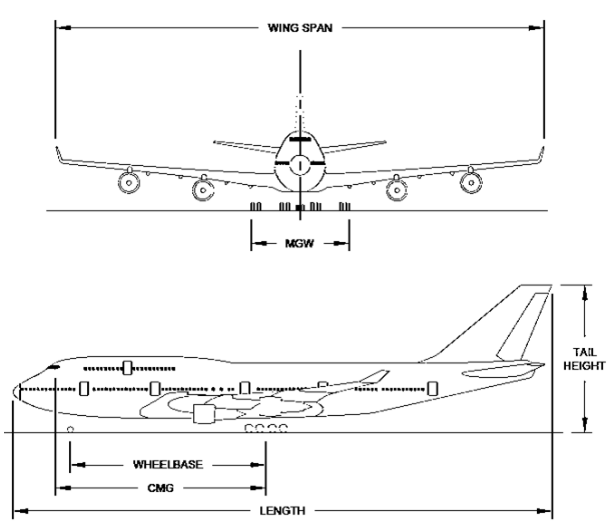
Pre-construction surveys and analysis will determine the amount of grading and drainage work will be required to construct an airport project. Both the costs of initial work and future airport development should be considered when making design decisions.

Basic Design Process

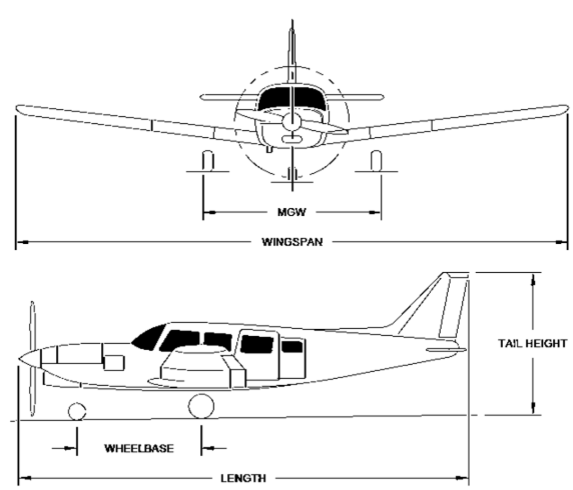
There are five fundamental aspects of airport design: aircraft performance and size, air traffic management, safe and effective operations, noise effects, and obstacles in the airways. Aircraft performance and size should already be determined during the airport planning process and specified on the ALP. It is always prudent, however, to assess the fleet mix and determine the realistic (and updated) aircraft an airport may accommodate. Air traffic management is largely outside of the scope of engineering projects and safe and effective operations are addressed on many levels during a project. Noise effects and obstacles in the airways need to be evaluated on a case-by-case basis and in compliance with local ordinances and federal requirements.

The foremost step in a design project is assessing the level of demand the aircraft will present and applying the criteria associated with the selection. This demand is determined by the type of approach the runway accommodates (instrument or visual), weight and size of the largest aircraft within the fleet mix, and other factors. For airports with two or more runways, it is desirable to design all airport elements to meet the requirements of the most demanding runway and taxiway constraints. This is not always practical, however, and may not be universally applied due to economic or other limits. Once the previous factors are considered, one or more design aircraft are selected for the individual airport. This may be a single aircraft type or a composite of several different aircraft that combines the most demanding features. Such features are approach speed, landing and takeoff distance, aircraft weight, cockpit to main gear distance, main gear width, wingspan, maximum single wheel weight, and tail height. In most cases, the design aircraft is a composite representing a collection of aircraft classified by three parameters: Aircraft Approach Category (AAC), Airplane Design Group (ADG), and Taxiway Design Group (TDG). Needless to say, it is not sensible to base airport design on an aircraft that uses the airport infrequently.

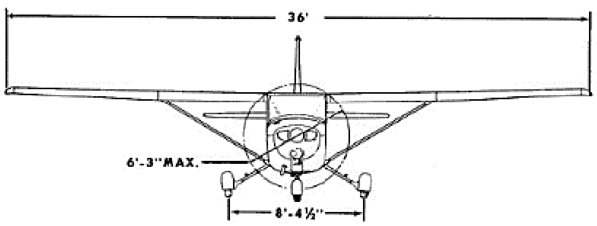
The following are sample schematics of aircraft dimensions:



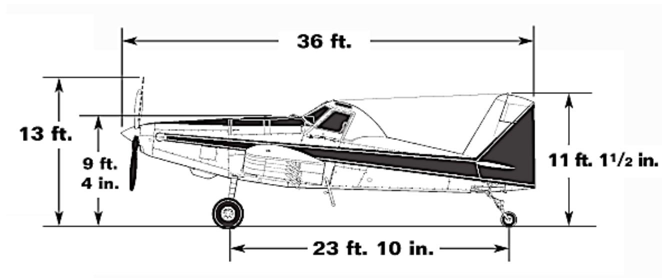
Standard Dimensions for Large Aircraft



Standard Dimensions for Small Aircraft



Source: Cessna Aircraft Company.



