U.S. Department
of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Airport Design | Date: Draft | AC No: 150/5300-13B
Initiated By: AAS-100 | Change:

1 Purpose.

This Advisory Circular (AC) contains the Federal Aviation Administration's (FAA) standards and recommendations for airport design.

2 Cancellation.

This AC cancels AC 5300-13A, *Airport Design*, dated September 28, 2012.

3 Applicability.

The FAA recommends using the standards and guidelines in this AC for application at civil airports in support of the FAA's responsibilities to provide an airport system that considers safety, efficiency, capacity and environment. This AC does not constitute a regulation, is not mandatory and is not legally binding in its own right. It will not be relied upon as a separate basis by the FAA for affirmative enforcement action or other administrative penalty. Except for the projects described in subparagraphs 2, 3 and 4 below, conformity with this AC is voluntary, and nonconformity will not affect rights and obligations under existing statutes and regulations:

1. Use of these standards and guidelines are practices the FAA recommends establishing an acceptable level of safety, efficiency and capacity for development of civil airports.
2. This AC provides one, but not the only, acceptable means of meeting the requirements of 14 Code of Federal Regulations (CFR) Part 139, *Certification of Airports*.
3. Use of these standards is mandatory for projects funded under Federal grant assistance programs, including the Airport Improvement Program (AIP). See Grant Assurance #34.
4. This AC is mandatory, as required by regulation, for projects funded by the Passenger Facility Charge (PFC) program. See PFC Assurance #9.

4 Related Documents.

Refer to paragraph 1.12 for documents referenced to this AC. ACs and FAA Orders referenced in the text of this AC do not include a revision letter, as they refer to the latest version.

5 Principal Changes.

The AC incorporates the following principal changes:

1. Restructured the entire document, locating design standards in the chapters with supporting information in the appendices. Chapters and Appendices are organized and updated as follows:
    a. Chapter 1, Introduction:
        i. Added new paragraphs explaining the meaning of terms for:
            1. Standard, paragraph 1.2.1.1.
            2. Recommended Practice, paragraph 1.2.1.2.
            3. Requirement, paragraph 1.2.1.3.
        ii. Added or revised definitions in paragraph 1.5:
            1. Commercial Service Airport, item 28.
            2. Critical Aircraft, item 30.
            3. Parallel Taxiway, item 73.
            4. Runway Visual Range, item 85.
            5. Taxiway Centerline, item 93.
        iii. Separated TDG 2 into TDG 2A and TDG 2B in Figure 1-1 and related discussions and tables throughout this document.
        iv. Removed TDG 7 and revised MGW dimensions for TDG 5 and TDG 6 in Figure 1-1 and related discussions and tables throughout this document.
    b. Chapter 2, Design Principles (formerly Design Process):
        i. Expanded discussion for design process in paragraph 2.4, and visibility minimums in paragraph 2.4.2.
        ii. Added paragraph 2.5.2 on Wrong Surface Event.
        iii. Expanded latter portion of chapter to include discussions on Modification to Standards in paragraph 2.6, Safety Management System (SMS) in paragraph 2.7, and Diverse Aeronautical Uses of Airports (operations in the RSA) in paragraph 2.8.
        iv. Expanded guidance and information related to diverse aeronautical uses on airports in paragraph 2.8.
        v. Moved Table 2-1, Changes in Airport Design Standards Associated with an Upgrade in the First Two Components (Aircraft Approach Category [AAC]

and Airplane Design Group [ADG]) of the Runway Design Code (RDC); Table 2-2, Changes in Airport Design Standards Associated with Lowering the Third Component (Approach Visibility Minimums) of the Runway Design Code (RDC); and Table 2-3, Aircraft Characteristics and Design Components to new Appendix L.

c. Chapter 3, Runway Design:

i. Moved Crosswind Component table to Appendix B.

ii. Moved runway historical and background information to Appendix I.

iii. Moved Declared Distance information to Appendix H.

iv. Moved Approach and Departure Code information to Appendix K.

v. Revised approach and departure tables in paragraph 3.5.

vi. Updated approach surface discussion in paragraph 3.5.1 and added New approach obstacle clearance Figure 3-4, Figure 3-5, and Figure 3-6.

vii. Updated departure surface to forthcoming TERPS criteria in paragraph 3.5.2 and revised obstacle clearance surface values in Table 3-1, Table 3-2, Table 3-3, and Table 3-4.

viii. Expanded departure surface guidance in paragraph 3.5.2 and added new departure obstacle clear area surface Figure 3-8, Figure 3-9, and Figure 3-10.

ix. Added new paragraph 3.6.5 on Overlapping Runway Safety Areas.

x. Expanded line of sight discussion in paragraph 3.7.

xi. Added new paragraph 3.8 on Parallel Runway Separation.

xii. Added new Figure 3-31 and expanded discussion on transverse slopes in paragraph 3.15.2.

xiii. Expanded Table 3-5, Transverse Grades.

xiv. Expanded turf runway discussion in paragraph 3.15.6.

xv. Removed Interactive Table 3-5, Runway Design Standards Matrix. This is available online as a design tool at https://www.faa.gov/airports/engineering/airport_design/.

xvi. Added new Table 3-7 to facilitate locating runway design standards in Appendix G based on AAC and ADG.

d. Chapter 4, Taxiway and Taxilane Design:

i. Reduced dimensions for taxilane object free area (TOFA) and taxiway separation (taxiway separation, taxiway centerline to fixed or moveable object, and wingtip clearance) as described in paragraph 4.5 and shown in revised Table 4-1. Revised these same standards for taxilanes.

ii. Updated Table 4-2; Taxiway Edge Safety Margin (TESM) for TDG 5 and TDG 6 is now 14 ft (4.25 m).

iii. Updated taxiway turn and intersection criteria in paragraph 4.8.

iv. Updated Taxiway Fillet Design Tool with new criteria in this chapter. This is available online as a design tool at https://www.faa.gov/airports/engineering/airport_design/.

e. Chapter 5, Aprons:

i. Expanded discussion on types of aprons in paragraph 5.2.

ii. Moved information on bridges to Chapter 6.

f. Chapter 6, Airfield Systems and Facilities (formerly Chapter 6, Navigation Aids (NAVAIDs) and On-airport Air Traffic Control Facilities (ATC-F)):

i. Consolidated information on NAVAIDs (CSWN) from other chapters.

ii. Contains information on systems and facilities only as it related to airport design.

g. Removed former Chapter 7, Airfield Bridges and Tunnels.

h. Appendix A (formerly Appendix 1), Aircraft Characteristics:

i. Added new Figure A-3 on folding wingtip aircraft.

i. Appendix B (formerly Appendix 2), Wind Analysis, as follows:

i. Relocated Table B-1 on crosswind component from former Chapter 3.

j. Appendix D (formerly Appendix 4), End-Around-Taxiway (EAT) Screens:

i. Added evaluation by licensed engineer to establish structural integrity of the EAT Screen.

k. Appendix E (formerly Appendix 5, General Aviation Aprons and Hangars), General Aviation Facilities:

i. Relocated information from various areas of document on general aviation (GA) facilities to this appendix.

l. Appendix F (formerly Appendix 6, Compass Calibration Pad), Compass Calibration Pad Survey:

i. Consolidated information into this appendix.

ii. Moved runway historical and background information from former Chapter 3.

iii. Added Runway Object Clearing information.

m. New Appendix J (formerly Appendix 8, Taxiway Fillet Design), Taxiway Additional Information.

i. Describes examples of taxiway designs with elevated safety risks.

ii. Removed TDG 7. Separated TDG 2 into TDG 2A (Table J-3) and TDG 2B (Table J-4) and included these additional fillet design dimensions.

iii. Added paragraph J.4 containing a description of the methodology and calculations used for reductions in taxiway standards.

iv. Added reference to the Taxiway Fillet Design Tool, available online at https://www.faa.gov/airports/engineering/airport_design/.

n. New Appendix K, Approach and Departure Reference Codes, containing former paragraph 323, Approach and Departure Reference Codes, and updated as follows:

i. Developed new Figure K-1 for airplane design group (ADG V-VI Departures.

ii. Updated Table K-1 on approach reference code.

iii. Relocated information from former Chapter 3.

2. Revised and updated figures throughout.

3. Updated the format of the document in this version and made minor editorial changes throughout.

6 Using this Document.

Hyperlinks (allowing the reader to access documents located on the internet and to maneuver within this document) are provided throughout this document and are identified with underlined text. When navigating within this document, return to the previously viewed page by pressing the “ALT” and “ ←” keys simultaneously.

Figures in this document are schematic representations and are not to scale.

7 Use of Metrics.

Throughout this AC, U.S. customary units are used followed with “soft” (rounded) conversion to metric units. The U.S. customary units govern.

8 Where to Find this AC.

You can view a list of all ACs at https://www.faa.gov/regulations_policies/advisory_circulars/. You can view the Federal Aviation Regulations at https://www.faa.gov/regulations_policies/faa_regulations/.

9 Feedback on this AC.

If you have suggestions for improving this AC, you may use the Advisory Circular Feedback form at the end of this AC.

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CHAPTER 1. Introduction

1.1 Policy.

The FAA has statutory responsibilities to serve the public's interest by developing a national aviation system that is safe, secure and efficient. Per Title 49 United States Code (USC), Chapter 401, General Provisions, Section (§) 40101(d):

> *"[T]he [FAA] Administrator shall consider the following matters, among others, as being in the public interest: (1) assigning, maintaining, and enhancing safety and security as the highest priorities in air commerce, (2) regulating air commerce in a way that best promotes safety and fulfills national defense requirements, (3) encouraging and developing civil aeronautics, including new aviation technology."*

1.1.1 Policy for Airport Development.

The FAA has specific responsibilities related to development and improvement of airports. These responsibilities establish the purpose and need for airport design standards. Title 49 USC Chapter 471, *Airport Development*, establishes the following objectives, in part, as policy:

1. Safe operation of the airport system
2. Minimize noise impact on nearby communities
3. Enhance development of cargo hub airports
4. Serve passengers and cargo efficiently and effectively
5. Promote economic development
6. Provide for protection and enhancement of natural resources and quality of the environment
7. Enhance safety and capacity to maximum extent feasible by increasing efficiency and decreasing delays
8. Ensure non-aviation usage of the navigable airspace does not decrease the safety and capacity of the airport and surrounding airspace
9. Encourage use of innovative technology to promote safety, capacity and efficiency.

1.2 Standards, Recommended Practices, and Requirements.

The use of the standards and recommendations contained in this advisory circular (AC) support the FAA's statutory responsibilities. These standards and recommendations represent the most effective means to meet aviation demand in a manner consistent with national policy. Implementation of these standards and recommendations does not limit or regulate the operations of aircraft.

1.2.1 Meaning of Terms.

1.2.1.1 **Standard.**

A physical characteristic, quality, configuration, function, operation or procedure established by the FAA as a benchmark for uniformity, safety, capacity, performance, economy and environmental quality. The FAA standards serve a prominent role in fulfilling the FAA's statutory responsibilities summarized in paragraph 1.1.1.

1.2.1.2 **Recommended Practice.**

Supplemental measures and guidelines the FAA recognizes as being beneficial towards enhancing safety, capacity or efficiency. Recommended practices imply discretionary application to address a site-specific condition.

1.2.1.3 **Requirement.**

A condition or action that establishes an obligation to conform. Mandatory language such as "must", "shall", "required" or "requirements" used in this AC describe obligations that originate in either federal statutes or regulations. This AC does not establish or modify any requirements.

1.2.1.4 **Design Consideration.**

Additional factors to take into account during airport design that may influence application of a standard or recommended practice.

1.2.2 Application of Airport Design Standards.

The standards and recommendations in this AC cover a wide range of size and performance characteristics of aircraft anticipated to operate at an airport. Airport development conforming to the standards of this AC establish an acceptable level of safety that ensures optimum operation of the critical aircraft without individual restrictions or location-specific encumbrances affecting utility and efficient airport operations.

1.2.3 Operations Exceeding Airport Standards.

The standards in this AC do not prevent, regulate or control operation of aircraft at an airport even though the physical characteristics of the runways, taxiways and aprons are sub-standard for a particular aircraft operation. While an aircraft operation exceeding airport standards is not inherently unsafe, such operations have potential to introduce hazards and risks to the pilot as well as other aircraft, vehicles, individuals and facilities on the airport.

1.2.3.1 Specific operational controls may be necessary in order to establish an acceptable level of safety for operation of aircraft that exceed the standards at the airport. As applicable, consult with the appropriate FAA office (e.g. Airports, Flight Technologies and Procedures Division (AFS-400), Air Traffic Organization) to identify potential adjustments to operational procedures that can accommodate these operations. Refer to AC 150/5000-17, *Critical Aircraft and Regular Use Determination*, for guidance related to critical aircraft.

1.3 Federal Regulations.

The following federal regulations have a prominent role for development of an airport. This listing is not inclusive of all federal regulations that have applicability at an airport.

1.3.1 Title 14 CFR Part 77, Safe, Efficient Use and Preservation of the Navigable Airspace (Part 77).

Part 77 requires proponents of construction or alteration on or near an airport to give timely notification to the FAA. This notification serves as the FAA basis for:

1. Evaluating the effect of the proposed construction or alteration on safety in air commerce and the efficient use and preservation of the navigable airspace and of airport traffic capacity at public use airports;
2. Determining whether the effect of proposed construction or alteration is a hazard to air navigation;
3. Determining appropriate marking and lighting recommendations, using AC 70/7460-1, *Obstruction Marking and Lighting*;
4. Determining other appropriate measures to be applied for continued safety of air navigation; and
5. Notifying the aviation community of the construction or alteration of objects that affect the navigable airspace, including the revision of charts, when necessary.

The FAA Obstruction Evaluation/Airport Airspace Analysis (OE/AAA) website https://oeaaa.faa.gov/oeaaa is available for electronic submission of this notice. FAA Order JO 7400.2, *Procedures for Handling Airspace Matters*, establishes the FAA's policy for processing airspace matters.

1.3.2 Title 14 CFR Part 139, Certification of Airport (Part 139).

Part 139 regulates airports having scheduled air carrier operations with more than nine passenger seats or unscheduled air carrier operations with more than 30 passenger seats. This includes "joint-use airports" (also known as "shared-use airports"). This AC, along with other applicable ACs, contains methods and procedures acceptable to the FAA Administrator that certificate holders may use to comply with Part 139 requirements.

1.3.3 Title 14 CFR Part 157, Notice of Construction, Alteration, Activation and Deactivation of Airports (Part 157).

Part 157 establishes standards and notification requirements for anyone proposing to construct, alter, or deactivate a civil or joint-use (civil/military) airport. This regulation also addresses proposals that alter the status or use of an airport. This notification serves as the FAA basis for evaluating the effects of the proposed action on the safe and efficient use of airspace by aircraft and the safety of persons and property on the ground. Notification allows the FAA to identify potential aeronautical hazards in advance, thus preventing or minimizing the adverse impacts to the safe and efficient use of navigable airspace.

1.3.4 Title 49 CFR Part 1542, Airport Security (Part 1542).

Part 1542 is a Transportation Security Administration regulation governing the security of airports that serve air carriers and commercial operations. Compliance with Part 1542 satisfies the public protection requirements of § 139.335 from Part 139. Key elements of Part 1542 requirements include:

- Airport security program
- Secured area
- Air operations area
- Security identification display area
- Access control systems
- Personnel identification systems.

1.4 Environmental Protection.

The National Environmental Policy Act (NEPA) requires Federal agencies to disclose to the public a clear, accurate description of potential environmental impacts that a proposed Federal action and reasonable alternatives would cause. Federal assistance in airport development projects and airport layout plan (ALP) approvals are federal actions that require the FAA to follow the procedures of the NEPA in connection with project approval. FAA compliance with NEPA aligns with the FAA's mission to protect and enhance natural resources and the quality of the environment. For additional guidance and information, refer to the following FAA documents:

1. FAA Order 1050.1, *Policies and Procedures for Considering Environmental Impacts*.
2. FAA Order 5050.4, *National Environmental Policy Act (NEPA) Implementing Instructions for Airport Actions.*

1.5 Definitions.

The definitions in this paragraph are relevant to airport design standards.

1. *Accelerate-Stop Distance Available (ASDA).* See Declared Distances.
2. *Aeronautical Study.* Process by which the FAA determines the impact of an object on the safe and efficient use of airspace (refer to CFR Part 77) or the impact of an airport proposal (refer to CFR Part 157).
3. *Air Operations Area (AOA).*
    a. For Part 139 certificated airports, air operations area is that portion of an airport in which security measures of 49 CFR Part 1540 apply. This area includes aircraft movement areas, aircraft parking areas, loading ramps, and safety areas, for use by aircraft regulated under 49 CFR part 1544 or 1546, and any adjacent

areas (such as general aviation areas) that are not separated by adequate security systems, measures, or procedures. Reference 49 CFR § 1540.5.

b. For non-part 139 airports (e.g. General aviation airports), the air operations area is the paved and unpaved areas of an airport intended to facilitate aircraft movement. Generally, the air operations area encompasses that part of the airport within the perimeter fence.

4. *Air Traffic Control Facilities (ATC-F)*. Electronic equipment and buildings aiding air traffic control (ATC) for communications, surveillance of aircraft including weather detection and advisory systems. See Table 1-1.

5. *Aircraft.* For this AC, the terms "aircraft" and "airplane" are synonymous, referring to all types of fixed-wing airplanes, including gliders. Unless specifically noted, these two terms exclude powered lift (tilt-rotors) and single rotor and dual rotor helicopters.

6. *Aircraft Approach Category (AAC).* As specified in 14 CFR Part 97 § 97.3, *Symbols and Terms Used in Procedures*, a grouping of aircraft based on a reference landing speed (V_{REF}), if specified, or if V_{REF} is not specified, 1.3 times stall speed (V_{SO}) at the maximum certificated landing weight. V_{REF}, V_{SO}, and the maximum certificated landing weight are those values as established for the aircraft by the certification authority of the country of registry. In addition, the Operational Specifications under Part 121, Part 129, or Part 135 for a specific operator and aircraft type may specify a minimum approach speed that is the AAC, rather than V_{REF}.

7. *Airplane*. A fixed-wing aircraft that is heavier than air and is supported in flight by the dynamic reaction of the air against its wings (see Aircraft).

8. *Airplane Design Group (ADG).* A classification of aircraft based on wingspan and tail height. When the aircraft wingspan and tail height fall in different groups, the higher group applies. See Table 1-2.

9. *Airport Elevation.* The highest point on an airport's usable runways expressed in feet above mean sea level (MSL).

10. *Airport Layout Plan (ALP).* A scaled drawing (or set of drawings), in either hardcopy or electronic form, of existing and future airport facilities that provides a graphic representation of the existing and long-term development plan for the airport and demonstrates the preservation and continuity of safety, utility, and efficiency of the airport to the satisfaction of the FAA.

11. *Airport Reference Code (ARC).* An airport designation that signifies the airport's highest Runway Design Code (RDC), minus the third (visibility) component of the RDC. The ARC is for planning and design only and does not limit the aircraft that may be able to operate safely on the airport.

12. *Airport Reference Point (ARP).* The approximate geometric center of all usable runways at the airport.

13. *Airport.* An area of land used for or intended for the landing and takeoff of aircraft, including associated buildings and facilities, if any.

14. *Aligned Taxiway.* A non-standard taxiway configuration with the centerline aligned with a runway centerline. Sometimes referred to as an "inline taxiway." Aligned taxiways represent a runway/taxiway configuration that increases the risk of a runway incursion.

15. *Approach Procedures with Vertical Guidance (APV).* An instrument approach based on a navigation system that is not required to meet the precision approach standards of ICAO Annex 10 but provides course and glidepath deviation information.

16. *Approach Reference Code (APRC).* A code signifying the current operational capabilities, within current standards, of a runway and associated parallel taxiway with regards to landing operations.

17. *Approach Surface Baseline.* A horizontal line tangent to the surface of the earth at the runway threshold aligned with the final approach course.

18. *Blast Fence.* A barrier used to divert or dissipate jet blast or propeller wash.

19. *Blast Pad.* A surface adjacent to the ends of runways provided to reduce the erosive effect of jet blast and propeller wash.

20. *Building Restriction Line (BRL).* For planning considerations, a line identifying suitable and unsuitable locations for buildings on the airport.