Source: Air Tractor Inc.

Per A/C 150-5300-13A, Aircraft Design Group (ADG) and Aircraft Approach Category (AAC) are as follows:

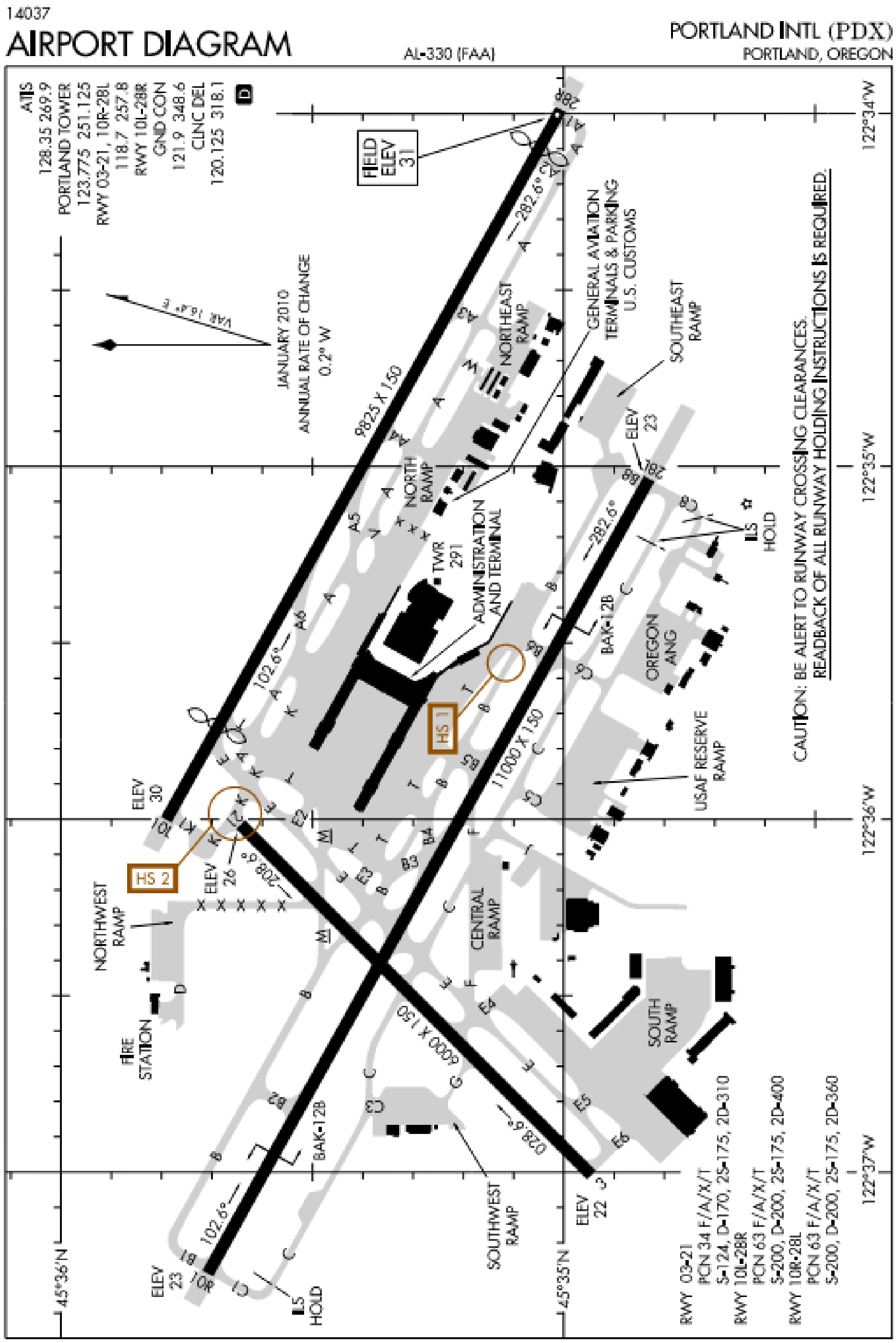
Group #	Tail Height (ft [m])	Wingspan (ft [m])
I	< 20′ (< 6 m)	< 49′ (< 15 m)
II	20′ - < 30′ (6 m - < 9 m)	49′ - < 79′ (15 m - < 24 m)
III	30′ - < 45′ (9 m - < 13.5 m)	79′ - < 118′ (24 m - < 36 m)
IV	45′ - < 60′ (13.5 m - < 18.5 m)	118′ - < 171′ (36 m - < 52 m)
V	60′ - < 66′ (18.5 m - < 20 m)	171′ - < 214′ (52 m - < 65 m)
VI	66′ - < 80′ (20 m - < 24.5 m)	214′ - < 262′ (65 m - < 80 m)

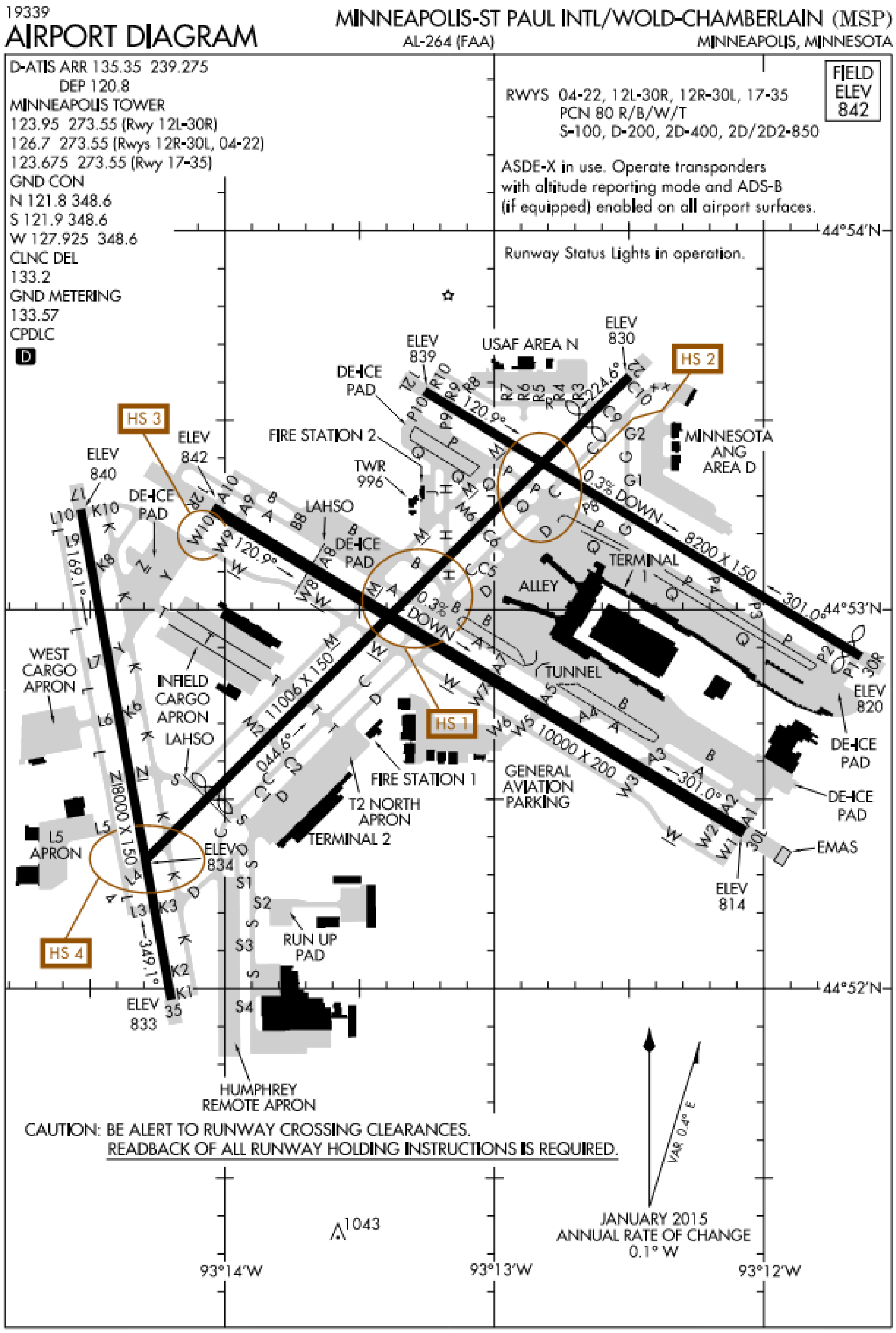
AAC	V_{REF}/Approach Speed
A	Approach speed less than 91 knots
B	Approach speed 91 knots or more but less than 121 knots
C	Approach speed 121 knots or more but less than 141 knots
D	Approach speed 141 knots or more but less than 166 knots
E	Approach speed 166 knots or more