21. *Bypass Taxiway.* An entrance taxiway used to manage aircraft queuing demand by providing multiple runway access points.

22. *Category-I (CAT-I).* An instrument approach or approach and landing with a HAT or minimum descent altitude not lower than 200 ft (60 m) and with either a visibility not less than ½ statute mile (800 m), or a runway visual range not less than 1800 ft (550 m).

23. *Category-II (CAT-II).* An instrument approach or approach and landing with a HAT lower than 200 ft (60 m) but not lower than 100 ft (30 m) and a runway visual range not less than 1200 ft (350 m).

24. *Category-III (CAT-III).* An instrument approach or approach and landing with a HAT lower than 100 ft (30 m), or no HAT, or a runway visual range less than 1200 ft (350 m).

25. *Circling Approach.* A maneuver initiated by the pilot to align the aircraft with a runway for landing when a straight-in landing from an instrument approach is not possible or is not desirable.

26. *Clearway (CWY).* A defined rectangular area beyond the end of a runway cleared or suitable for use in lieu of runway to satisfy takeoff distance requirements (see also Takeoff Distance Available [TODA]).

27. *Cockpit to Main Gear Distance (CMG).* The distance from the pilot's eye to the main gear turn center.

28. *Commercial Service Airport.* A public use airport receiving scheduled passenger aircraft service and at least 2,500 annual passenger boardings. Refer to the official the definition of Title 49 USC § 47102.

29. *Compass Calibration Pad.* An airport facility used for calibrating an aircraft compass.

30. *Critical Aircraft.* The critical aircraft is the most demanding aircraft type, or grouping of aircraft with similar characteristics, that make regular use of an airport. Regular use is 500 annual operations, excluding touch-and-go operations. See AC 150/5000-17. The critical aircraft determines the applicable design standards for facilities on the airport including runway, taxiway, etc. Previously referred to as "design aircraft".

31. *Crossover Taxiway.* A taxiway connecting two parallel taxiways (also referred to as a "transverse taxiway").

32. *Decision Altitude (DA).* A specified altitude on a vertically-guided approach at which a pilot initiates a missed approach if the pilot cannot establish the required visual reference to continue the approach. DA is referenced to mean sea level (MSL).

33. *Declared Distances.* The distances the airport owner declares available for an aircraft's takeoff run, takeoff distance, accelerate-stop distance, and landing distance requirements. The distances are:

    a. *Takeoff Run Available (TORA)* – the runway length declared available and suitable for the ground run of an aircraft taking off;

    b. *Takeoff Distance Available (TODA)* – the TORA plus the length of any remaining runway or clearway beyond the far end of the TORA; the full length of TODA may need to be reduced because of obstacles in the departure area;

    c. *Accelerate-Stop Distance Available (ASDA)* – the runway plus stopway length declared available and suitable for the acceleration and deceleration of an aircraft aborting a takeoff; and

    d. *Landing Distance Available (LDA)* – the runway length declared available and suitable for landing an aircraft.

34. *Departure End of Runway (DER).* The end of the runway that is opposite the landing threshold. Also known as the stop end of runway.

35. *Departure Reference Code (DPRC).* A code signifying the current operational capabilities, within current standards, of a runway with regard to takeoff operations.

36. *Displaced Threshold.* A threshold that is located at a point on the runway beyond the beginning of the runway. See threshold.

37. *End-Around Taxiway (EAT).* A taxiway designed to cross the extended centerline of a runway, which does not require specific clearance from air traffic control (ATC) to cross the extended centerline of the runway.

38. *Entrance Taxiway.* A taxiway designed for use by an aircraft for direct entry to a runway. An entrance taxiway may also serve as an exit from the runway.

39. *Exit Taxiway.* A taxiway designed for aircraft exit only from a runway:

    a. *Acute-Angled Exit Taxiway* – A taxiway forming an angle less than 90 degrees from the runway centerline.

    b. *High Speed Exit Taxiway* – An acute-angled exit taxiway forming a 30-degree angle with the runway centerline, designed to allow an aircraft to exit a runway quickly without having to decelerate to typical taxi speed.

40. *Fixed-By-Function Navigation Aid (NAVAID).* An air navigation aid positioned in a specific location in order to provide an essential benefit for aviation is fixed-by-function. Table 6-1 gives fixed-by-function designations for various NAVAIDs as they relate to the Runway Safety Area (RSA) and Runway Object Free Area (ROFA).

41. *Frangible.* A physical characteristic whereby an object retains its structural integrity and stiffness up to a designated maximum load, but on impact from a greater load, breaks, distorts, or yields in such a manner as to present the minimum hazard to aircraft. See AC 150/5220-23, *Frangible Connections*.

42. *General Aviation (GA).* All non-scheduled civil flights conducted by non-commercial aircraft. General aviation covers local recreational flying to business transport that is not operating under the FAA regulations for commercial air carriers.

43. *General Aviation Airport.* A public-use airport that: 1) does not have scheduled service, or 2) has scheduled service with less than 2, 500 annual passenger boardings. Refer to the official definition at Title 49 USC § 47102. FAA Report, *General Aviation Airports: A National Asset* - May 2012, establishes the following classifications of General Aviation airports: National, Regional, local and basic.

44. *Glide Path Angle (GPA).* The GPA is the angle of the final approach descent path relative to the approach surface baseline.

45. *Glideslope (GS).* Equipment in an Instrument Landing System (ILS) that provides electronic vertical guidance to landing aircraft.

46. *Hazard to Air Navigation.* An existing or proposed object that the FAA, as a result of an aeronautical study, determines will have a substantial adverse effect upon the safe and efficient use of navigable airspace by aircraft, operation of air navigation facilities, or existing or potential airport capacity.

47. *Height Above Airport (HAA).* The height of the circling approach descent altitude (MDA) above the airport elevation.

48. *Height Above Touchdown (HAT).* The height of the decision altitude or Minimum Descent Altitude (MDA) above the threshold.

49. *High-energy area/intersection.* An area or intersection within the middle third of a runway.

50. *Hot Spot.* A location on an airport movement area with a history of potential risk of collision or runway incursion, and where heightened attention by pilots/drivers/controllers is necessary.

51. *International Civil Aviation Organization (ICAO)*. ICAO is a United Nations specialized agency that manages the administration and governance of the Convention on International Civil Aviation. ICAO works with its Member States and industry groups to reach consensus on international civil aviation Standards and Recommended Practices and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector.

52. *Instrument Flight Procedure (IFP).* An instrument flight procedure is a series of predetermined maneuvers for aircraft operating under instrument flight rules, i.e. IFR conditions, when visual flight is not possible due to weather or other visually restrictive conditions. These maneuvers allow for the orderly transition of the aircraft through a particular airspace. The term "instrument flight procedure" refers to instrument approaches, instrument departures, and instrument en route operations.

53. *Island.* A non-serviceable paved or grassy area bounded by taxiway, taxilane, or apron pavement.

54. *Joint-Use Airport*. An airport owned by the Department of Defense, at which both military and civilian aircraft make shared use of the airfield. Refer to Part 139.

55. *Landing Distance Available (LDA).* See Declared Distances.

56. *Large Aircraft.* An aircraft with a maximum certificated takeoff weight of more than 12,500 lbs (5670 kg).

57. *Low Impact Resistant (LIR) Support.* A support designed to resist operational and environmental static loads and fail when subjected to a shock load such as that from a colliding aircraft.

58. *Main Gear Width (MGW).* The distance from the outer edge to outer edge of the widest set of main gear tires.

59. *Minimum Descent Altitude (MDA)*. The lowest altitude, expressed in feet above mean sea level (MSL), to which descent is authorized on final approach or during circle-to-land maneuvering in execution of a standard instrument approach procedure where no electronic glideslope is provided.

60. *Modification of Standards.* Any approved deviation from published FAA standards applicable to an airport design, construction, or equipment project that is necessary to accommodate an unusual local condition for a specific project while maintaining an acceptable level of safety and performance. See FAA Order 5300.1.

61. *Movement Area.* A designated area consisting of runways, taxiways, taxilanes, and other areas of an airport that are used for taxiing or hover taxiing, air taxiing, takeoff, and landing of aircraft including helicopters and tilt-rotors, exclusive of loading aprons and aircraft parking areas. At airports with operating ATCTs, positive control of aircraft operating in the movement areas is exercised by Air Traffic Control (reference Part 139).

62. *Navigation Aid (NAVAID)*. Electronic and visual air navigation aids, lights, signs, and associated supporting equipment.

63. *Non-movement area*. The areas of an airport that are used for taxiing or hover taxiing, or air taxiing aircraft including helicopters and tilt-rotors, but are not part of the movement area (i.e. the loading aprons and aircraft parking areas).

64. *Non-Precision Approach (NPA).* An instrument approach based on a navigation system that provides course deviation information, but no glidepath deviation information.

65. *Non-Precision Runway.* A runway (other than a precision runway) with at least one end having a non-precision approach procedure.

66. *Object.* Includes, but is not limited to, above ground structures, Navigational Aids (NAVAIDs), equipment, vehicles, natural growth, terrain, and parked or taxiing aircraft.

67. *Object Free Area (OFA).* An area centered on the surface of a runway, taxiway, or taxilane centerline provided to enhance the safety of aircraft operations by remaining clear of objects, except for objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes.

68. *Obstacle.* An existing object at a fixed geographical location or which may be expected at a fixed location within a prescribed area with reference to which vertical clearance is necessary during flight operation.

69. *Obstacle Clearance Surface (OCS).* An evaluation surface that defines the minimum required obstruction clearance for approach or departure procedures.

70. *Obstacle Free Zone (OFZ).* The OFZ is the three-dimensional airspace along the runway and extended runway centerline that is clear of obstacles for protection for aircraft landing or taking off from the runway and for missed approaches. The OFZ consist of four distinct surfaces; Runway OFZ, Precision OFZ, Inner-Transitional OFZ, and the Inner-Approach OFZ.

71. *Obstruction to Air Navigation.* An object of greater height than any of the heights or surfaces presented in Subpart C of Title 14 CFR Part 77, *Standards for Determining Obstructions to Air Navigation or Navigational Aids or Facilities*.

72. *Offset approach*. Approach that is conducted at an angle offset from the runway centerline. A typical offset approach is 3 degrees to the right or left of the straight in runway heading.

73. *Parallel Taxiway*. A continuous taxiway path that is located laterally to the runway it serves and provides access to one or both runway ends without entering the runway safety area or runway obstacle free zone; it is not necessary for all points along the centerline of a parallel taxiway to be equidistant from the runway centerline.

    a. *Dual Parallel Taxiways* – Two side-by-side taxiways, parallel to each other and the runway (usually called inner parallel and outer parallel taxiway relative to the runway being served).

b. *Full Parallel Taxiway* – A parallel taxiway extending the full length of the runway to provide access to both runway ends.

c. *Partial Parallel Taxiway* – A parallel taxiway extending less than full length of the runway to provide access to only one runway end.

74. *Plans-on-File*. Plans-on-file represents the airport's future airfield development including, but not limited to, runway extensions or construction of taxiways. Obligated airports submit their plans-on-file to the FAA by way of their Airport Layout Plan, whereas non-obligated airports submits through FAA Form 7480-1 in accordance with 14 CFR Part 157.

75. *Precision Approach (PA).* An instrument approach based on a navigation system that provides course and glidepath deviation information.

76. *Precision Runway.* A runway with at least one end having a precision approach procedure.

77. *Primary Airport (large hub, medium hub, small hub, non-hub).* A commercial service airport with 10,000 annual passenger boardings. Refer to the official definition at Title 49 USC § 47102.

78. *Public Use Airport*. An airport used for public purposes that is 1) under control of or owned by a public agency, or 2) under private ownership that is a reliever airport or has scheduled passenger service with at least 2,500 annual passenger boardings Refer to the official definition at Title 49 USC § 47102.

79. *Regular Use.* As defined in AC 150/5000-17, regular use is 500 annual operations, including both itinerant and local operations, but excluding touch-and-go operations. An operation is either a takeoff or landing.

80. *Runway (RW).* A defined rectangular surface on an airport prepared or suitable for the landing or takeoff of aircraft.

81. *Runway Design Code (RDC).* A code signifying the design standards that apply to an existing or planned runway.

82. *Runway Incursion.* Any occurrence at an airport involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and takeoff of aircraft.

83. *Runway Protection Zone (RPZ).* An area at ground level prior to the threshold or beyond the runway end to enhance the safety and protection of people and property on the ground.

84. *Runway Safety Area (RSA).* A defined area surrounding the runway consisting of a prepared surface suitable for reducing the risk of damage to aircraft in the event of an undershoot, overshoot, or excursion from the runway.

85. *Runway Visual Range (RVR).* An instrumentally derived value that represents the horizontal visual range a pilot will see down the runway from the approach end. It is based on the sighting of either high intensity runway lights or on the visual contrast of other targets whichever yields the greater visual range. RVR, in contrast

to prevailing or runway visibility, is based on what a pilot in a moving aircraft should see looking down the runway.

86. *Shoulder*. An area adjacent to the defined edge of paved runways, taxiways, or aprons designed to transition between the pavement and the adjacent surface; support aircraft and emergency vehicles deviating from the full-strength pavement; enhanced drainage; and blast protection.

87. *Small Aircraft.* For the purpose of this AC, an aircraft with a maximum certificated takeoff weight of 12,500 lbs (5670 kg) or less.

88. *Stopway.* An area beyond the takeoff runway, no less wide than the runway and centered upon the extended centerline of the runway, able to support the airplane during an aborted takeoff, without causing structural damage to the airplane, and designated by the airport for use in decelerating the airplane during an aborted takeoff.

89. *Takeoff Distance Available (TODA).* See Declared Distances.

90. *Takeoff Run Available (TORA).* See Declared Distances.

91. *Taxilane (TL).* A defined taxi path designed for low speed and precise maneuvering of aircraft. Taxilanes provide access from taxiway to aircraft parking positions and other terminal areas. Taxi speeds on taxilanes are generally not more than 15 mph (13 kts).

92. *Taxiway (TW).* A defined path established for the taxiing of aircraft from one part of an airport to another. Taxi speeds on taxiways will typically range from 15 mph (13 kts) to 35 mph (30 kts).

93. *Taxiway Centerline*. A surface painted marking on the taxiway that provides continuous visual reference for pilot steering of aircraft during taxi operations. On straight taxiway sections, the taxiway centerline represents the physical center of the taxiway width. On curved taxiway sections, the taxiway centerline represents the optimum steering path even though the marking itself may not be located at the physical center of the pavement section.

94. *Taxiway Design Group (TDG).* A classification of airplanes based on outer to outer Main Gear Width (MGW) and Cockpit to Main Gear distance (CMG).

95. *Taxiway Edge Safety Margin (TESM).* The distance between the outer edge of the landing gear of an airplane with its nose gear on the taxiway centerline and the edge of the taxiway pavement.

96. *Taxiway/Taxilane Safety Area (TSA).* A defined surface alongside the taxiway prepared or suitable for reducing the risk of damage to an aircraft deviating from the taxiway.

97. *Threshold (TH).* The beginning of that portion of the runway available for landing. In some instances, the threshold may be displaced. “Threshold” always refers to landing, not the start of takeoff.

98. *Threshold Crossing Height (TCH).* For the purposes of this AC, the TCH is the theoretical height above the runway threshold at which the aircraft’s glideslope (GS)

antenna would be if the aircraft maintains the trajectory established by the Instrument Landing System (ILS) GS, or the height of the pilot’s eye above the runway threshold based on a visual guidance system.

99. *Visibility Minimums.* The ability, as determined by atmospheric conditions and expressed in units of distance, to see and identify prominent unlighted objects by day and prominent lighted objects by night. Visibility is reported as statute miles or hundreds of feet.

100. *Visual Runway*. A runway without an instrument approach or departure procedure, except circling-only approaches.

101. *Wingspan*. The maximum horizontal distance from one wingtip to the other wingtip, including the horizontal component of any extensions such as winglets or raked wingtips. See Appendix A.

1.6 Categories and Codes.

1.6.1 Aircraft Approach Categories (AAC).

A grouping of aircraft related to aircraft approach speed (operational characteristic) per Table 1-1.

Table 1-1. Aircraft Approach Category (AAC)

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

1.6.2 Airplane Design Group (ADG).

A grouping of aircraft related to aircraft wingspan or tail height (physical characteristics), whichever is most restrictive. Refer to see Table 1-2.

Table 1-2. Airplane Design Group (ADG)

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)

1.6.3 Visibility Minimums.

The runway's lowest visibility published on an instrument approach chart expressed by RVR values in feet of 1200, 1600, 2400, 4000, and 5000 per Table 1-3. For visual approach only runway, use "VIS" in lieu of an RVR value.

Table 1-3. Visibility Minimums

RVR (ft) *	Instrument Flight Visibility Category (statute mile)
5000	Not lower than 1 mile
4000	Lower than 1 mile but not lower than ¾ mile
2400	Lower than 3/4 mile but not lower than 1/2 mile
1600	Lower than 1/2 mile but not lower than 1/4 mile
1200	Lower than 1/4 mile

Note: * RVR values are not exact equivalents.

1.6.4 Runway Design Code (RDC).

A three-component code relating AAC, ADG and approach visibility minimums establishing the design characteristics for a particular runway. The critical aircraft with regular use defines the AAC and ADG components of RDC, whereas the runway's lowest visibility published on an instrument approach chart determines the visibility component. The RDC convention is as follows:

RDC: AAC-ADG-RVR

Example: D-IV-1200

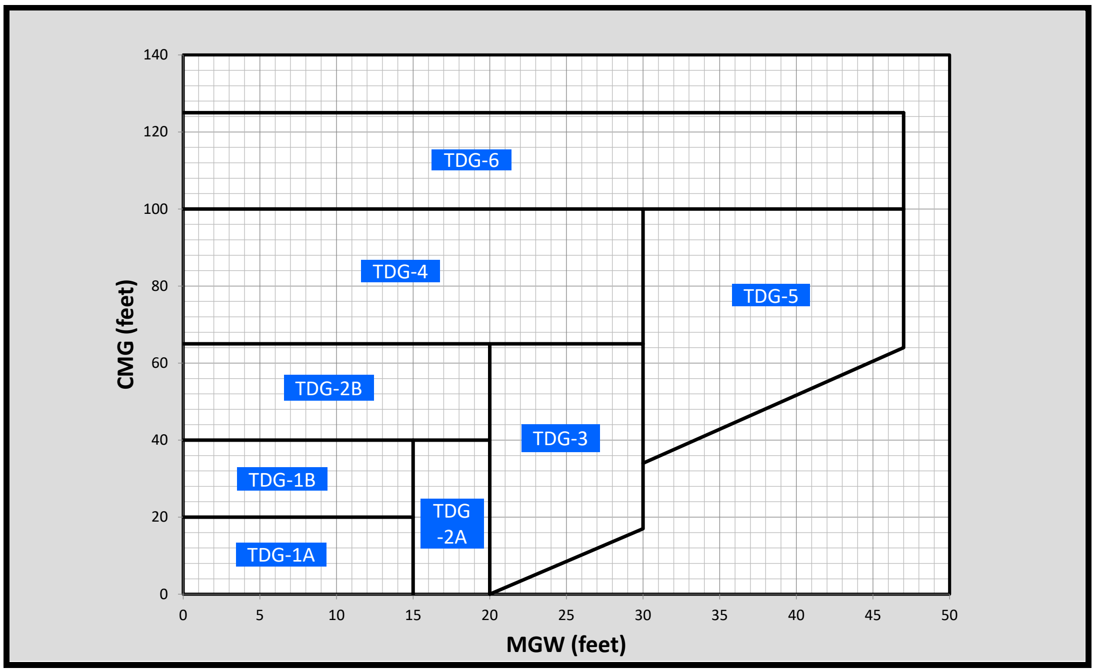
1.6.4.1 **Application.**

RDC establishes the standards that apply to a specific runway, existing or future. This can vary per runway. For example, an airport's air carrier runway may have an RDC of C-IV-1200. The same airport's general aviation runway may have an RDC of B-II-2400. The airport's ALP may show both an existing RDC and future RDC.

1.6.5 Taxiway Design Group (TDG).

TDG is the grouping of aircraft based on undercarriage dimensions. TDG relates the cockpit to main gear dimension and the width of the main gear. The TDG is a primary design factor for taxiway/taxilane width and fillet standards. Under certain conditions where it is critical to maintain a 50-degree nose gear steering angle, the TDG may determine the necessary runway to taxiway and taxiway/taxilane separation values. Separate areas of an airport may have different TDG classifications due to segregation of aircraft types and sizes. See Figure 1-1.

Figure 1-1. Taxiway Design Groups (TDGs)



1.7 Airport Layout Plan (ALP).

An ALP is a graphic representation of existing facilities and proposed development plans for an airport. Airports that receive federal assistance accept a grant assurance that obligates it to maintain a current ALP. See paragraph 1.9.1 for additional information on federal obligations. Refer to the FAA's Office of Airport Planning and Environmental (APP-400) guidance for additional information on the development of ALPs.

1.8 Airport Data.

Airport planning, design, and evaluation activities require information that accurately describe the location, characteristics and condition of airport facilities, infrastructure and off-airport structures. This information consists of geospatial data collected during the planning, design, and construction phase of airport development. It is paramount for airport operators to accurately collect and report safety-critical data to the FAA in a timely manner.

1.8.1 Aeronautical Studies.

The FAA conducts aeronautical studies of proposed development on and adjacent to airports under Part 77 as described in paragraph 1.1. These studies assess the potential impact on air navigation using the best available data and plans on file. Physical changes to airport elements can adversely affect the accuracy of such studies. The FAA encourages airport operators to submit airfield changes to the FAA as soon as changes are planned. This includes timely submittal of ALP updates. In particular, ensure that the FAA has the latest data on actual and planned facilities for the following elements:

- Runway ends.
- Displaced thresholds.
- High and low points on the runway surfaces.
- Helipads.

1.8.2 Airport Master Record.

The Airport Master Record (see https://adip.faa.gov/agis/public/#/public) describes the basic operational and services data of the airport. The primary purpose of the Airport Master Record is to identify the minimum data and information about the existing physical infrastructure, characteristics, services, operations, and status of all airports composing the National Airspace System (NAS). Title 49 U.S.C. § 47130 authorizes the FAA to collect and manage this data.

1.8.2.1 The FAA uses this data for flight information publications, navigation databases, and various analyses. Airport operators, FAA inspectors and state-sponsored inspectors may collect and submit data for the master record.

1.8.2.2 Timely collection and submittal of data reflecting changed conditions enhances the accuracy of aeronautical information. Refer to AC 150/5300-19, *Airport Data and Information Program*, for additional guidance and information.

1.8.3 Aeronautical Surveys.

The FAA uses aeronautical survey data to support development and modification of instrument procedures. The FAA reviews all Instrument Flight Procedures (IFP) on a periodic basis – approximately every two years. The FAA uses this data, in part, to:

1. Protect existing runway approaches from proposed development and discovered obstacles that could create a hazard to air navigation by:

a. Raising approach minima,
b. Restricting night operations, or
c. Canceling approach procedures.

2. Provide for the design and development of new IFPs to the lowest visibility minimums possible,
3. Provide accurate information for planning studies that assess the impact of airport noise, and
4. Ensure that review and coordination of on-airport development proposals maintain critical clearance standards for the completed project.

1.8.3.1 **Applicable Advisory Circulars.**

1. AC 150/5300-16, *General Guidance and Specifications for Aeronautical Surveys: Establishment of Geodetic Control and Submission to the National Geodetic Survey*
2. AC 150/5300-17, *Standards for Using Remote Sensing Technologies in Airport Surveys*
3. AC 150/5300-18, *General Guidance and Specifications for Submission of Aeronautical Surveys to NGS: Field Data Collection and Geographic Information System (GIS) Standards*

1.8.4 Plans on File.

The information on file with the FAA influences the determination resulting from aeronautical studies. Having an up to date plan-on-file with the FAA ensures proposed airport development receives full consideration during FAA studies. An update to the ALP is the conventional method to transmit development information. Filing notification of proposed development represents another method of establishing a plan-on-file. Keeping plan-on-file data and information current, complete and accurate greatly improves the effectiveness of FAA evaluations. For any new runway, runway extension, or planned runway upgrade, the necessary plan data include as a minimum:

1. Planned runway end and threshold coordinates and elevation
2. Proposed type of instrument approach
3. Desired visibility minimum(s)
4. Indication of whether the airport will have a designated instrument departure runway.

1.9 **Federal Assistance Program.**

Title 49 USC § 47104 authorizes the FAA to administer a grant program that provides financial assistance for project grants at public use airports for airport planning and development. Refer to paragraph 3 for applicability of the standards of this AC under financial assistance programs. Refer to FAA Order 5100.38, *Airport Improvement*

Program Handbook, or contact the local FAA airports district office (ADO) for specific information on matters concerning project eligibility. This AC does not establish, modify or address project eligibility under the grant program.

1.9.1 Obligations.

Airport sponsors agree to certain obligations when they accept Federal grant funds or Federal property transfers for airport purposes. Conformance to the FAA standards in this AC are a factor in determining an airport's compliance with select obligations. The FAA enforces these obligations through its Airport Compliance Program. More information on the Airport Compliance Program can be found in FAA Order 5190.6, *FAA Airport Compliance Manual*. For a complete list of assurance obligations, visit the FAA Grant Assurances webpage.

1.10 **State Role.**

Each state has an aeronautical office or similar department that oversees civil aviation activities in the state. The degree of involvement varies between states. Typical state activities include:

1. Maintaining state aviation system plans
2. Conducting airport inspections
3. Updating Airport Master Records (FAA Form 5010)
4. Working with local agencies on airport zoning and environmental matters
5. Providing supplemental financial assistance.
6. Protecting environment resources
7. Promoting aviation education
8. Licensing of airports

1.10.1 State Standards.

In limited circumstances, the FAA can approve standards developed by a State for development of non-primary airports.

1.10.1.1 Title 49 USC § 47105(c) allows the FAA to approve standards a State prescribes for airport development at non-primary airports. This provision excludes the FAA standards for safety of approaches. Once approved by the FAA, the State's standards apply instead of FAA comparable standards.

1.10.1.2 Title 49 USC § 47114(d)(5) prescribes the use of State highway specifications for airfield pavement construction at nonprimary airports serving aircraft not exceeding 60,000 pounds gross weight provided the FAA determines safety is not adversely affected and the expected service life of pavement is not less than what FAA standards provide. Refer to

AC 150/5100-13, *Development of State Aviation Standards for Airport Pavement Construction,* for additional details.

1.10.2 State Highway Specifications.

As permitted by 49 USC § 47114(d)(5), a state may request use of highway specifications for pavement construction at nonprimary airports serving aircraft that do not exceed 60,000 lbs (27,216 kg). The FAA may approve such use provided safety is not adversely affected and the life of the pavement, with necessary maintenance, is equivalent to the service life expected from FAA standards.

1.11 Local Government Role.

A local governmental is typically responsible for the proper maintenance and operation of the airport it owns. Local government units may have regulations and ordinances affecting airport development and operation. Many local governmental units establish zoning ordinances that benefit the protection of airspace surrounding an airport and persons residing close to an airport. Additionally, local rules may exist for storm water management, building codes and fire code.

1.12 Related Documents and Federal Regulations.

The following is a list of documents referenced in this AC and additional related information. Most Advisory Circulars, FAA Orders, and Regulations are available online at www.faa.gov. All references to ACs, FAA Orders, and Federal Regulations are to the most recent versions.

1.12.1 Advisory Circulars (ACs).

Advisory Circulars are available at https://www.faa.gov/regulations_policies/advisory_circulars/.

1. AC 43-215, *Standardized Procedures for Performing Aircraft Magnetic Compass Calibration*
2. AC 70/7460-1, *Obstruction Marking and Lighting*.
3. AC 103-6, *Ultralight Vehicle Operations – Airports, ATC, and Weather*.
4. AC 90-66, *Non-Towered Airport Flight Operations.*
5. AC 105-2, *Sport Parachuting.*
6. AC 120-28, *Criteria for Approval of Category III Weather Minima for Takeoff, Landing and Rollout.*
7. AC 120-29, *Criteria for Approval of Category I and Category II Weather Minimums for Approach*.
8. AC 120-57, *Surface Movement Guidance and Control System*.
9. AC 150/5000-17, *Critical Aircraft and Regular Use Determination*
10. AC 150/5020-1, *Noise Control and Compatibility Planning for Airports*.

11. AC 150/5060-5, *Airport Capacity and Delay*.
12. AC 150/5070-6, *Airport Master Plans*.
13. AC 150/5070-7, *The Airport System Planning Process*
14. AC 150/5100-13, *Development of State Aviation Standards for Airport Pavement Construction*.
15. AC 150/5100-17, *Land Acquisition and Relocation Assistance for Airport Improvement Program Assisted Projects*.
16. AC 150/5190-4, *A Model Zoning Ordinance to Limit Height of Objects around Airports*.
17. AC 150/5190-6, *Exclusive Rights at Federally Obligated Airports*.
18. AC 150/5190-7, *Minimum Standards for Commercial Aeronautical Activities*.
19. AC 150/5200-33, *Hazardous Wildlife Attractants On or Near Airports*.
20. AC 150/5200-34, *Construction or Establishment of Landfills near Public Airports*.
21. AC 150/5200-35, *Submitting the Airport Master Record in Order to Activate a New Airport*.
22. AC 150/5210-15, *Aircraft Rescue and Firefighting Station Building Design*.
23. AC 150/5210-22, *Airport Certification Manual (ACM)*.
24. AC 150/5220-16, *Automated Weather Observing Systems (AWOS) for Non-Federal Applications*.
25. AC 150/5220-18, *Buildings for Storage and Maintenance of Airport Snow and Ice Control Equipment and Materials*.
26. AC 150/5220-22, *Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns*.
27. AC 150/5220-23, *Frangible Connections*.
28. AC 150/5220-26, *Airport Ground Vehicle Automatic Dependent Surveillance – Broadcast (ADS-B) Out Squitter Equipment*.
29. AC 150/5230-4, *Aircraft Fuel Storage, Handling, and Dispensing on Airports*.
30. AC 150/5300-7, *FAA Policy on Facility Relocations Occasioned by Airport Improvements or Changes*.
31. AC 150/5300-14, *Design of Aircraft Deicing Facilities*.
32. AC 150/5300-16, *General Guidance and Specifications for Aeronautical Surveys: Establishment of Geodetic Control and Submission to the National Geodetic Survey*.
33. AC 150/5300-17, *Standards for Using Remote Sensing Technologies in Airport Surveys*.

34. AC 150/5300-18, *General Guidance and Specifications for Submission of Aeronautical Surveys to NGS: Field Data Collection and Geographic Information System (GIS) Standards*.
35. AC 150/5300-19, *Airport Data and Information Program*
36. AC 150/5320-5 (UFC 3-230-01), *Surface Drainage Design*.
37. AC 150/5320-6, *Airport Pavement Design and Evaluation*.
38. AC 150/5320-12, *Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces*.
39. AC 150/5320-15, *Management of Airport Industrial Waste*.
40. AC 150/5325-4, *Runway Length Requirements for Airport Design*.
41. AC 150/5335-5, *Standardized Method of Reporting Airport Pavement Strength – PCN*.
42. AC 150/5340 and AC 150/5345 series.
43. AC 150/5340-1, *Standards for Airport Markings*.
44. AC 150/5340-5, *Segmented Circle Airport Marker System*.
45. AC 150/5340-18, *Standards for Airport Sign Systems*.
46. AC 150/5340-30, *Design and Installation Details for Airport Visual Aids*.
47. AC 150/5345-43, *Specification for Obstruction Lighting Equipment*.
48. AC 150/5345-44, *Specification for Runway and Taxiway Signs*.
49. AC 150/5345-52, *Generic Visual Glideslope Indicators (GVGI)*.
50. AC 150/5360-9, *Planning and Design of Airport Terminal Facilities at Non-Hub Locations*.
51. AC 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities*.
52. AC 150/5370-2, *Operational Safety on Airports during Construction*.
53. AC 150/5370-10, *Standard Specifications for Construction of Airports*.
54. AC 150/5370-15, *Airside Applications for Artificial Turf*.
55. AC 150/5380-9, *Guidelines and Procedures for Measuring Airfield Pavement Roughness*
56. AC 150/5390-2, *Heliport Design*.
57. AC 150/5395-1, *Seaplane Bases*.

1.12.2 Engineering Briefs.

Engineering Briefs cover specific technical areas to supplement Advisory Circulars. Engineering Briefs are available at: https://www.faa.gov/airports/engineering/engineering_briefs/.

1.12.3 FAA Orders.

FAA Orders are available at https://www.faa.gov/regulations_policies/orders_notices/.

1. Order 1050.1, *Policies and Procedures for Considering Environmental Impacts*.
2. Order 5050.4, *National Environmental Policy Act (NEPA) Implementing Instructions for Airport Projects*.
3. Order 5090.3, *Field Formulation of the National Plan of Integrated Airport Systems (NPIAS)*.
4. Order 5100.37, *Land Acquisition and Relocation Assistance for Airport Projects*.
5. Order 5100.38, *Airport Improvement Program Handbook*.
6. Order 5190.6, *FAA Airport Compliance Manual*.
7. Order 5200.8, *Runway Safety Area Program*.
8. Order 5200.9, *Financial Feasibility and Equivalency of Runway Safety Area Improvements and Engineered Material Arresting Systems*.
9. Order 5200.11, *FAA Airports (ARP) Safety Management System (SMS)*.
10. Order 5300.1, *Modifications to Agency Airport Design, Construction, and Equipment Standards*.
11. Order 6030.20, *Electrical Power Policy*.
12. Order 6310.6, *Primary/secondary Terminal Radar Siting Handbook*.
13. Order 6480.4, *Airport Traffic Control Tower Siting Criteria*.
14. Order 6560.10, *Runway Visual Range (RVR)*.
15. Order 6560.20, *Siting Criteria for Automated Weather Observing Systems (AWOS)*.
16. Order 6560.21, *Siting Guidelines for Low Level Windshear Alert System (LLWAS) Remote Facilities*.
17. Order JO 6580.3, *Remote Communications Facilities Installation Standards Handbook*.
18. Order 6700.20, *Non-Federal Navigational Aids, Air Traffic Control Facilities, and Automated Weather Systems*
19. Order 6750.16, *Siting Criteria for Instrument Landing Systems*.
20. Order 6750.36, *Site Survey, Selection, and Engineering Documentation for ILS and Ancillary Aids*.
21. Order 6780.5, *DME Installation Standards Handbook Type FA-96-39*.
22. Order 6820.9, *VOR, VOR/DME, VORTAC Installation Standard Drawings*.
23. Order 6820.10, *VOR, VOR/DME and VORTAC Siting Criteria*.
24. Order JO 6850.2, *Visual Guidance Lighting Systems*.
25. Order 6850.10, *Runway End Identifier Lighting (REIL) System Standard Drawings*.

26. Order 6850.19, *Frangible Coupling*.
27. Order 6850.20, *Medium Intensity Approach Lighting System Threshold Lighting Backfit*
28. Order 6950.23, *Cable Loop Communication Systems at Airport Facilities*.
29. Order 7110.65, *Air Traffic Control*
30. Order 7110.104, *Non-Federal Automated Weather Observation System (AWOS) Connection to the Weather Messaging Switching*.
31. Order 7110.308, *Simultaneous Dependent Approaches to Closely Spaced Parallel Runways*
32. Order JO 7400.2, *Procedures for Handling Airspace Matters*.
33. Order 8200.1, *United States Standard Flight Inspection Manual*.
34. Order 8260.3, *United States Standard for Terminal Instrument Procedures (TERPS)*.
35. Order 8260.43, *Flight Procedures Management Program.*
36. Other Orders in the 8260 series, https://www.faa.gov/regulations_policies/orders_notices/.

1.12.4 Federal Regulations.

The Electronic Code of Federal Regulations is available at https://www.ecfr.gov/.

1. 14 CFR Part 77, *Safe, Efficient Use, and Preservation of the Navigable Airspace*
2. 14 CFR Part 139, *Certification of Airports*
3. 14 CFR Part 157, *Notice of Construction, Alteration, Activation, and Deactivation of Airports*
4. 14 CFR Part 1542, *Airport Security*

1.12.5 United States Code (U.S.C.).

The United States Code is available at https://www.govinfo.gov/.

1. 49 U.S.C. Chapter 401, *General Provisions*.
2. 49 U.S.C. Chapter 471, *Airport Development*.

1.12.6 FAA Forms.

FAA Forms are located at https://www.faa.gov/forms/.

1. Form 5010, *Airport Master Record*.
2. Form 7460-1, *Notice of Proposed Construction or Alteration*.
3. Form 7480-1, *Notice of Landing Area Proposal*.

1.12.7 Other FAA Documents.

1. *Aeronautical Information Manual (AIM)*, https://www.faa.gov/air_traffic/publications/.
2. *Aeronautical Information Publication*, http://www.faa.gov/air_traffic/publications/media/aip.pdf.
3. *U.S. Chart Supplement (formerly known as Airport/Facility Directory)*, http://www.faa.gov/air_traffic/flight_info/aeronav/productcatalog/supplementalcharts/AirportDirectory/.
4. FAA Airport Diagrams, https://adip.faa.gov.
5. FAA-H-8083, *Glider Flying Handbook*
6. FAA Memorandum, *Interim Guidance on Land Uses Within a Runway Protection Zone*, dated 9/27/2012, https://www.faa.gov/airports/planning_capacity/media/interimLandUseRPZGuidance.pdf.
7. FAA/USDA manual, *Wildlife Hazard Management at Airports*, https://www.faa.gov/airports/airport_safety/wildlife/resources/media/2005_faa_manual_complete.pdf.
8. Grant Assurances – Airport Sponsors, https://www.faa.gov/airports/aip/grant_assurances/media/airport-sponsor-assurances-aip.pdf.

1.12.8 Non-FAA Documents.

1. Airport Cooperative Research Program (ACRP) Reports, http://onlinepubs.trb.org/onlinepubs/acrp/.
2. American Association of State Highway and Transportation Officials (AASHTO) M268, *Standard Specification for Retroreflective Sheeting for Flat and Vertical Traffic Control Applications*.
3. American Society for Testing and Materials International (ASTM) D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, http://www.astm.org/Standards/D4956.htm.
4. ASTM E810, *Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting Utilizing the Coplanar Geometry*, http://www.astm.org/Standards/E810.htm.
5. Federal Specification FP-85, *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*.
6. Illuminating Engineering Society of North America (IES), *Recommended Practice for Airport Service Area Lighting*.
7. International Air Transport Association (IATA), *Airport Development Reference Manual (ADRM)*.

8. NASA/Aviation Safety Reporting System (ASRS) Directline Issue No. 6, August 1993, *Ground Jet Blast Hazard*, http://asrs.arc.nasa.gov/publications/directline/dl6_blast.htm.

9. National Fire Protection Association (NFPA) 407, *Standard for Aircraft Fuel Servicing*, http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=407.

10. NFPA 409, *Standard on Aircraft Hangars*, http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=409.

11. NFPA 415, *Standard on Airport Terminal Building, Fueling Ramp Drainage and Loading Walkways*, http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=415.

12. Transportation Security Administration document, *Recommended Security Guidelines for Airport Planning and Construction*, https://www.sskies.org/images/uploads/subpage/PARAS_0004.Recommended_Security_Guidelines.FinalReport.v2.pdf.

13. Transportation Security Administration Information Publication A-001, *Security Guidelines for General Aviation Airports*, https://www.tsa.gov/sites/default/files/2017_ga_security_guidelines.pdf.

14. United States Parachute Association (USPA), *Basic Safety Requirements (BSR).*

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CHAPTER 2. Design Principles

2.1 General.

Airport design is a process that involves identifying aeronautical use and needs at an airport followed by application of FAA standards for various airport elements. The objective is to ensure airport development that meets aviation needs while maintaining an acceptable level of safety and capacity with appropriate consideration to the environment.

2.2 Airport Planning Relationship to Airport Design.

2.2.1 Airport design and airport planning are complementary processes. Airport planning provides a framework to guide future airport development. Airport planning incorporates FAA design standards in a manner that addresses existing and future airport needs and demands.

2.2.2 The approved ALP graphically depicts existing airport facilities and infrastructure as well as proposed development.