Combined, these classifications specify what type of aircraft is being evaluated. For example, a Cessna Citation CJ2+ is considered a B-II, with a wingspan of 50' and V_{REF} of 115 kts. A Boeing 777-300 is a D-V with wingspan of 200' and V_{REF} of 149 kts.

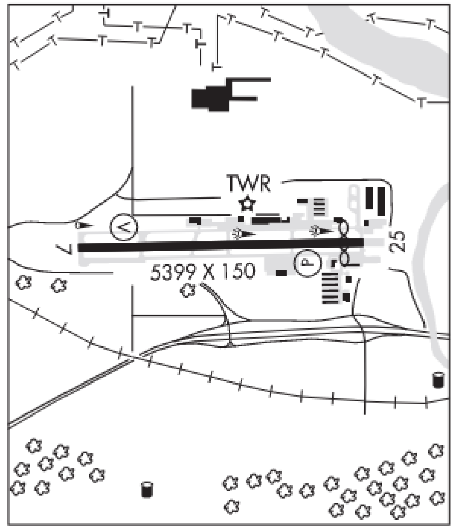
In summary, these specifications determine the probable loads and geometry that apply to an airport project. Taxiway Design Group (TDG) and its applicability will be discussed in a following course.

Appendix A: Airport Diagrams



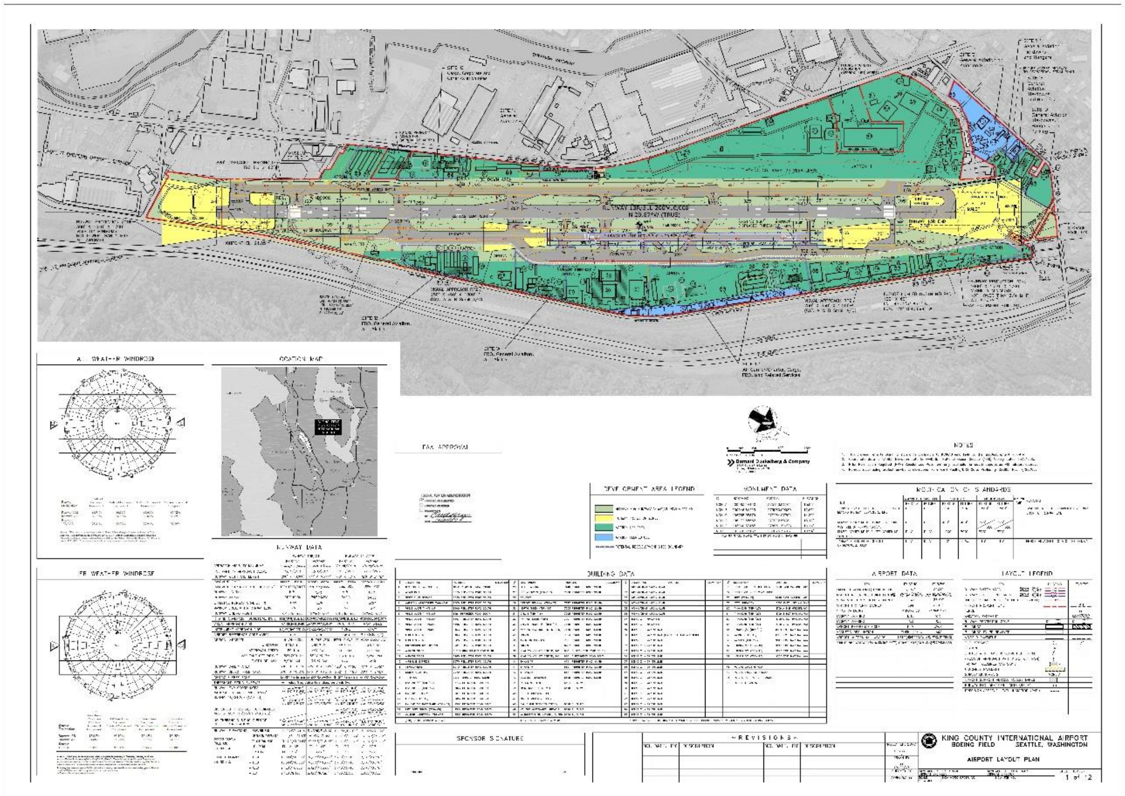

19339
AIRPORT DIAGRAM
MINNEAPOLIS-ST PAUL INTL/WOLD-CHAMBERLAIN (MSP)
AL-264 (FAA)
MINNEAPOLIS, MINNESOTA
D-ATIS ARR 135.35 239.275
DEP 120.8
MINNEAPOLIS TOWER
123.95 273.55 (Rwy 12L-30R)
126.7 273.55 (Rwys 12R-30L, 04-22)
123.675 273.55 (Rwy 17-35)
GND CON
N 121.8 348.6
S 121.9 348.6
W 127.925 348.6
CLNC DEL
133.2
GND METERING
133.57
CPDLC
D
RWYS 04-22, 12L-30R, 12R-30L, 17-35
PCN 80 R/B/W/T
S-100, D-200, 2D-400, 2D/2D2-850
FIELD ELEV 842
ASDE-X in use. Operate transponders with altitude reporting mode and ADS-B (if equipped) enabled on all airport surfaces.
Runway Status Lights in operation.
44°54'N
44°53'N
44°52'N
USAF AREA N
MINNESOTA ANG AREA D
HS 1
HS 2
HS 3
HS 4
FIRE STATION 2
TWR 996
LAHSO
DE-ICE PAD
ELEV 839
ELEV 830
ELEV 842
ELEV 840
ELEV 820
ELEV 834
ELEV 814
ELEV 833
0.3% DOWN
8200 X 150
10000 X 200
11006 X 150
8000 X 150
TERMINAL 1
ALLEY
TUNNEL
WEST CARGO APRON
INFIELD CARGO APRON
L5 APRON
FIRE STATION 1
T2 NORTH APRON
TERMINAL 2
GENERAL AVIATION PARKING