2.2.3 Related planning guidance:

1. AC 150/5000-17, *Critical Aircraft and Regular Use Determination*
2. AC 150/5020-1, *Noise Control and Compatibility Planning for Airports*
3. AC 150/5060-5, *Airport Capacity and Delay*
4. AC 150/5070-6, *Airport Master Plans*

2.3 Present Needs versus Future Demand.

2.3.1 The selection of airport design criteria has future implications. Airport designs based only on existing aircraft currently using the airport can severely limit the airport's ability to accommodate future operations of more demanding aircraft. Conversely, it is not practical or economical to base airport design on aircraft that will not realistically use the airport.

2.3.2 A key factor to consider during airport design is the spatial relationship between a runway and other airport elements, such as taxiways, aprons and airfield structures. This relationship can affect future growth at the airport. Once constructed, it is very costly to relocate airfield infrastructure that conflicts with the operation of more demanding aircraft. This may preclude the airport from benefitting from improved approach procedures.

2.3.3 To prevent constraints to future airport development, consider the separation standards for the next higher ADG, AAC, TDG and approach visibility minimums during current airport design activities. Also consider the OFZ needed for aircraft that exceed the

RDC (that will use the runway with less than regular use) in order to avoid possible operational restrictions. See Appendix L.

2.4 Design Process.

The airport design process involves a series of steps that align current airport needs with appropriate development that satisfies these needs, taking into consideration safety, capacity, economics and the environment. The steps generally include the following:

1. Identify critical aircraft (size and AAC, ADG, and TDG).
2. Identify reasonably attainable visibility minimums.
3. Establish applicable RDC.
4. Apply appropriate design standards contained in this AC.

2.4.1 Critical Aircraft.

As defined in AC 150/5000-17, the critical aircraft is the most demanding aircraft type, or grouping of aircraft with similar characteristics, that make regular use of the airport. Regular use is 500 annual operations, including both itinerant and local operations but excluding touch-and-go operations. The critical aircraft enables airport planners and engineers to design the airport to meet the operational needs of the aircraft while applying the applicable standards. The critical aircraft may be a single aircraft or a composite of several different aircraft having the most demanding characteristic(s) of each (see paragraph 1.6.2). Table L-3 in Appendix L relates characteristics to various design components. Refer to AC 150/5000-17 for FAA guidance. Regular-use criteria apply to the determination of the critical aircraft.

2.4.2 Considerations for Visibility Minimums.

While lower visibility minimums are desirable, runway design factors ranging from obstacles in the approach path to separation and buffers around the runway become much more restrictive. The determination of the approach visibility minimums for a runway include the demand for lower minimums, the resulting benefits and the associated costs.

2.4.3 Visibility Categories.

For purpose of airport design, the following are the four categories of visibility. Note these categories and definitions do not match with Part 77.

2.4.3.1 Visual (V).

Runways classified as visual are not suitable for Instrument Flight Rules (IFR) operations. The exception being circling-only approaches. These runways do not permit a straight-in approach. For the purpose of airport design, runways with circling-only approaches fall under the visual visibility category. Visual runways:

1. Support Visual Flight Rules (VFR) operations only,

2. Are unlighted or lighted with Low Intensity Runway Lights (LIRL) or Medium Intensity Runway Lights (MIRL), and
3. Have only visual (basic) runway markings as defined in AC 150/5340-1.

2.4.3.2 Non-Precision Approach (NPA).

A non-precision approach is an instrument approach based on a navigation system that provides course deviation information, but no glidepath deviation information. NPA runways:

1. Only support IFR approach operations to visibilities of 1/2 statute mile (0.8 km) or greater and have a HAT no lower than 250 feet.
2. Rely on NAVAIDs providing lateral only guidance for instrument approaches such as Very High Frequency Omnidirectional Range (VOR), non-directional beacon (NDB), Area Navigation (RNAV) Lateral Navigation (LNAV), localizer performance (LP), localizer (LOC).
3. Generally, have lengths at least 3,200 feet (975 m) long, with a minimum width based on RDC.
4. Have runway edge lights using at least LIRL or MIRL.
5. Have non-precision runway markings as defined in AC 150/5340-1.

2.4.3.3 Approach Procedure with Vertical Guidance (APV).

APV is an instrument approach based on a navigation system that is not required to meet the PA standards of ICAO Annex 10 but provides course and glidepath deviation information. Runways classified as APV handle instrument approach operations where the navigation system provides vertical guidance down to 200 feet HAT and visibilities to as low as 1/2 statute mile. APV runways:

1. May apply to the following approach types: LNAV/ Vertical Navigation (VNAV), Localizer Performance with Vertical Guidance (LPV), or Area Navigation (RNAV)/ Required Navigation Performance (RNP).
2. Typically have a length of at least 3,200 feet (975 m) in length and a typical width of at least 60 feet (18.5 m).
3. Typically have a runway with at least a MIRL and non-precision runway markings as defined in AC 150/5340-1.

2.4.3.4 Precision Approach (PA).

A precision approach is an instrument approach based on a navigation system that provides course and glidepath deviation information. Runways classified as precision handle instrument approach operations supporting an instrument approach with HAT lower than 250 feet and visibility lower than 3/4 statute mile, down to and including Category (CAT) III. Precision Instrument Runways (PIR):

1. Support IFR operations with visibilities down to and including CAT-III with the appropriate infrastructure.
2. Have navigational systems capable of supporting precision operations that include ILS and Ground Based Augmentation System (GBAS) Landing System (GLS). (Order JO 6850.2 contains descriptions of various approach lighting systems.)
3. Have runways lengths of at least 4,200 feet (1280 m).
4. Have minimum runway width of at least 75 feet (23 m) with the typical width being 100 feet (30 m).
5. Are lighted with High Intensity Runway Lights (HIRL).
6. Have precision runway markings as defined in AC 150/5340-1.

2.4.4 Establish Applicable RDC.

Establishing the critical aircraft and justified visibility minimums establishes the RDC. Refer to paragraph 1.6.4 for further information.

2.4.5 Apply Applicable Design Standards.

The RDC determines the applicable standards for the runway design. Each runway will have a specific RDC establishing design criteria such as runway to taxiway separations, safety areas, object free areas and obstacle free zones.

2.4.5.1 **Example.**

Consider an airport may have a runway for air carrier operations and a runway for GA operations. The runway serving air carrier operations may have an RDC of D-IB-2400 while the runway serving GA operations may have an RDC of B-II-5000.

2.5 Key Safety Considerations for Airport Design.

2.5.1 Runway Incursions.

A runway incursion is any occurrence involving the incorrect presence of an aircraft, vehicle or person in a protected area designated for landing or takeoff of aircraft. Airfield geometry is a factor affecting the risk associated with runway incursion. Appropriate consideration of this aspect during runway and taxiway design can mitigate the factors that lead to increased risk of runway incursion. Refer to Chapter 4 and Appendix J for taxiway design practices that reduce the risk of runway incursions. Certain runway configurations can increase the risk of runway incursions. The list includes, but is not limited to:

1. Close proximity of thresholds
2. Closely spaced parallel runways

3. Wide expanses of pavement between intersecting runways.

2.5.2 Wrong Surface Events.

A wrong-surface event is an occurrence when an aircraft lands or departs on the wrong runway or on a taxiway. The causal factors for such events are broad. As it relates to airport design, airfield pavement geometries may contribute to wrong surface events. Some considerations that can increase the risk of wrong-surface events include:

1. The width of a parallel taxiway plus its shoulders may visually appear as a runway to a pilot on final approach to the associated runway.
2. The presence of wide expanse of pavement at runway approach ends obscures the location of the landing threshold.
3. The presence of wide expanse of pavement fillet causing the pilot to mistake inner parallel taxiway as the runway.
4. Parallel runways without standard separation distance.
5. Close proximity of thresholds of non-parallel runways.

2.6 Modification of Standards.

Site-specific conditions may make it impractical to meet fully, all FAA design standards at an airport. The FAA will consider, on a case-by-case basis, modifications to the design standards provided the modification results in an acceptable level of safety and efficiency. Specific operational controls may be necessary to establish an acceptable level of safety for operation of aircraft at the airport. The FAA views approved modifications of standards as interim measures intended to mitigate unique local conditions. Unless the FAA explicitly states otherwise in the approval action, FAA expects airports with approved modifications to pursue ways to meet design standards either incrementally over time or at such time it becomes practical to correct fully the non-standard condition.

2.7 Safety Management Systems (SMS).

FAA Order 5200.11 describes the basis for implementing SMS for airports certificated under 14 CFR Part 139. This order also specifies when Safety Risk Management is implemented, including ALP reviews and certain types of Modifications of Standards.

2.8 Diverse Aeronautical Uses on Airports.

Airports can support a diverse range of aeronautical activities. In addition to conventional airplane operations, aeronautical activities may include taildraggers, powered-parachutes, helicopters, parachute drop zones, balloons, gliders, weight-shift-control aircraft, airships, banner towing, and others. Some of these aeronautical activities use non-standard airport surfaces, particularly at general aviation airports. FAA Order 5190.6, *Airport Compliance Manual*, provides guidance on reasonably accommodating these activities while addressing safety concerns and related considerations, including coordination with other FAA offices such as Flight Standards and the Air Traffic Organization.

2.8.1 Heliports/Helipads.

Refer to AC 150/5390-2 for guidance on helicopter facilities on airports. AC 150/5390-2 provides recommended distances between the helicopter final approach and takeoff area center to runway centerline as well as safety dimensions for helipads are also discussed.

2.8.2 Light Sport Aircraft and Ultralights.

These aircraft have a maximum takeoff weight under 1,320 lbs (599 kg) and 254 lbs (115 kg) respectively. Their maximum stall speed is not more than 45 knots and 24 knots respectively. Since these aircraft regularly operate on turf runways, follow the guidance in paragraph 3.15.6. Otherwise, use the standards in this AC for small aircraft with approach speeds of more than 50 knots, and less than 50 knots, respectively. Refer to AC 103-6 for further guidance.

2.8.3 Seaplanes.

Refer to AC 150/5395-1.

2.8.4 Parachute Operations.

Parachute operations represent an allowable aeronautical activity at federally obligated airports subject to compliance with reasonable terms and regulatory requirements. Per 14 CFR § 105, parachute operations on an airport require prior coordination with the airport operator. Part 105 also establishes requirements to notify Air Traffic and obtain authorizations from Air Traffic and Flight Standards for parachute operations. Federally obligated airports consent to grant assurances when receiving federal assistance. Two assurances of importance as it relates to parachute operations are: 1) a commitment to operate and maintain the airport in a safe and serviceable manner, and 2) an obligation to provide access to all types, kinds, and classes of aeronautical activities without unjust discrimination. Refer to FAA Order 5190.6 for information addressing reasonable accommodation of parachute operations at an airport, safety considerations, and coordination with other appropriate FAA offices. Additional guidance on parachute operations as it relates to airport design include:

- 14 CFR, Part 105, *Parachute Operations*
- FAA Order 7110.65
- FAA Order 7210.3, *Facility Operation and Administration*

- AC 150/5190-7, *Minimum Standards for Commercial Aeronautical Activities*
- AC 105-2, *Sport Parachuting*
- AC 90-66, *Non-Towered Airport Flight Operations*
- United States Parachute Association (USPA), *Basic Safety Requirements (BSR)*

2.8.5 Aircraft Operations in the Unpaved Runway Safety Area (RSA).

The primary function of an RSA is to enhance the safety of aircraft that undershoot, overrun or veer off the runway. Pilots of certain aircraft (such as ultralights, powered-parachutes, helicopters, gliders, agricultural aircraft, etc.) occasionally use the unpaved portion of the RSA adjacent to a runway for takeoffs, landings or other operations (e.g. banner towing). While aircraft operations from the unpaved portion of an RSA are not inherently unsafe, such operations have potential to introduce various hazards and risks to the pilot as well as other aircraft, vehicles, individuals and facilities on the airport.

2.8.5.1 Key risk factors to consider include:

1. The separation standards of Tables G-1 through G-12 in Appendix G do not consider landing and takeoff operations from the RSA adjacent to the paved runway surface.
2. Aeronautical studies conducted as part of a Part 77 evaluation do not cover operations to and from a runway safety area.

2.8.5.2 From an airport design perspective, the optimum approach for an airport with a demonstrated need for operations from a turf surface is the development of a standard turf runway per paragraph 3.15. Runway justification conditions and regular-use criteria apply if the airport desires Federal assistance with development of a turf runway.

2.8.5.3 Grant Assurance 19 requires the owner of an airport developed with federal grant assistance to operate its airport at all times in a safe and serviceable condition. An airport with operations in the RSA adjacent to the runway pavement may need to assess the operational safety implications, with assistance from the FAA, in order to ensure an acceptable level of safety. Refer to FAA Order 5190.6 for guidance on reasonably accommodating these activities while addressing safety considerations and coordination with other FAA offices such as Flight Standards and the Air Traffic Organization.

2.8.5.4 The Flight Standards District Office (FSDO) serves a primary role in determining an acceptable level of safety for aircraft operations within the unpaved portion of an RSA. In many cases, existing FAA regulations, guidance, and operational procedures are sufficient to establish an acceptable level of safety. In other cases, operational mitigations may be necessary based on Flight Standards safety assessment and guidance. Contact the applicable FSDO for questions related to safety of aircraft operations within the unpaved portion of an RSA.

2.8.5.5 Consider the following factors when assessing aircraft operations in the runway safety area:

1. Education of the pilot community to reflect aircraft operations in the RSA represents an operation on the paved runway.
2. The separation values and hold line locations on the runway side, where RSA operations occur, may be inadequate to mitigate identified risk.
3. Provision for frequent inspection and maintenance of the RSA to ensure a serviceable condition.
4. Provision of airport informational notes in the chart supplement and AWOS broadcasts.

2.8.6 Unmanned Aircraft Systems (UAS).

See https://www.faa.gov/uas/ or contact the appropriate FAA Regional or Airports District Office for guidance.

2.8.7 Gliders.

The airport design standards that apply to powered aircraft apply to gliders as well, including self-launching gliders. The long wing lengths and low wingtip clearance common with gliders can present conflicts with airport infrastructure (e.g. lights, signs, etc.) whenever the glider is not the critical aircraft meeting regular use criteria. Similar to an aircraft at a runway holding position, a glider and its associated tow vehicle may stage in a runway object free area. However, support equipment such as vehicles, trailers, stands, dollies, etc., represent objects that need to be clear of active safety areas, object free areas and obstacle free zones. Airports with recurring glider activity can ensure safe operation of gliders at the airport by assessing available separation clearances and ensuring appropriate operational controls are in place. Refer to FAA document FAA-H-8083, *Glider Flying Handbook*, for additional considerations. Contact the appropriate FAA Regional or Airports District Office for additional guidance regarding site-specific safety assessments.

CHAPTER 3. Runway Design

3.1 Introduction.

The runway design standards, recommendations, design considerations, and requirements in this chapter describe features essential for safe and efficient takeoff and landing operations. These include, but are not limited to:

- Runway design concepts and considerations
- Runway end siting requirements
- Runway geometry and layout
- Runway Line of Sight (LOS)
- Parallel runway separation
- Runway to parallel taxiway separation
- Runway Safety Area (RSA)
- Runway Object Free Area (ROFA)
- Runway Protection Zone (RPZ)
- Runway Visibility Zone (RVZ)
- Clearways
- Stopways
- Surface gradient
- Turf runways
- Instrument approach procedures

3.2 Runway Design Code (RDC).

The Runway Design Code (RDC) determines the standards that apply to a specific runway and parallel taxiway allowing optimal safe operations by the critical aircraft under desired meteorological conditions. The RDC is based on existing and planned development and has no operational application. Refer to the online Runway Design Standards Matrix Tool or Appendix G for specific dimensional design criteria. Except when noted, dimensional standards are independent of the surface type of the runway.

3.3 Runway Design Concepts and Considerations.

3.3.1 Runway Length.

Use AC 150/5325-4 to determine the runway length for the critical aircraft. Key factors include:

1. Critical aircraft takeoff and landing distances.
2. Obstacle clearance for all aircraft intended to use the runway.
3. Airport elevation.
4. Airport climate condition.
5. Surface gradient.

3.3.2 Runway Threshold.

Runway length, obstructions, and visibility requirements are key factors when locating a runway threshold.

1. The appropriate obstacle clearance surface is clear of obstacles.
2. Operational mitigations may be necessary to address obstacle penetrations of standard approach surfaces.
3. Refer to paragraph 3.5 and Table 3-1, Table 3-2, Table 3-3, and Table 3-4 for OCS standards.

3.3.3 Number of Runways.

Runway location and orientation are paramount to airport safety, efficiency, economics, and environmental impact. Capacity and/or wind coverage determine the number of runways needed.

3.3.3.1 Capacity

Use AC 150/5060-5 for planning guidance on runway capacity.

3.3.3.2 Orientation and Wind.

The primary runway orientation is normally in the direction of the prevailing wind. A wind data analysis considers wind speed and direction for existing and forecasted operations for local meteorological conditions.

1. Refer to Appendix B for wind analysis for airport planning and design.
2. Design for a crosswind runway when the primary runway orientation:
   a. provides less than 95.0 percent wind coverage, and
   b. regular use for the critical aircraft needing crosswind coverage exists per AC 150/5000-17.
3. Wind coverage is based on the allowable crosswind component not exceeding the values in Table B-1.

3.3.4 Airspace Analysis and Obstruction to Air Navigation.

The runway orientation determines the approach and departure path for the design level of service. An obstruction survey identifies objects that may affect aircraft operations in this path. Contact the local FAA Regional Office or Airports District Office for assistance and information regarding the following matters:

- Existing and planned IFPs
- Missed approach procedures
- Departure procedures
- Traffic patterns influencing airport layouts and locations
- Obstructions to air navigation.

3.3.5 Environmental Factors.

An evaluation under the National Environmental Policy Act (NEPA) considers the impact of runway development on existing and proposed land use, noise on nearby residents, air and water quality, wildlife, and historical/archeological features. See FAA Order 1050.1 and FAA Order 5050.4.

3.3.6 Topography.

Topography affects:

1. The amount of grading and drainage work necessary to develop a runway; both existing and long term. See AC 150/5320-5 for further guidance.
2. Instrument Flight Procedures (IFPs) when it is necessary to increase minima to keep flight paths clear of terrain in the approach surfaces.
    a. The presence of precipitous terrain may also result in increased minima to provide additional clearance.
    b. For takeoff, establishing an obstacle departure procedure may be needed when operating under IFR to ensure safe clearance from rising terrain.

3.3.7 Wildlife Hazards.

Consider the location of bird and wildlife attractants (e.g. ponds, wetlands, storm water detention, trees, etc.) when establishing runway orientation.

1. See AC 150/5200-33, AC 150/5200-34, and FAA/USDA manual, Wildlife Hazard Management at Airports.
2. Guidance is also available through local FAA Airports offices.

3.3.8 Geospatial Survey.

Perform surveys in accordance with AC 150/5300-16, AC 150/5300-17, and AC 150/5300-18.

3.3.9 Runway Markings and Airport Sign Systems.

1. AC 150/5340-1 addresses runway markings.
2. AC 150/5340-18 addresses airport sign systems.
3. AC 150/5340-30 addresses airport lighting.

3.3.10 Navigation Aids (NAVAIDs).

NAVAIDs provide desired visual and electronic signals that support visual and instrument approach access. Chapter 6 provides relevant NAVAID information that support runways.

3.3.11 Runway Design.

As a minimum, the design of runways and runway extensions involves an evaluation of the following standards:

- RSA, paragraph 3.9.

- OFZ, paragraph 3.10.
- Runway Object Free Area (ROFA), paragraph 3.11.
- Runway Protection Zone (RPZ), paragraph 3.12.
- Approach and Departure Surfaces, paragraphs 3.5.1 and 3.5.2.
- Runway to taxiway separation standards using the online Runway Design Standards Matrix Tool or Appendix G.
- Runway Line of Sight, paragraph 3.7.
- Runway Obstacle Clearance Surface (OCS), Table 3-1, Table 3-2, Table 3-3, and Table 3-4.

3.3.12 Approach and Departure Imaginary Surfaces.

The FAA utilizes three sets of imaginary surfaces to evaluate and protect the approach and departure areas of a runway.

3.3.12.1 14 CFR Part 77.

1. Provides the standards for identifying obstructions to air navigation.
2. Consist of the primary, approach, transitional, horizontal, and conical surfaces.
3. FAA presumes obstructions are hazards to air navigation unless further aeronautical study concludes that the object is not a hazard.