EMAS
RUN UP PAD
HUMPHREY REMOTE APRON
CAUTION: BE ALERT TO RUNWAY CROSSING CLEARANCES.
READBACK OF ALL RUNWAY HOLDING INSTRUCTIONS IS REQUIRED.
VAR 0.4° E
JANUARY 2015
ANNUAL RATE OF CHANGE
0.1° W
1043
93°14'W
93°13'W
93°12'W

PORTLAND–TROUTDALE (TTD)(KTTD) 10 E UTC–8(–7DT) N45°32.96´ W122°24.08´ **SEATTLE**
39 B NOTAM FILE TTD **H–1B, L–1C**
RWY 07–25: H5399X150 (ASPH) S–19, D–25 MIRL **IAP, AD**
RWY 07: REIL. VASI(V4L)—GA 3.0° TCH 50´. Road.
RWY 25: REIL. PAPI(P4L)—GA 3.1° TCH 31´. Thld dsplcd 353´. Road.
RUNWAY DECLARED DISTANCE INFORMATION
RWY 25: TORA–5399 TODA–5399 ASDA–5399 LDA–5046
SERVICE: S4 **FUEL** 100LL, JET A **OX** 1 **LGT** Rwy 07 VASI and PAPI Rwy 25 opr continuously. ACTIVATE MIRL Rwy 07–25—CTAF.
AIRPORT REMARKS: Attended 1500–0600Z‡. Migratory flocks of waterfowl on and invof arpt. Portland Intl arpt (PDX) Rwy 10L–28R extended centerline crosses arpt, twr may issue restrictions due to PDX tfc. Multiple const cranes 110´ AGL or blo located 2700´ SW of Rwy 25 thld. Extensive helicopter ops on and adjacent to west ends of parallel twys, no early turnouts. NS ABTMT procedures in effect, call 503–460–4100 or 800–938–6647. Noise sensitive areas border the arpt west and south. Avoid low level over flts of residential areas. Recommend between SS and SR Rwy 07 left tfc and Rwy 25 rft tfc due to bluff 500´ south of arpt. Rwy 25 PAPI is baffled 08° left and rgt of centerline. Commercial acft and oprs of acft with an FAA certified maximum gross ldg weight that exceeds 10,000 lbs are rqr to pay a ldg fee. Ldg fee.