3.3.12.2 United States Standard for Terminal Instrument Procedures (TERPS).

1. Prescribes the criteria for designing and evaluating instrument flight procedures (IFPs).
2. Specifies the minimum measure of obstacle clearance that provides a satisfactory level of vertical protection from obstructions for IFR procedures.
3. Establishes the standard takeoff and landing minimums for instrument runways.

3.3.12.3 Runway Obstacle Clearance Surfaces (OCS).

See paragraph 3.5 and the dimensional values in Table 3-1, Table 3-2, Table 3-3, and Table 3-4:

1. Prescribes the criteria for evaluating runways serving only visual operations, and
2. Provides basic planning surfaces, as it relates to instrument runways, intended to protect select TERPS surfaces.

3.4 Runway End Siting Criteria.

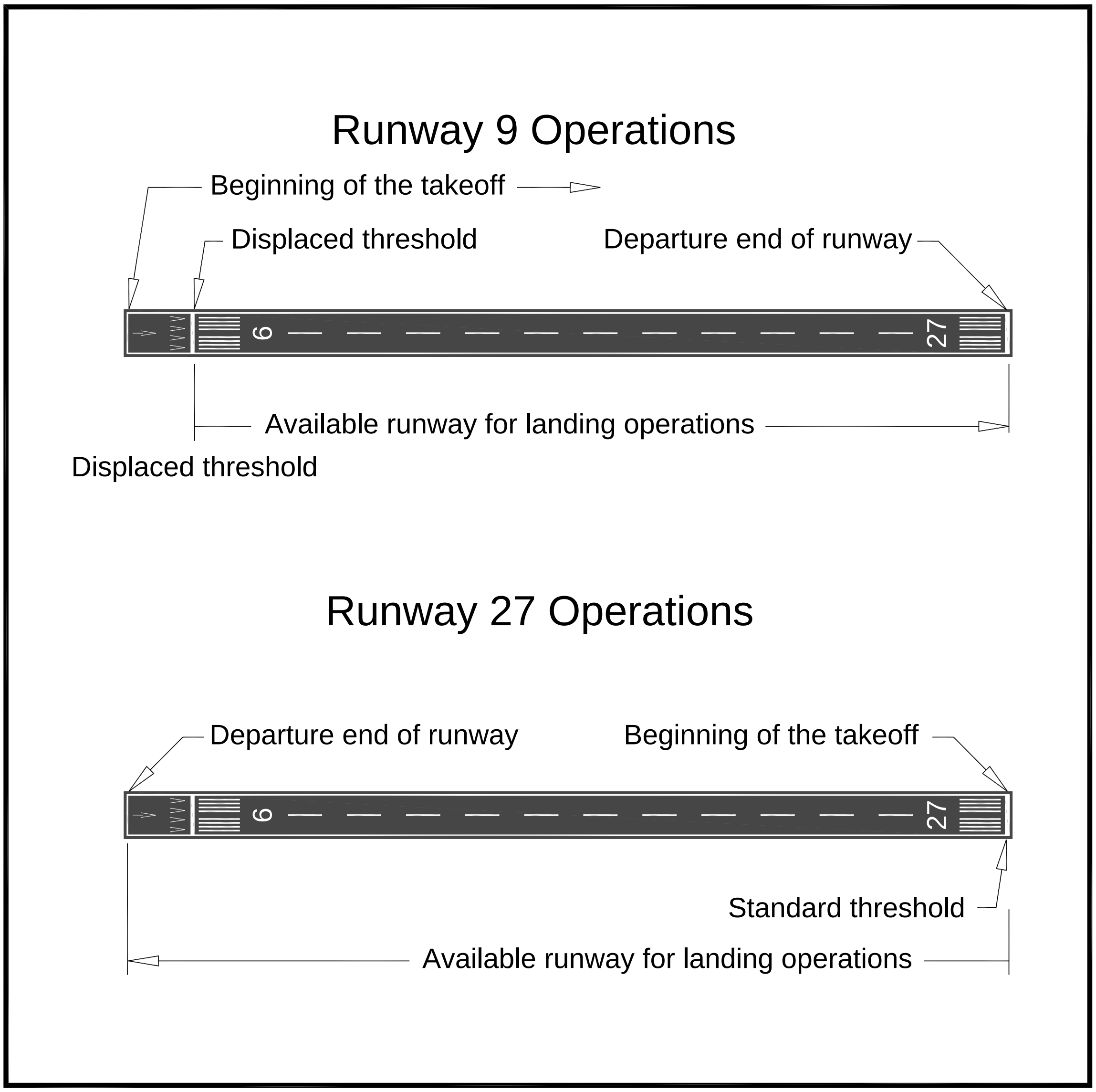
For runways with instrument procedures, base the final design on a detailed analysis applying the criteria of FAA Order 8260.3, *United States Standard for Terminal*

Instrument Procedures (TERPS). This analysis is typically done by the FAA Flight Procedures Office. Runway ends and runway thresholds are two distinct design elements.

3.4.1 Runway Ends.

The runway ends are the physical ends of a rectangular prepared surface that constitutes a runway. (See Figure 3-1).

Figure 3-1. Runway Ends



Note 1: For runway marking standards, see AC 150/5340-1.
Note 2: For runway lighting standards, see AC 150/5340-30.

3.4.2 Runway Threshold.

A standard runway threshold provides obstacle clearance for landing aircraft. The optimum location of a threshold is the beginning of the runway.

3.4.2.1 Standards.

Locate the threshold to meet the following criteria:

1. No obstacle penetration of the approach surface per Table 3-1, Table 3-2, and Table 3-3.
2. Location allows for standard RSA, ROFA, and OFZ.

3.4.2.2 Design Considerations.

Consider the ultimate approach visibility minimums planned for the runway.

3.4.3 Displaced Threshold.

When it is impractical to locate a threshold at the runway end, it may be necessary to apply a displaced threshold. A displaced threshold reduces runway length available for landings in one direction. The portion of the runway prior to the displaced threshold typically remains available for takeoffs. Depending on the circumstances surrounding the displacement, operations from the opposite runway end may or may not be affected. Refer to Appendix H for related information on declared distances. Generally, a runway threshold displacement provides:

1. A means for obtaining additional RSA prior to the threshold.
2. A means for obtaining additional ROFA prior to the threshold.
3. A means for locating the RPZ to mitigate incompatible land uses.
4. Obstacle clearance in the land approach area of a runway.
5. Increased arrival capacity with certain parallel runway approach procedures. See FAA Order 7110.308, *Simultaneous Dependent Approaches to Closely Spaced Parallel Runways*.

3.4.3.1 Design Considerations.

Consider a displaced threshold only after a full evaluation establishes that displacement is the best available alternative. While threshold displacement is often a convenient solution for constrained airports, the evaluation needs to weigh the trade-offs and consequences of a displaced threshold. These include factors such as:

1. Approach light systems and NAVAIDs may require relocation.
2. Threshold displacement may result in existing taxiways, holding bays and aprons now being located forward of a runway threshold thus creating potential situations where taxiing aircraft may penetrate a protected surface such as an approach surface or a Precision Obstacle Free Zone (POFZ).

3. Additional holding positions may be necessary to keep aircraft clear of approach and departure surfaces.
4. Threshold displacement may result in holding positions on the parallel taxiways where pilots may not expect to encounter a holding position.

3.4.4 Departure End of the Runway.

When a clearway is not present, the departure end of the runway indicates the end of the prepared runway surface (e.g. full-strength pavement) available and suitable for departure.

3.4.5 Establishing and Protecting Runway Ends.

When establishing runway ends, ensure:

1. All applicable approach surfaces of Table 3-1, Table 3-2, Table 3-3, and TERPs surfaces of Table 3-6 associated with the threshold are clear of obstacles.
2. The 40:1 departure surface associated with the ends of designated instrument departure runways are clear of obstacles per paragraph 3.5.2.
3. Standard dimensions for the RSA and ROFA are available.
4. Incompatible objects and activities remain clear of the RPZ per paragraph 3.12.
5. Controls in the form of land-use restriction, zoning, easements or acquisition are in place to protect approach and departure surfaces from adverse conditions such as:
    a. proposed development, or
    b. natural vegetation growth.
6. Critical area and obstacle clearance surface associated with electronic and visual NAVAIDs such as a Visual Glideslope Indicator (VGSI), ALS, or Instrument Landing System (ILS) remain clear of interfering sources.

3.5 Approach and Departure Surfaces.

Table 3-1, Table 3-2, Table 3-3, and Table 3-4 present the dimensional standards applicable to varying runway types based on normal conditions (e.g. standard 3-degree glidepath angle). Meeting the criteria of this table will protect the use of the runway in both visual and instrument meteorological conditions near the airport while ensuring maximum runway utility. Final published visibility minimums are determined, in part, by applying the criteria described in FAA Order 8260.3.

3.5.1 Approach Surfaces.

The approach surfaces defined in this paragraph are distinct from the approach surfaces defined in Part 77. The FAA determines final published visibility minimums by applying the criteria prescribed in TERPS. The specific size, slope and starting point of the surface depend upon the visibility minimums and the type of procedure associated with the runway end.

3.5.1.1 **Standard.**

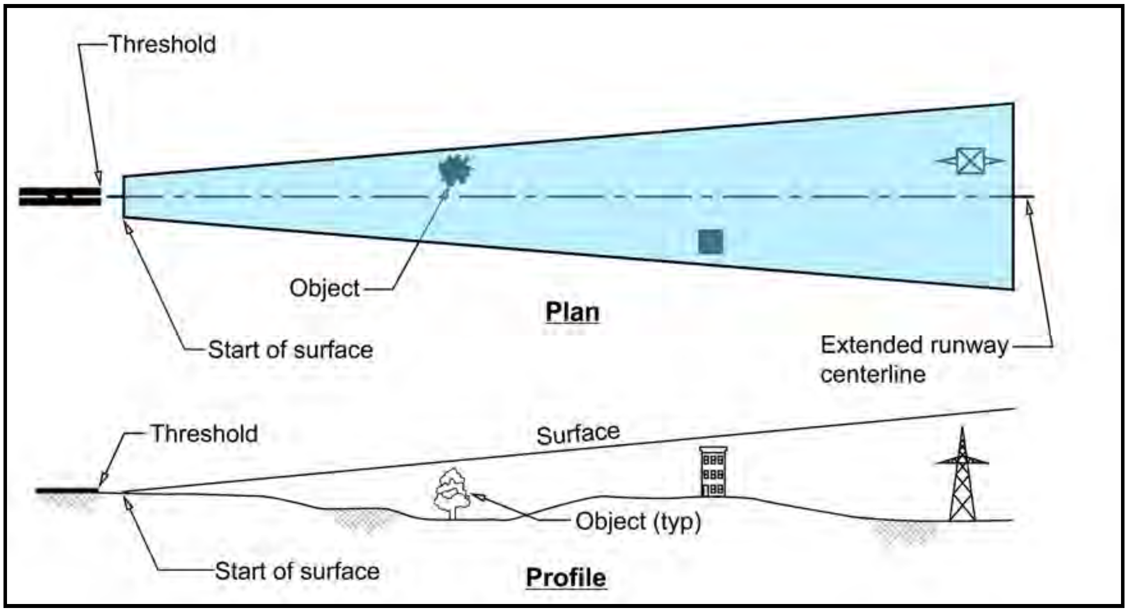
Approach surfaces protect runway use for both visual and instrument aircraft operations.

1. Visual runway (Table 3-1) approach surfaces are clear of obstacles.
2. Instrument runway (Table 3-2 and Table 3-3) approach surfaces are clear of obstacles.
3. The approach surface has a trapezoidal shape per Figure 3-2 and Table 3-1, Table 3-2, and Table 3-3.
4. If necessary to avoid obstacles, the instrument approach surface may be offset as shown in Figure 3-7. Contact the Flight Procedures Team for more information on offset instrument approaches.

3.5.1.2 **Design Considerations.**

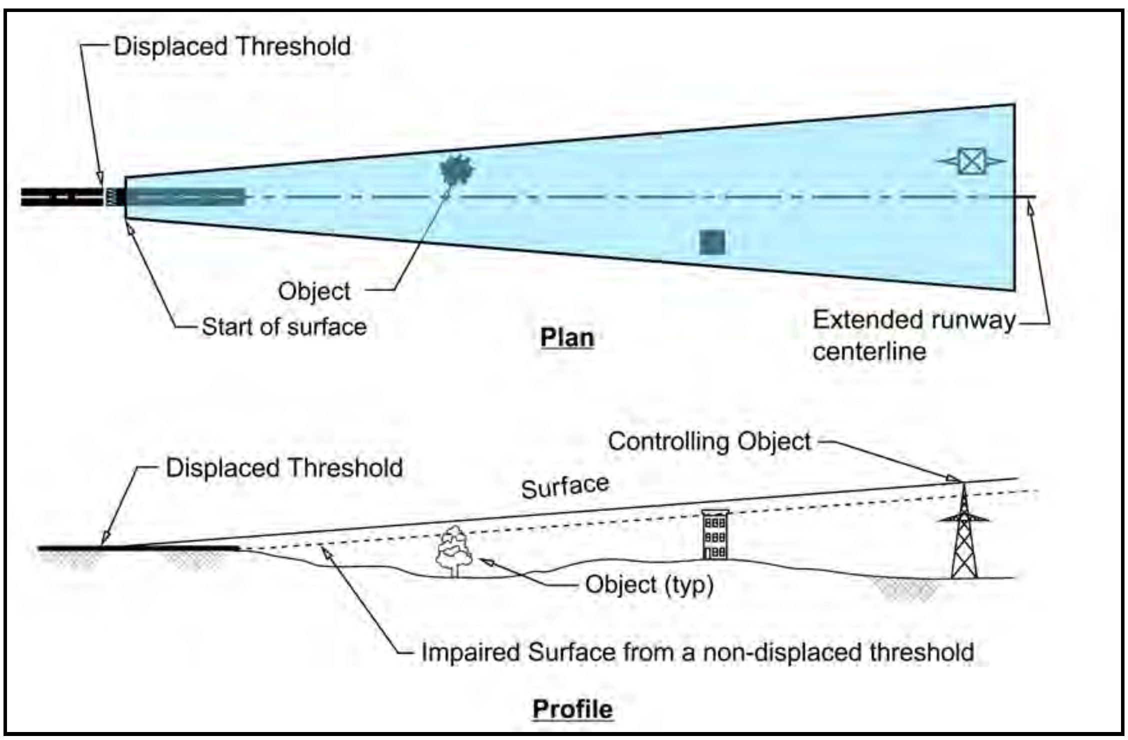
1. Evaluate any obstacle penetrating the approach surfaces in Table 3-1, Table 3-2, and Table 3-3 through the Obstruction evaluation/Airport Airspace Analysis (OE/AAA) process.
2. The instrument approach surfaces in Table 3-2 and Table 3-3 are for airport planning purposes and reflect the visual segment of an instrument approach procedure as defined in TERPS. Other TERPS criteria may apply.
3. Ensure protection of runway ends from proposed development or natural vegetation growth that could penetrate the approach surfaces:
   a. Protection measures include land use restrictions and zoning, easements, and property acquisitions (see AC 150/5020-1).
   b. Refer to Engineering Brief No. 91, *Management of Vegetation in the Airport Environment*, for information on the removal or topping of vegetation as well as the collection, submission, and management of data regarding vegetation on and around airports.
4. Consider operational surfaces associated with electronic and visual NAVAIDs such as a Visual Glideslope Indicator (VGSI), Approach Lighting System (ALS), or Instrument Landing System (ILS).
5. For planning purposes, ensure objects remain clear of the OCS prescribed in Table 3-1, Table 3-2, and Table 3-3.
6. For instrument runways, the FAA mitigates existing obstacles that penetrate an instrument OCS and cannot be removed, relocated, or lowered by adjusting minima.
7. Displacing the threshold may mitigate obstacle(s) penetrating the approach surface. See Figure 3-3.
8. The FAA will not issue a modification of standard for standards prescribed in Table 3-1, Table 3-2, and Table 3-3.

Figure 3-2. Standard Approach Surface



Note 1: The starting elevation of the approach slope is the elevation of the runway threshold.
Note 2: Refer to Figure 3-3 for a displaced threshold.

Figure 3-3. Displaced Threshold



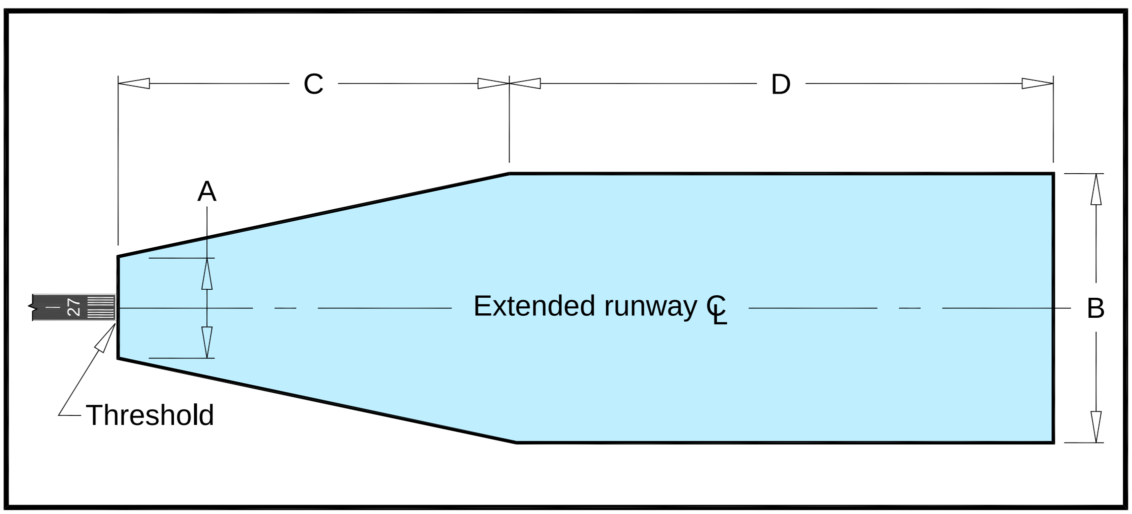
Note 1: The starting elevation of the approach slope is the elevation of the runway displaced threshold.

Table 3-1. Visual and Daytime IFR Circling Obstacle Clearance Surfaces

OCS	Runway Type	Dimensional Standards Feet (Meters)				Slope
		A	B	C	D	
OCS 1	Approach end of runways serving small airplanes with approach speeds less than 50 knots.	120 (37)	300 (91)	500 (152)	2,500 (762)	15:1
OCS 2	Approach end of runways serving small airplanes with approach speeds of 50 knots or more.	250 (76)	700 (213)	2,250 (686)	2,750 (838)	20:1
OCS 3	Approach end of runway serving large airplanes	400 (122)	1,000 (305)	1,500 (457)	8,500 (2591)	20:1

Note 1: Table is applicable to visual day or night runways and day-time only circling. For runway ends authorized for night circling, see Table 3-2.
Note 2: Refer to the published instrument approach charts to determine if circling is available.
Note 3: Approach surface begins at the runway threshold.