AIRPORT MANAGER: 503-415-6119
WEATHER DATA SOURCES: ASOS 135.625 (503) 492–2887.
COMMUNICATIONS: CTAF 120.9 **ATIS** 135.625 503 –492–7634 **UNICOM** 122.95
® **PORTLAND APP CON** 118.1 284.6 (100°–279° HIGH) 299.2 (280°–099°) 124.35
TROUTDALE TOWER 120.9 254.3 (1500–0600Z‡) **GND CON** 121.8
® **PORTLAND DEP CON** 124.35 299.2
CLEARANCE DELIVERY PHONE: For CD ctc Portland Apch at 503-493-7545.
AIRSPACE: CLASS D svc 1500–0600Z‡; other times CLASS E.
RADIO AIDS TO NAVIGATION: NOTAM FILE PDX.
BATTLE GROUND (H) VORTACW 116.6 BTG Chan 113 N45°44.87´ W122°35.49´ 125° 14.4 NM to fld. 253/21E.
TACAN AZIMUTH & DME unusable:
035°–085° byd 35 NM blo 10,000´
COMM/NAV/WEATHER REMARKS: Frequency 121.5 not avbl at twr.

Appendix B: Airport Layout Plan



Reference Material

For further reading and additional reference material regarding the topics in this course, the following documents are valuable to the design engineer:

1. AC 150/5300-13A; *Airport Design*
2. AC 150/5070-6, *Airport Master Plans*
3. AC 150/5070-7, *The Airport System Planning Process*
4. AC 150/5200-33, *Hazardous Wildlife Attractants on or Near Airports*
5. AC 150/5220-20, *Airport Snow and Ice Control Equipment*
6. AC 150/5300-14, *Design of Aircraft Deicing Facilities*
7. AC 150/5320-5, *Surface Drainage Design*
8. AC 150/5370-2, *Operational Safety on Airports During Construction*
9. AC 150/5370-10, *Standards for Specifying Construction of Airports*
10. AC 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities*
11. FAA Order 1050.1, *Policies and Procedures for Considering Environmental Impacts*
12. FAA Order 5050.4, *National Environmental Policy Act Implementing Instructions for Airports*
13. FAA Order 5100.38, *Airport Improvement Program*
14. FAA Order 5190.6, *FAA Airport Compliance*
15. 14 CFR Part 77, *Safe, Efficient Use, and Preservation of the Navigable Airspace*
16. 14 CFR Part 139, *Certification of Airports*
17. 14 CFR Part 150, *Airport Noise Compatibility*
18. 14 CFR Part 151, *Federal Aid to Airports*
19. 14 CFR Part 152, *Airport Aid Program*
20. 14 CFR Part 157, *Notice of Construction, Alteration, Activation, and Deactivation of Airports*
21. 49 CFR Part 1544, *Airport Security*
22. Airport Engineering, Ashford et al., *Wiley & Sons, 4th ed.*
23. Planning and Design of Airports, *Horonjeff et al., McGraw-Hill, 5th ed.*

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Title Page:	*Madison Municipal Airport*; Brent Spry, 2018
Page 3:	*Columbia Gorge Regional Airport:* Unknown
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	Floatplane: Author's Collection
	Coast Guard Helicopter: Author's Collection
	Jess Dixon in his Flying Automobile; Kobel Feature Photos (Frankfurt, IN), 1940
	Hot Air Balloon; Greg Goebel, 2013
	Mavic Pro Platinum; Sven Teschke, 2019
	Hang Glider Demonstrating Abilities; Andrew Stobart, 2007
Page 5:	*Runway 35 Final Approach*: Author's Collection
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	Apron with Parked Aircraft (Left): Author's Collection
	Delta Airlines Boeing 767-300 MSP (Right); redlegsfan21, 2016
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	Singapore 38 Taxis past United Hangar at LAX; InSapphoWeTrust, 2012
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	VOR Station: Author's Collection
Page 9:	*ASOS & Wind Cone*: Author's Collection
	Oshkosh Snow Removal Vehicles; Perry Aston, U.S. Air Force, 2009
Page 14:	*JFK Tower & Terminal*; Eheik, 2005
Page 15:	*American Airlines Boeing 787-8 Landing at LAX*; Jakkrit Prasertwit, 2015
Page 18:	*Planes and Birds*; Maarten Visser, 2011
	20111117-APHIS-DB-0001; US Dept. of Agriculture, 2011
Page 25:	*Portland-Hillsboro Airport*, M.O. Stevens, 2007