Figure 3-4. Visual and Daytime IFR Circling Obstacle Clearance Surfaces



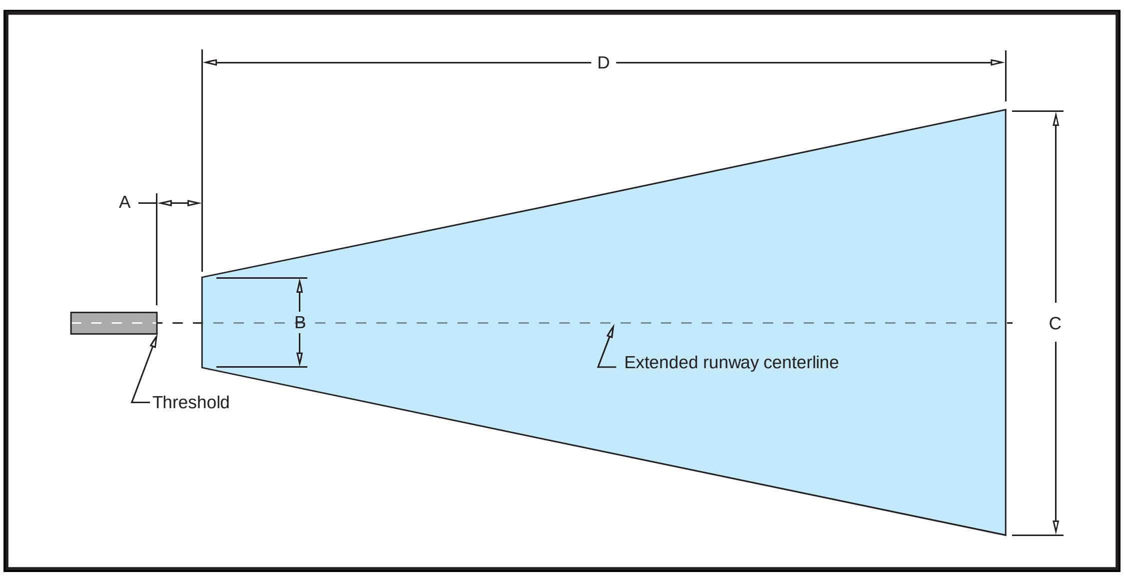
Note 1: Refer to Table 3-1 for dimensional values.
Note 2: Surface slopes upward from starting point.

Table 3-2. Non-Precision and Nighttime IFR Circling Obstacle Clearance Surfaces

OCS	Runway Type	Visibility minimums	Dimensional Standards Feet (Meters)				Slope
			A	B	C	D	
OCS 4	Approach end of runways that supports nighttime IFR circling procedures and procedures only providing lateral guidance (VOR, NDB, LNAV, LP, and LOC).	≥ ¾ statute mile	200 (61)	400 (122)	3,400 (1036)	10,000 (3048)	20:1
		< ¾ statute mile	200 (61)	400 (122)	3,400 (1036)	10,000 (3048)	34:1

Note 1: See Appendix L for acronym list on IFR procedure names.
Note 2: Dimension A is relative to the runway threshold.
Note 3: Refer to the published instrument approach charts to determine if nighttime circling is available.
Note 4: See Table 3-6 for standards for instrument approach procedures.
Note 5: Table represents the TERPS visual portion of the final approach segment.
Note 6: Table is applicable to circling approaches that are available at night. For day-time only circling, refer to the applicable approach surface from Table 3-1.
Note 7: For airport planning purposes. Final visibility minimums is determined by Flight Procedures evaluating criteria in FAA Order 8260.3 and FAA Order 8260.58. Flight Procedures conducts a full IFP evaluation via an aeronautical study.
Note 8: Marking and lighting of obstacle penetrations to this surface or the use of a Visual Guidance Lighting System (VGLS) may mitigate displacement of the threshold. Contact the Flight Procedures Team if existing obstacles penetrate this surface.
Note 9: 10,000 feet (3048 m) represents a nominal value for planning purposes. The length is dependent on the Visual Descent Point (VDP) location.

Figure 3-5. Non-Precision and Nighttime IFR Circling Obstacle Clearance Surfaces



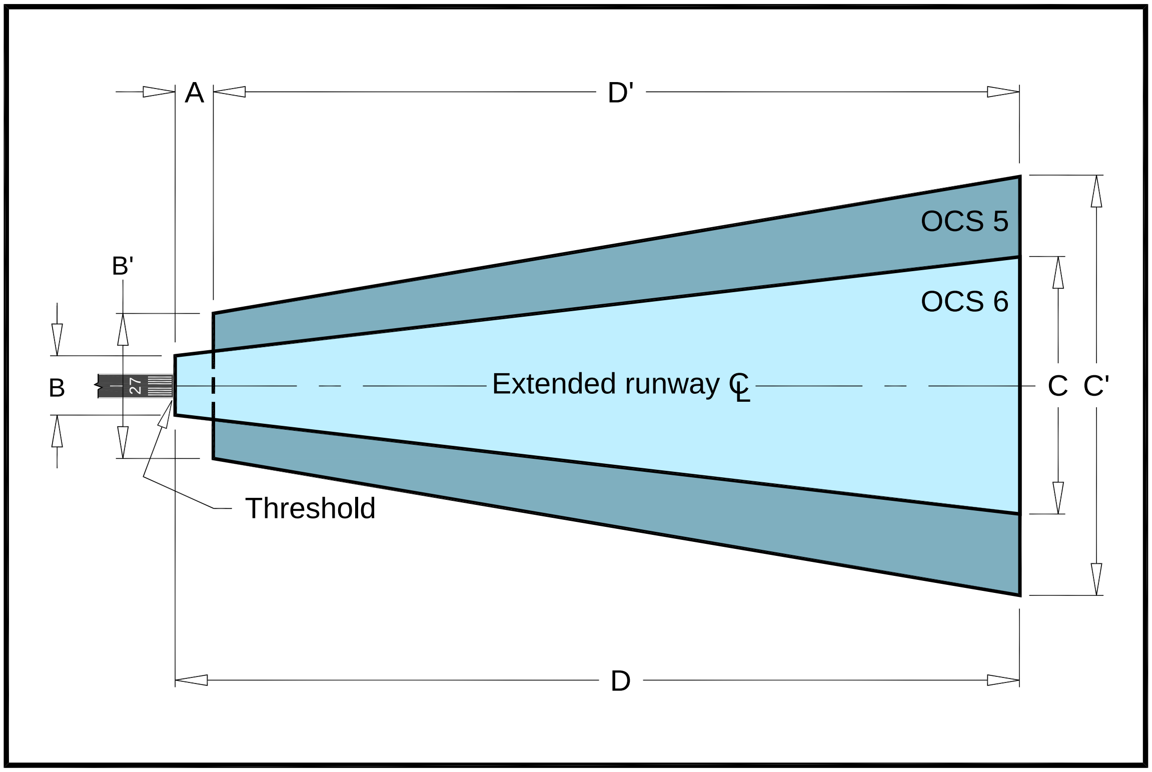
Note: Refer to Table 3-2 for dimensional values.

Table 3-3. APV and PA Instrument Runway Obstacle Clearance Surfaces

OCS	Runway Type	Visibility	Dimensional Standards Ft (M)				Slope
		Minimums	A	B	C	D[7]	
OCS 5	Approach end of runways providing ILS, MMLS, PAR, and LDA with glidepath, LPV, LNAV/VNAV, RNP, or GLS.	≥ ¾ statute mile	200 (61)	400 (122)	3,400 (1036)	10,000 (3048)	20:1
		< ¾ statute mile	200 (61)	400 (122)	3,400 (1036)	10,000 (3048)	34:1
OCS 6	Approach end of runways providing ILS, MMLS, PAR, and LDA with glidepath, LPV, LNAV/VNAV, RNP, or GLS.	All	0	Runway Width	1,520 (463)	10,000 (3048)	30:1

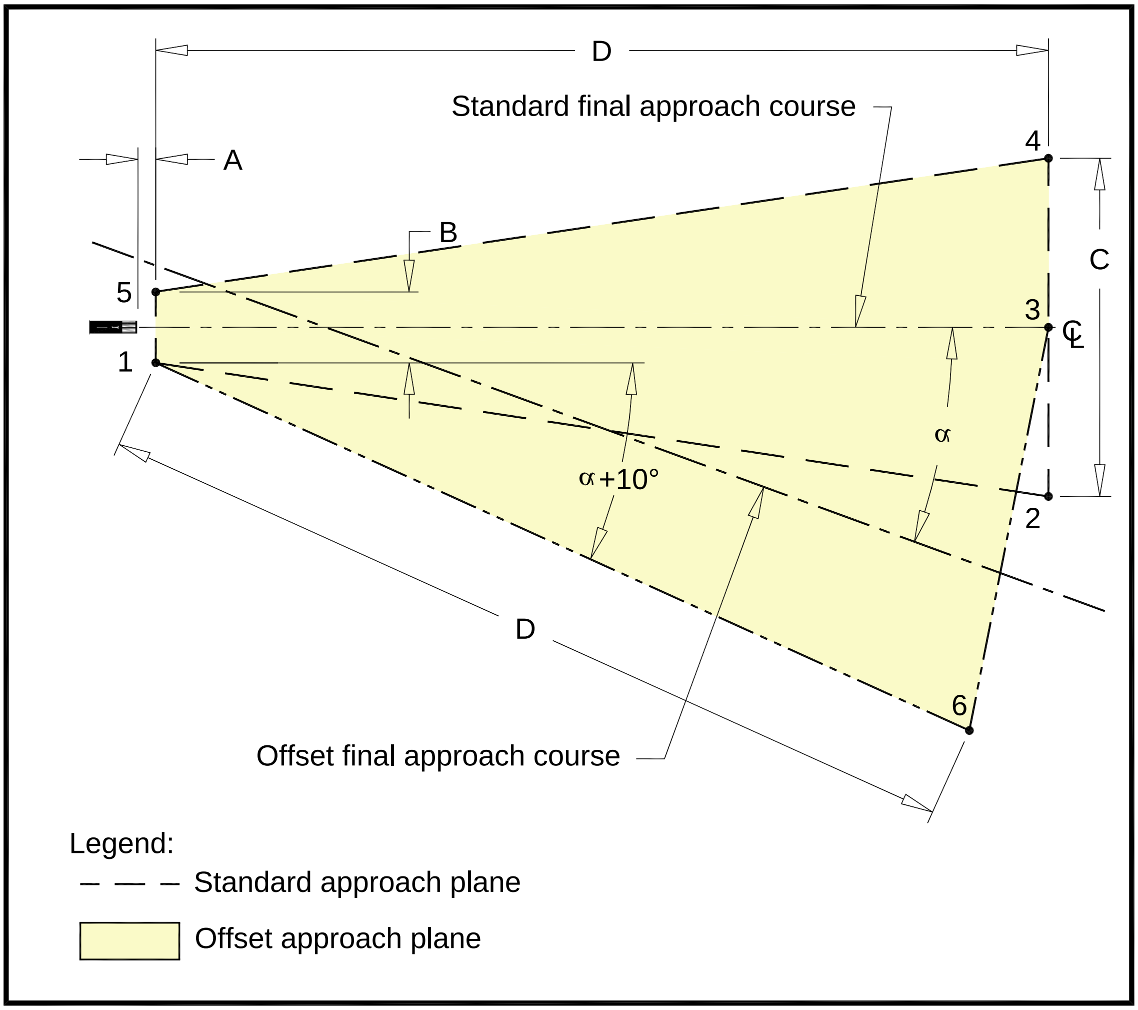
Note 1: See Appendix L for acronym list on IFR procedure names.
Note 2: Dimension A is relative to the runway threshold.
Note 3: See Table 3-6 for standards for instrument approach procedures.
Note 4: OCS 5 represents the TERPS visual portion of the final approach segment. OCS 6 represents the TERPS Vertical Guidance Surface (VGS). Both surfaces apply for APV and PA procedures. Contact the Flight Procedures Team if existing obstacles penetrate this surface.
Note 5: For airport planning purposes. Final visibility minimums are determined by Flight Procedures evaluating criteria in FAA Order 8260.3 and FAA Order 8260.58. Flight Procedures conducts a full IFP evaluation via an aeronautical study.
Note 6: The FAA assesses TERPS final approach segment OCS criteria (i.e. W, X, Y surfaces) for all runway ends authorized for ILS, MMLS, PAR, and LDA with glide slope, LPV, and GLS procedures. Refer to FAA Order 8260.3 for additional information on TERPS surfaces.
Note 7: 10,000 feet (3048 m) represents a nominal value for planning purposes. The actual length is dependent on the precision final approach fix.

Figure 3-6. APV and PA Instrument Runway Obstacle Clearance Surfaces



Note: Refer to Table 3-3 for dimensional values.

Figure 3-7. Offset Approach Plane



Note 1: Refer to for all applicable dimensional standards and slopes.
Note 2: The offset area is defined by the perimeter 1-6-3-4-5-1.
Note 3: α = angle of the offset final approach (angle formed by the intersection of the offset final approach course with the extended runway centerline).

3.5.2 Departure Surfaces.

Clear departure surfaces allow pilots to follow standard instrument departure procedures, which assist pilots in avoiding obstacles during the initial climb from the terminal area. These procedures are published in the U.S. Terminal Procedures Publication (TPP). The departure surface applies to all runways unless otherwise specified in the TPP. The airport operator in coordination with the FAA identifies runway ends without an instrument departure surface as not available (for IFR departures). For runway ends that are visual and/or without a published instrument departure procedure, the application of the 40:1 instrument departure surface is desirable where practicable. There can be valid reasons for an airport operator to not protect the visual runway for the instrument departure surface, in the interest of other needed development on or near the airport. Refer to Appendix H for the effect declared distances may have on departure surfaces.

3.5.2.1 **Standards.**

1. The departure surface starts at the departure end of the runway elevation and matches the width of the usable runway.
   a. From the edge of the usable runway, the surface tapers upward to 150 feet at 500 feet on either side of the runway centerline.
   b. The surface slopes along the extended runway centerline at 40:1 until reaching 304 feet.
   c. Upon reaching 304 feet, the surface is level until the end of the departure surface.
2. See Figure 3-8 for standard size, shape and orientation of the departure surface.
3. Maintain the 40:1 instrument departure surface associated with the ends of runways with published instrument departure procedures to be clear of obstacles, or with applicable mitigation as identified in paragraph 3.5.2.2.

3.5.2.2 **Design Considerations.**

1. Evaluate any obstacle that penetrates the 40:1 departure surface through the Obstruction Evaluation/Airport Airspace Analysis (OE/AAA) process.
2. Ensure protection of runway ends from proposed development or natural vegetation growth that could penetrate the departure surfaces:
   a. Protection measures include land use restrictions and zoning, easements, and property acquisitions (see AC 150/5020-1).
   b. Refer to Engineering Brief No. 91, *Management of Vegetation in the Airport Environment*, for information on the removal or topping of vegetation as well as the collection, submission, and management of data regarding vegetation on and around airports.
3. If penetrations exist to the departure surface, the departure procedure may require a(an):
   a. Non-standard climb gradient, and/or
   b. Increase in the standard takeoff minimums, departure minimums, and/or
   c. Reduction in takeoff length.

Table 3-4. Instrument Departure Runway Obstacle Clearance Surface

OCS	Runway Type	Dimensional Standards Feet (Meters)					Slope
		A	B	C	D[2]	E	
OCS 7	Runways providing instrument departure operations.	Runway Width (RW)	500 (152) – ½ RW	7,512 (2290)	12,152 (3704)	6,152 (1875)	40:1

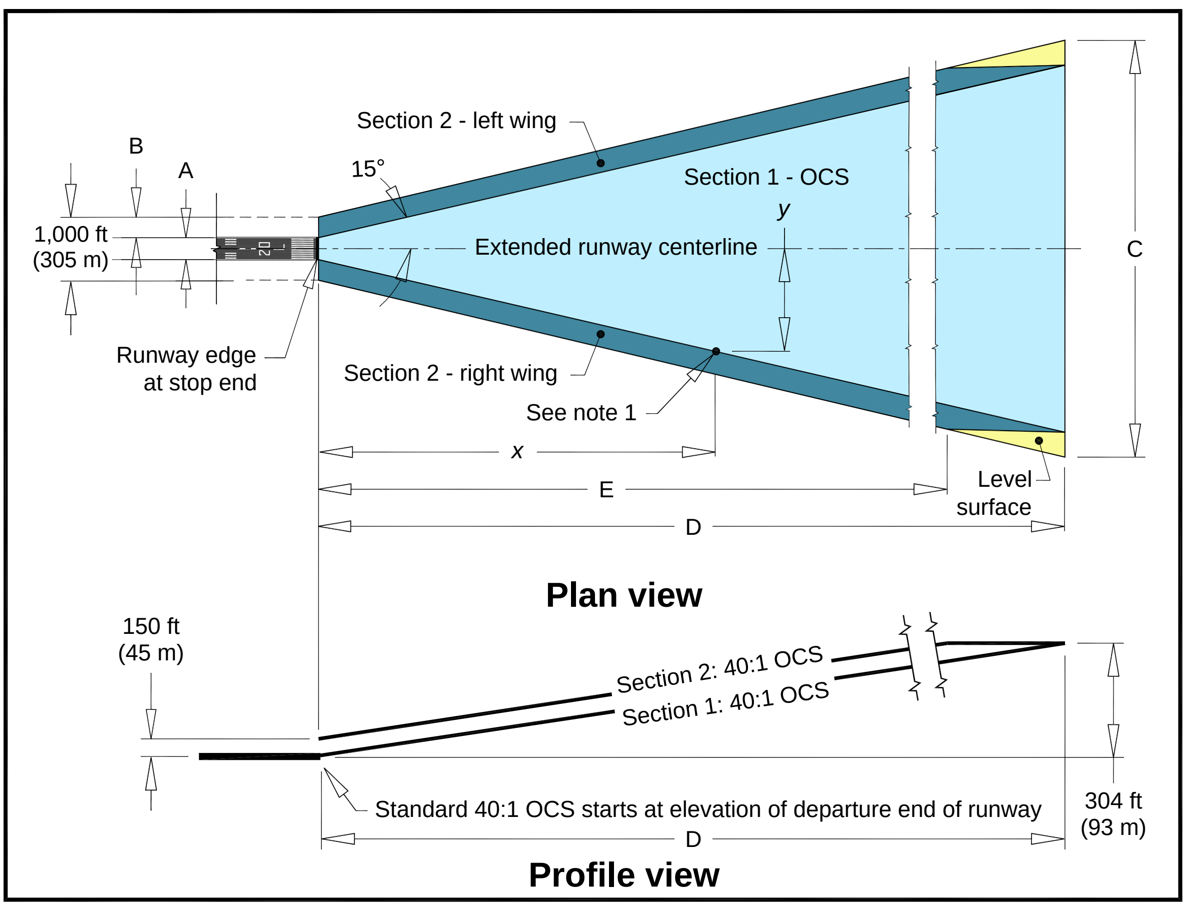
Note 1: Section 1 OCS starts at DER elevation for the width of the runway and rises along the extended runway centerline at 40:1. Section 2 starts at an equal elevation to the adjoining Section 1. Section 2 continues until reaching 304 ft and then levels off until reaching the line where Section 1 and Section 2 reach 304 ft above DER elevation then that part of Section 2 that leveled off continues at a 40:1 slope.

Note 2: The following formula determines the half width, y, of Section 1 from a distance, x, from the departure end of runway. Y = (½ * Runway Width) + (Tan 15° * X)

Note 3: The start of the surface is relative to the departure end of the runway. Runways with published declared distances, the TODA indicates the beginning of the OCS. See Figure 3-9.

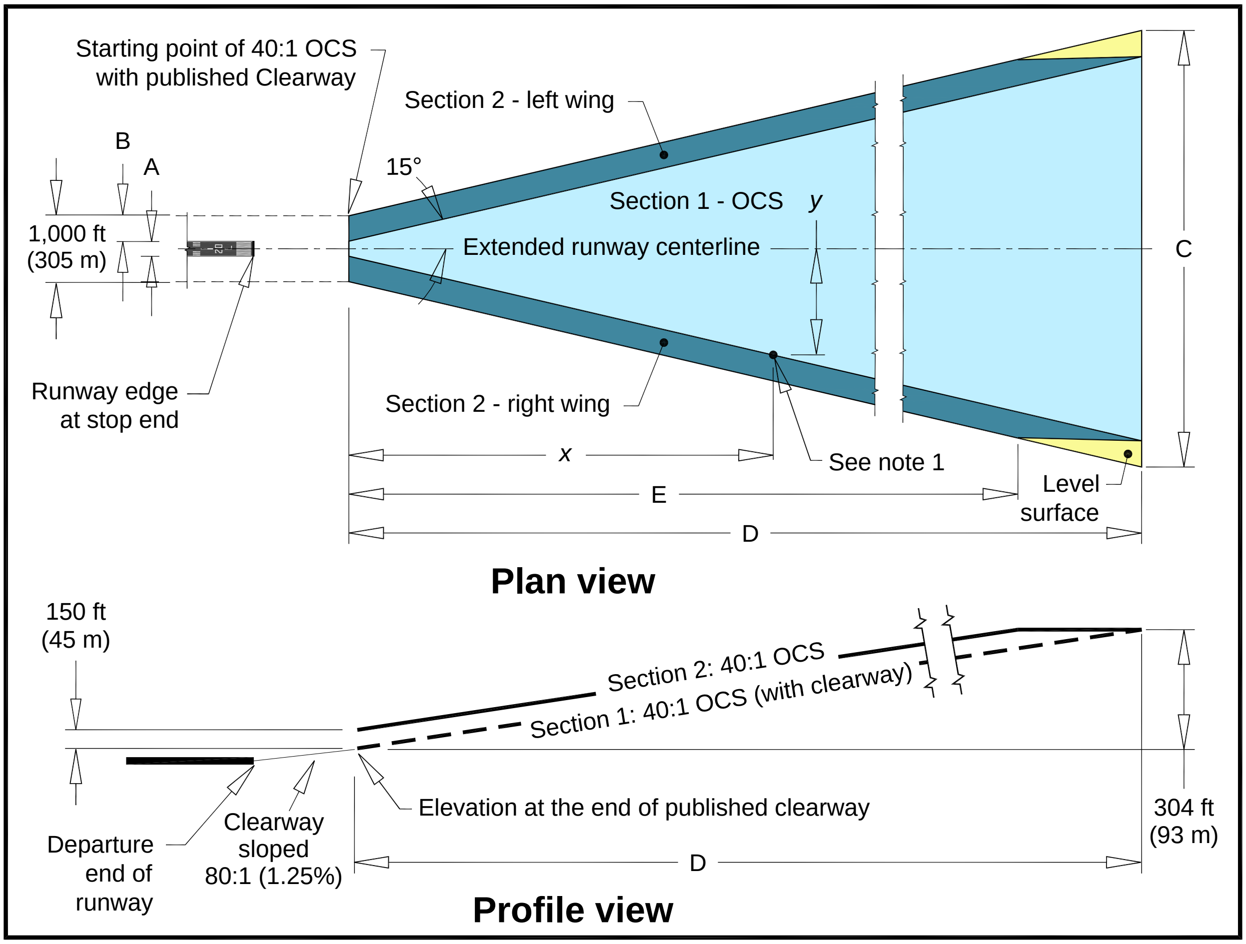
Note 4: 12,152 feet (3704 m) represents a 2 nm nominal value for planning purposes.

Figure 3-8. Instrument Departure Runway Obstacle Clearance Surface



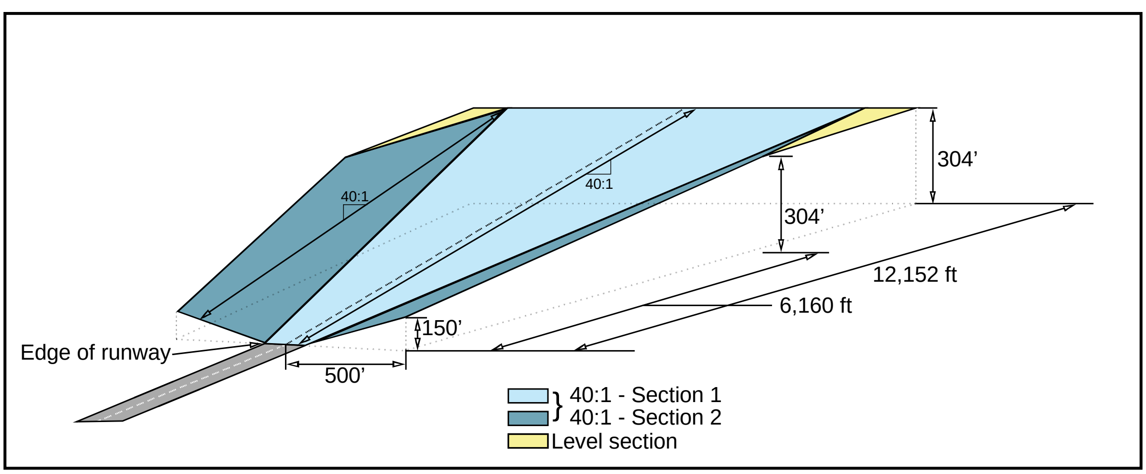
Note 1: The half-width of Section 1 is calculated by the formula:
Section $1_{\text{Half Width}}$ = (1/2 RWY Width) + (Tan 15° * X), where X = distance from stop end.

Figure 3-9. Departure Surface with Clearway



Note 1: The half-width of Section 1 is calculated by the formula:
Section $1_{\text{Half Width}}$ = (1/2 RWY Width) + (Tan 15° * X), where X = distance from stop end.

Figure 3-10. Departure Surface – Perspective View



3.6 Runway Geometry.

3.6.1 Runway Length.

Runway length accommodates landing and departure length needed by the critical aircraft. AC 150/5325-4 describes applicable methodologies for determining runway length.

3.6.2 Runway Width.

Appendix G and the online Runway Design Standards Matrix Tool present runway width standards based on Runway Design Code (RDC).

3.6.3 Runway Shoulders.

Runway shoulders provide resistance to jet blast erosion. Appendix G and the online Runway Design Standards Matrix Tool provide runway shoulder width standards. Refer to Figure 3-31 for a graphic depiction of runway shoulders. See Appendix C for additional information on jet blast. See AC 150/5320-6 for design procedures for paved airfield shoulders.

3.6.3.1 Standards.

1. Provide paved shoulders for runways serving the critical aircraft of Airplane Design Group (ADG) IV and larger.
2. Design shoulder pavement to support:
   a. The occasional veer-off from the runway of the critical aircraft.
   b. Passage of emergency and maintenance vehicles.
3. Provide turf, aggregate-turf, soil cement, lime or bituminous stabilized soil adjacent to runways serving the critical aircraft of ADG-I, ADG-II, and ADG-III.

3.6.3.2 Recommended Practices.

Provide paved shoulders for:

1. runways with ADG-III as the critical aircraft,
2. runways experiencing erosion of soil adjacent to the runway,
3. runways with soil not suitable for turf establishment (see AC 150/5320-6).

3.6.4 Runway Blast Pads.

Runway blast pads provide resistance to jet blast erosion beyond runway ends. Appendix G and the online Runway Design Standards Matrix Tool contain the standard length and width for blast pads for takeoff operations requiring blast erosion control. Blast pads are not stopways, though a paved stopway can serve as a blast pad. Refer to Figure 3-16, Chapter 6, and Appendix C. See AC 150/5320-6 for design procedures for blast pads.

3.6.4.1 **Standards.**

1. Design blast pad pavement similar to runway pavement to support occasional passage of:
   a. critical aircraft
   b. emergency and maintenance vehicles.
2. Design to the same longitudinal and transverse grades as the safety area.

3.6.5 Overlapping Runway Safety Areas.

Runway safety areas (see paragraph 3.9) represent a safety measure for aircraft during landing and takeoff operations. When two or more runways converge but do not intersect, thus creating overlapping RSAs, apply the standards of 3.6.5.1, to establish an acceptable level of safety in this area. Overlapping RSAs introduce safety risks and potential operational limitations. Refer to paragraph I.6 for information on the risk associated with overlapping RSAs.

3.6.5.1 **Standards.**

1. Configure runway ends, taxiways and holding positions to allow taxiing and holding aircraft to remain clear of all RSAs.
2. Configure runway ends to facilitate holding positions that allow holding aircraft to be perpendicular to the runway centerline per Scenarios #1 and #2 of Figure 3-11.
3. For existing configurations not meeting standards, develop a strategy to meet standards either:
   a. Incrementally over time, or
   b. At such time it becomes practical to correct fully the non-standard condition.

3.6.5.2 **Recommended Practices.**

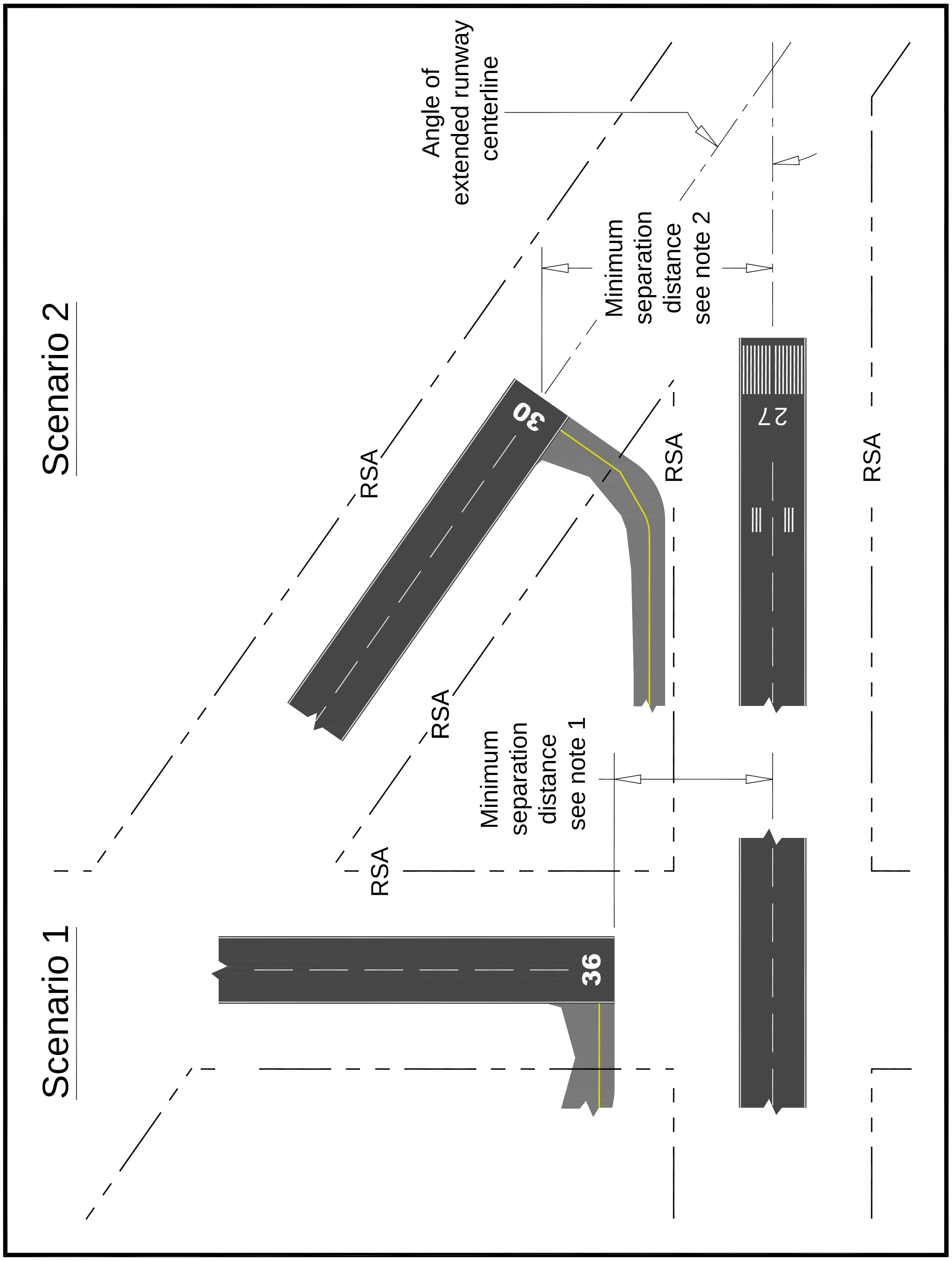
1. For multiple runways that converge but do not intersect, configure runway ends for the optimum condition of independent RSAs.
2. When the most demanding aircraft using the airport is not the critical aircraft with regular use, configure the runway ends, taxiways and holding positions, if practical, to preclude the need for operational controls.

3.6.5.3 **Design Considerations.**

1. Overlapping runway safety areas may create conditions resulting in holding positions on taxiways that do not lead directly to a runway.

2. Overlapping runway safety areas can present an elevated risk for wrong runway departures when an aligned taxiway is present. See Appendix I.

Figure 3-11. Converging Non-Intersecting Runways



Notes for Figure 3-11:

Note 1: Minimum distance is the standard runway centerline to taxiway centerline separation (Appendix G) minus ½ taxiway width.

Note 2: The minimum separation value is the necessary distance to allow an aircraft to hold without encroaching upon an RSA.

3.6.6 Intersecting Runways.

The intersection of two or more runways creates risks to airport safety and operational efficiency. The degree of risk will vary depending on the intersection location for each runway. See paragraph I.6 for additional information on the associated risk.

3.6.6.1 Standards.

1. Configure runways ends, taxiways and holding positions such that taxiing and holding aircraft remain clear of all RSAs.
2. Configure runway ends to facilitate holding positions that allow holding aircraft to be perpendicular to the runway centerline per Figure 3-12.
3. For existing configurations not meeting standards, develop a strategy to meet standards either:
    a. Incrementally over time, or
    b. At such time, when it becomes practical to correct fully the non-standard condition.

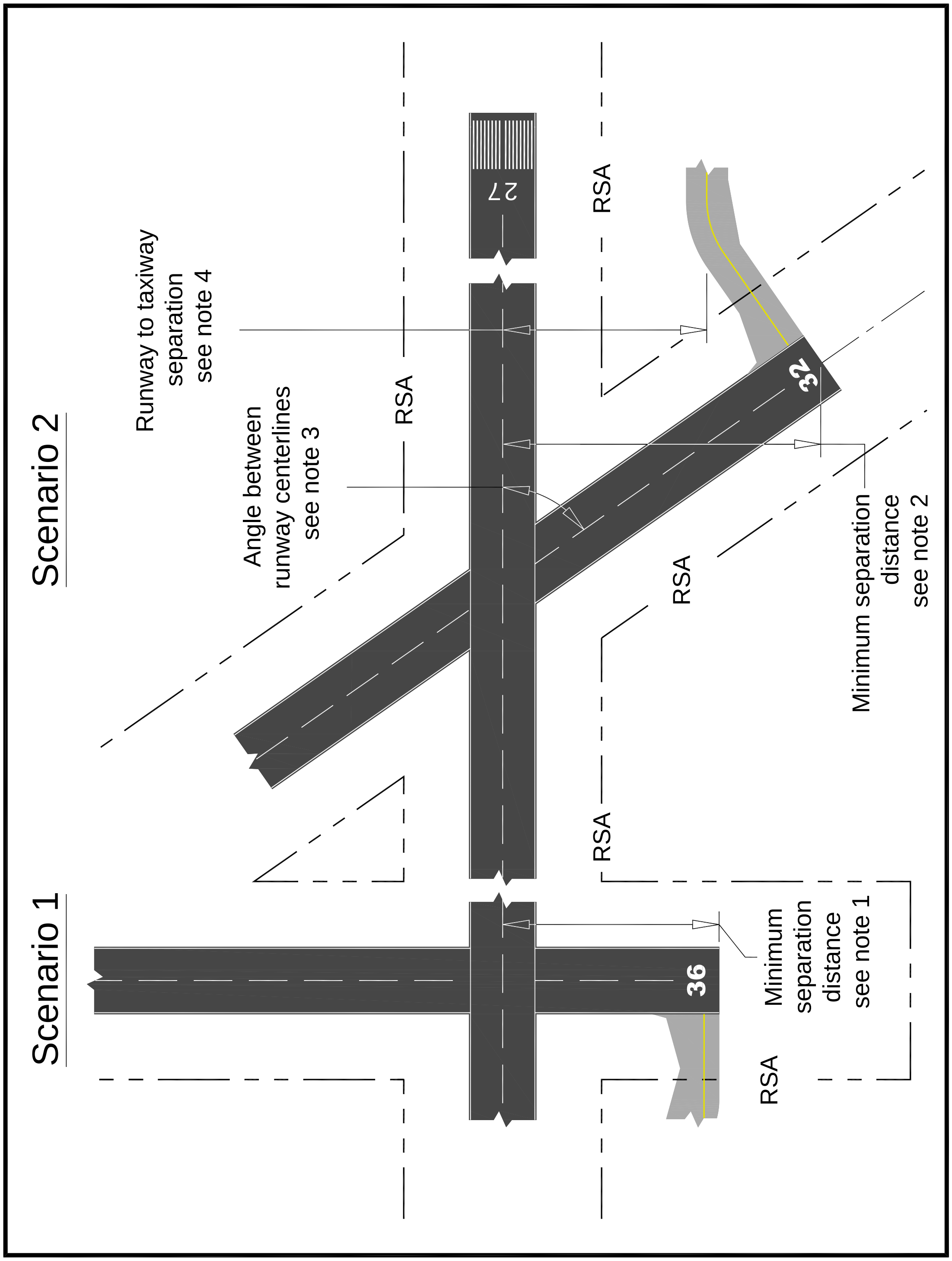
3.6.6.2 Recommended Practices.

1. Configure runways that intersect to eliminate the need to adjust aiming point markings and/or remove touchdown zone markings.
2. When the most demanding aircraft using the airport is not the critical aircraft with regular use, configure the runway ends, taxiways and holding positions, if practical, to preclude the need for operational controls.

3.6.6.3 Design Considerations.

1. Intersecting runways with runway ends in close proximity present an elevated risk for wrong runway departures. See Appendix I.
2. When two runways intersect, adjustment of pavement markings may be necessary for the lesser order runway as specified in AC 150/5340-1.
3. It is possible to locate the intersection between two precision instrument runways at an angle of as little as 33 degrees while maintaining standard markings.

Figure 3-12. Intersecting Runways



Note 1: Minimum distance: standard runway centerline to taxiway centerline separation plus ½ taxiway width.

Note 2: The minimum separation distance is the necessary distance to allow an aircraft to hold without encroaching upon an RSA.

Note 3: Refer to paragraph 3.6.6.2.

Note 4: See Appendix G for runway-taxiway separation value.

3.7 Runway Line of Sight.

The runway line of sight standards reduce conflicts among aircraft, and between aircraft and vehicles operating along active runways. The pilots on the runway can visually verify the location and actions of other aircraft and vehicles on the ground.

3.7.1 Individual Runways.

3.7.1.1 Standards.

1. For runways without full parallel taxiways, ensure any point 5 feet (1.5 m) above the runway centerline is mutually visible with any other point 5 feet (1.5 m) above the runway centerline.
2. For runways with a full parallel taxiway, ensure any point 5 feet (1.5 m) above the runway centerline is mutually visible with any other point 5 feet (1.5 m) above the runway centerline that is located at a distance that is less than one half the length of the runway.

3.7.2 Intersecting Runways.

The Runway Visibility Zone (RVZ) is an area formed by imaginary lines connecting two physically intersecting runways' line of sight points. A clear line-of-sight precludes buildings, structures and parked aircraft within the RVZ from blocking the pilots view to the intersecting runway. The RVZ allows for pilot situational awareness to avoid conflict with aircraft operating on an intersecting runway.

3.7.2.1 Standards.

The following standards apply to airports without an airport traffic control tower (ATCT) and airports with part-time ATCT operations.

1. Ensure any point 5 feet (1.5 m) above runway centerline and in the runway visibility zone (Figure 3-13) is mutually visible with any other point 5 feet (1.5 m) above the centerline of the crossing runway and inside the runway visibility zone.
2. Locate the runway line of sight points as follows:
    a. The end of the runway if runway end is located within 750 feet (229 m) of the crossing runway centerline.
    b. A point 750 feet (229 m) from the runway intersection (or extension) if the end of the runway is located within 1,500 feet (457 m) of the crossing runway centerline or extended centerline. See Figure 3-14.
    c. A point one-half of the distance from the intersecting runway centerline (or extension), if the end of the runway is located at least 1,500 feet (457 m) from the crossing runway centerline or extended centerline. See Figure 3-14.

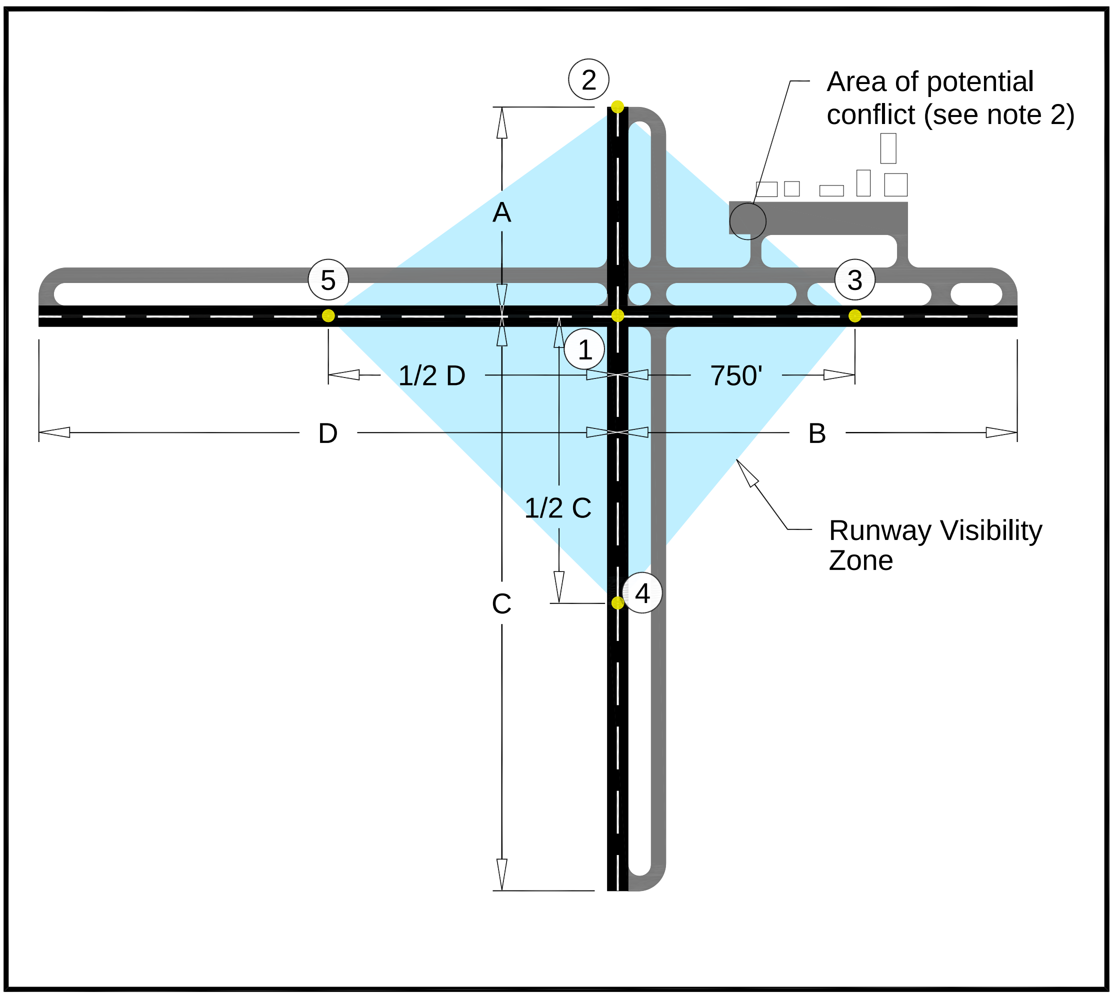
3.7.2.2 Recommended Practices.

For airports with a 24-hour ATCT, apply the RVZ criteria to intersecting runways as a supplemental safety measure.

3.7.2.3 Design Considerations.

Design apron layout to preclude aircraft parking positions that reside within an RVZ. Refer to the area of potential conflict shown on Figure 3-13.

Figure 3-13. Runway Visibility Zone



Note 1: Dimensions:

a. When A ≤ 750 ft (229 m), then ① to ② = distance to the end of the runway.

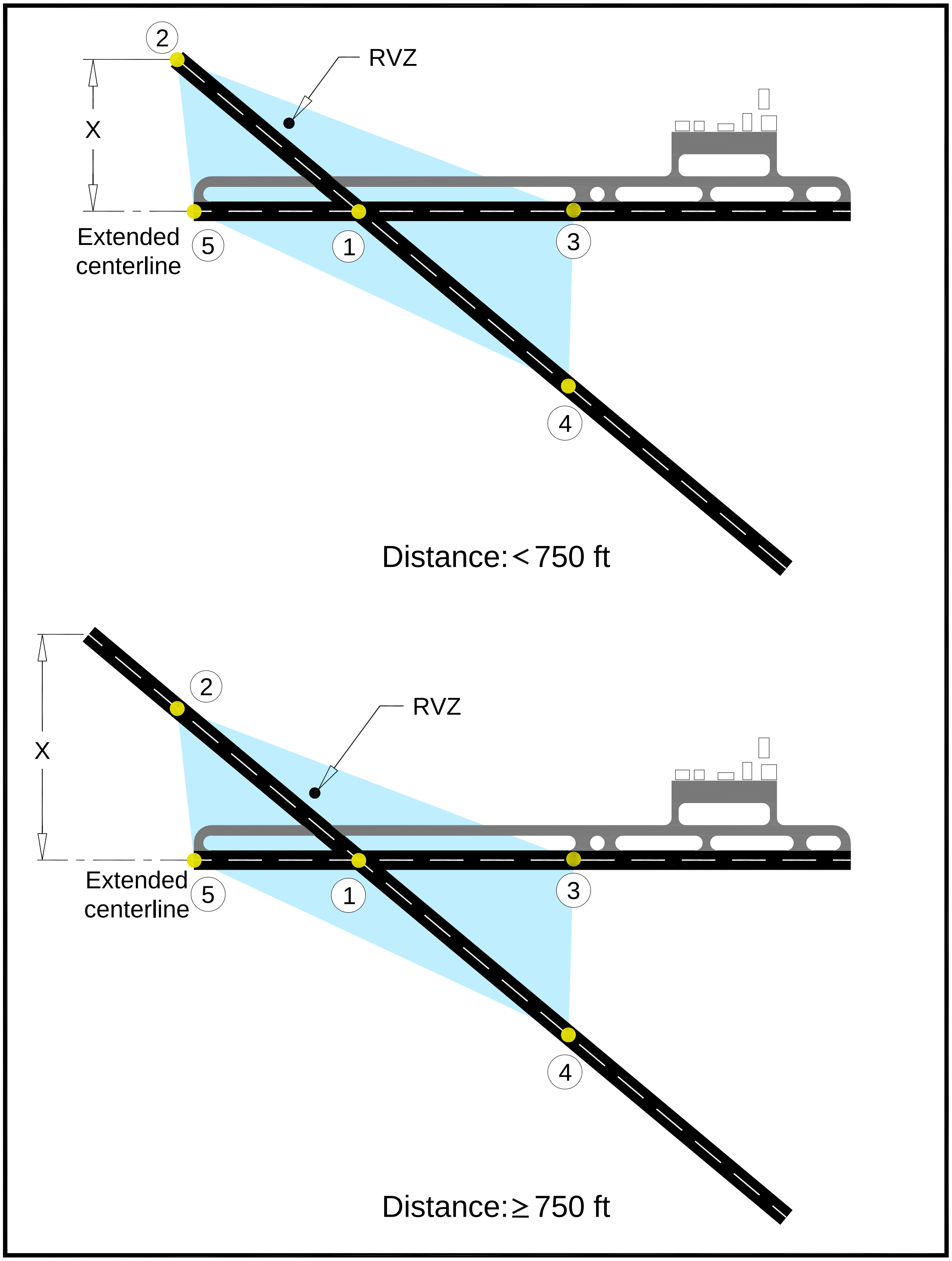
b. When B < 1500 ft (457 m) but > 750 ft (229 m), then ① to ③ = 750 ft (229 m).

c. When C ≥ 1500 ft (457 m), then ① to ④ = ½ C.

d. When D ≥ 1500 ft (457 m), then ① to ⑤ = ½ D.

Note 2: RVZs that include apron areas create potential line of sight conflicts whenever parked aircraft or hangar structure is present.

2298 **Figure 3-14. Runway Visibility Zone – Extended Centerline**



2299

Dimensions for Figure 3-14:

a. When the separation distance "X" <750 ft (229 m), then the ① to ② value equals distance to the end of the runway.
b. When the separation distance "X" ≥ 750 ft (229 m) but < 1500 ft (457 m), then the ① to ② value equals 750 ft (229 m).
c. When the separation distance "X" ≥ 1500 ft (457 m), then the ① to ②value equals ½ distance to the end of the runway.

3.7.3 Converging Non-Intersecting Runways.

The "See and Avoid" concept of 14 CFR part 91 is the primary safeguard for collision avoidance for separate aircraft operating on runways that converge but do not physically intersect. Airports can facilitate pilot vigilance by adapting a version of the RVZ as a supplemental safety measure.

3.7.3.1 Recommended Practice.

For runways that converge but do not intersect, provide a clear line-of-sight five feet above the pavement within an area bounded by select points on each runway to form a triangular visibility zone. Locate the line-of-sight points as follows:

1. The end of the runway if the runway end is located within a distance equal to 0.4 x Runway Length from the intersection with the converging runway centerline (actual or extension), or
2. A distance of 0.4 × Runway Length from the intersection with the converging runway centerline (actual or extension).

3.8 Parallel Runway Separation.

This section provides an overview of the basic separation criteria between parallel runways. The FAA continues to refine parallel runway separation standards for various operational scenarios as part of modernization efforts for the NAS, including the Next Generation Air Transportation System (NextGen). Consult the latest updates and notices for FAA Order 7110.65, *Air Traffic Control*, for specific operational procedures normally authorized for parallel runways, including information on relevant dependencies with aircraft avionics and NAS automation equipment. While referencing FAA Order 7110.65 is normally sufficient for conceptual airport layout, additional coordination with Flight Standards, Flight Procedures and Technologies Division (AFS-410) is necessary for development of detailed operational procedures and requirements for parallel runway procedures at a specific airport.

3.8.1 Basic Principles.

To attain IFR capability for simultaneous independent landings and takeoffs on parallel runways, the lateral separation between aircraft operating to parallel runways replaces, in whole or in part, the aircraft-to-aircraft separation necessary for single runway operations. For parallel runways having sufficient centerline-to-centerline separation, the FAA can authorize simultaneous operations during visual or instrument weather conditions. Parallel runways with less than the necessary separation distance will have dependent operations, with reduced capacity as compared to independent operations. Helipads have unique criteria for separation from runways and other helipads. Generally, departure operations follow criteria in paragraph 3.8.4. Arrival and mixed operations criteria vary. See FAA Order 7110.65 for applicable operating criteria which is applied to locate the helipad.

3.8.2 Visual Flight Rules (VFR).

3.8.2.1 **Standards.**

1. For simultaneous independent landings and takeoffs using VFR, the minimum separation between centerlines of parallel runways is 700 feet (213 m) at a towered or non-towered airport (also when the tower is not operating).
2. With an operating control tower, the minimum separation between centerlines of parallel runways for dependent landings and takeoffs using VFR can be not less than 300 feet (91 m).

3.8.2.2 **Design Considerations.**

With a narrow runway separation of 300 feet, preventing problematic taxiway geometry requires special attention. However, the 300-foot configuration may be suitable for a pair of pavement and turf runways. This avoids operating in the RSA of the paved runway for aircraft that prefer to use a grass surface. See paragraph 2.8.5 for discussion on operations within an RSA.

3.8.3 Simultaneous Instrument Flight Rules (IFR) Arrival Operations.

It is a condition of the separation criteria that the arriving aircraft establish itself on an IFP. Other criteria apply with ATC automation (in the Terminal Radar Approach Control Facilities [TRACON]), surveillance update rates, and ATC staffing for approach monitoring.

3.8.3.1 **Standards.**

1. For dual simultaneous instrument approaches for airports below 2,000 feet (610 m) elevation:
   a. For straight-in approaches, the minimum parallel runway centerline separation between adjacent runways is 3,600 feet (1097 m).
   b. Separation of 3,000 feet (914 m) between adjacent runways is allowable with an offset approach to one runway end.
2. For dual simultaneous instrument approaches for airports above 2,000 feet (610 m) elevation, the minimum parallel runway centerline separation of 4,300 feet (1097 m) between adjacent runways when straight-in approaches are used.

3. For adjacent runways with runway centerline separation of less than 4,300 feet (1097 m):
    a. Other simultaneous approach capabilities are possible with high update surveillance and/or use of Simultaneous Offset Instrument Approaches (SOIA).
    b. Contact the applicable FAA Airports Regional or District Office to initiate applicable FAA coordination.
4. For triple simultaneous instrument approaches for airports below 2,000 feet (610 m) elevation:
    a. The minimum parallel runway centerline separation of 3,900 feet (1189 m) between adjacent runways when straight-in approaches are used.
    b. A separation of 3,000 feet (1189 m) between adjacent runways is allowable with an offset approach to an applicable outboard runway.
5. For quadruple simultaneous instrument approaches:
    a. This capability does not currently exist in the NAS.
    b. Development of quadruple approach capabilities will involve a site-specific study by Flight Technologies and Procedures Division (AFS-400) with guidance implementation by ATO.

3.8.4 Simultaneous IFR Departures or Mixed Operations.

Simultaneous operations normally involve radar surveillance provided by ATC to monitor aircraft separation. ATC treats such operations on runways with centerline separation under 2,500 feet (762 m) as dependent runway operations when wake turbulence is a factor.

3.8.4.1 **Standards.**

1. Simultaneous departures:
    a. With the parallel runway centerline separation of at least 2,500 feet (762 m).
    b. In non-radar airspace, with the parallel runway centerline separation of at least 3,500 feet (1067 m).
2. Simultaneous radar-controlled approaches and departures (mixed operations) require the following parallel runway centerline separations:
    a. When the thresholds are not staggered, at least 2,500 feet (762 m).
    b. When the thresholds are staggered and the approach is to the near threshold, reducing the 2,500-foot (762 m) separation by 100 feet (30 m) for each 500 feet (152 m) of threshold stagger to a

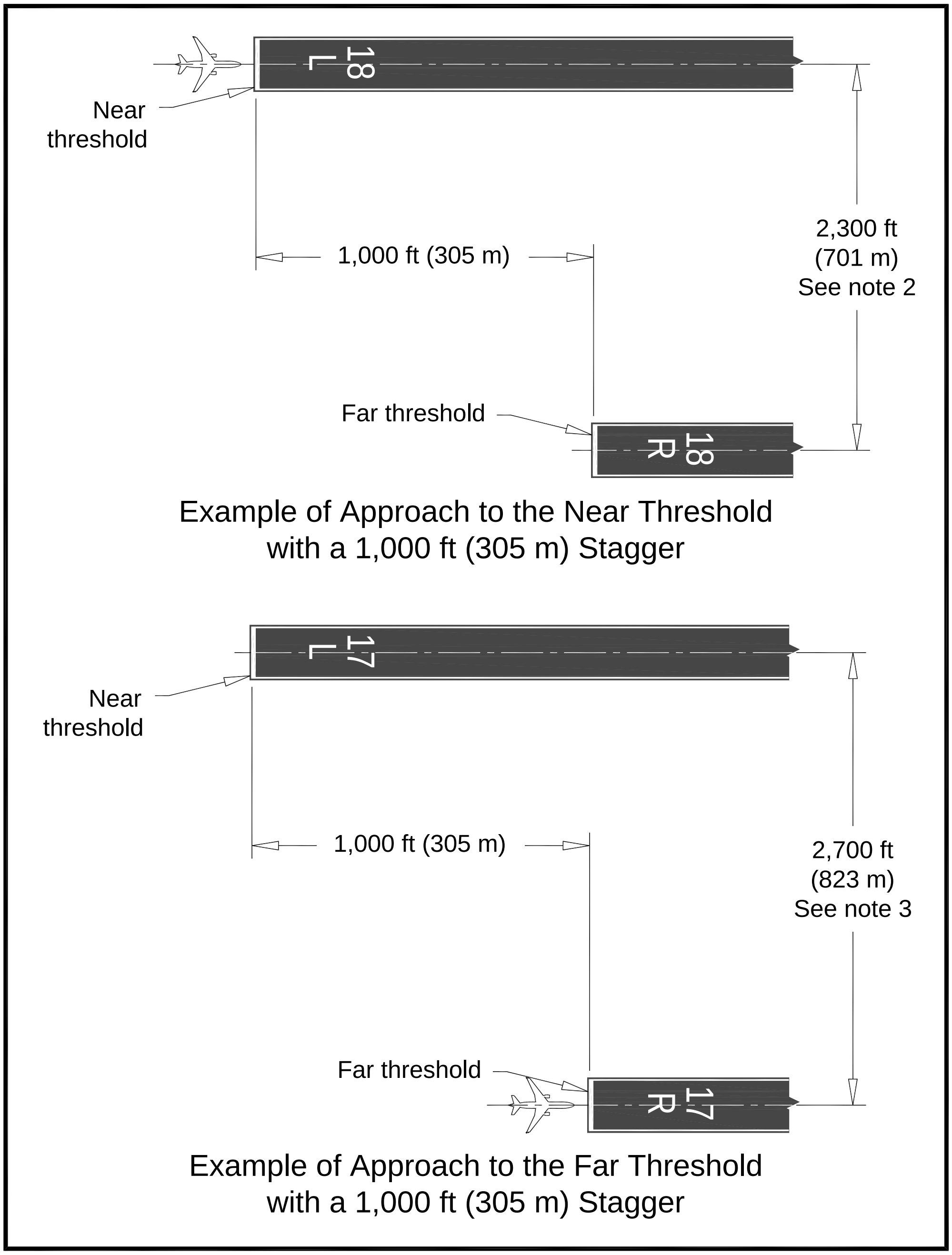
minimum separation of 1,000 feet (305 m) is allowable. See Figure 3-15.

c. When the thresholds are staggered and the approach is to the far threshold, increase the separation distance from the minimum 2,500-foot (762 m) by 100 feet (30 m) for every 500 feet (152 m) of threshold stagger. See Figure 3-15.

3.8.4.2 **Recommended Practices.**

1. The recommended minimum runway centerline separation distance for ADG-V and ADG-VI runways is 1,200 feet (610 m).
2. The increased separation allows for holding aircraft between the runways in the interest of safety (preventing incursions) and efficiency.
3. Terminal area space needs may dictate greater parallel runway separation than required for simultaneous IFR operations. Where practical, a parallel runway separation on the order of 5,000 feet (1524 m) provides efficient surface operations to and from a terminal located between the runways.
4. Provide a separation distance that permits future development (i.e. parallel taxiway) without causing relocation of a runway.

Figure 3-15. Parallel Runway Separation, Simultaneous Radar-Controlled Approach – Staggered Threshold



Note 1: Figure illustrates parallel runway separation adjustments from the standard 2,500 ft (762 m) for simultaneous radar-controlled approaches.

Note 2: Reduce the standard 2,500 ft (762 m) separation by 100 ft (30.5 m) for each 500 ft (152 m) of threshold stagger.

Note 3: Increase the standard 2,500 ft (762 m) separation by 100 ft (30.5 m) for each 500 ft (152 m) of threshold stagger. Figure illustrates parallel runway separation adjustments from the standard 2,500 ft (762 m) for simultaneous radar-controlled approaches.

3.9 Runway Safety Area (RSA) / Engineered Materials Arresting Systems (EMAS).

The RSA enhances the safety of aircraft that undershoot, overrun, or veer off the runway, and it provides greater accessibility for fire fighting and rescue equipment during such incidents. Figure 3-16 depicts the RSA. See Appendix I for historical and background information.

3.9.1 Standards.

3.9.1.1 Location.

The RSA is symmetrical to the runway centerline and runway extended centerline.

3.9.1.2 Dimensions.

Appendix G and the online Runway Design Standards Matrix Tool present RSA dimensional standards.

3.9.1.3 Grading.

Provide an RSA that is:

1. Cleared and graded with no potentially hazardous ruts, humps, depressions, or other surface variations;
2. Drained by grading or storm sewers to prevent water accumulation;
3. Capable, under dry conditions, of supporting snow removal equipment, Aircraft Rescue and Fire Fighting (ARFF) equipment, and the occasional passage of aircraft without causing major damage to the aircraft;
4. Graded to the longitudinal and transverse grades in paragraph 3.15.6.

3.9.1.4 Object Clearing.

Provide RSA free of objects excluding those objects that need to reside in the RSA because of function (i.e. fixed-by-function).

1. Configure airfield geometries to keep the RSA clear during an aircraft operation of:
    a. All portions of a holding or taxiing aircraft.
    b. All portions of a holding or moving ground vehicle.
2. Design objects in the RSA higher than 3 inches (76 mm) above surrounding grade to have a frangible point no higher than 3 inches (76 mm) above surrounding grade. See AC 150/5220-23.
3. Design other objects such as manholes and inlets that need to reside in the RSA:
    a. To be capable of supporting SRE vehicles, ARFF vehicles and occasional passage of the most demanding aircraft.

b. To the lowest possible height (e.g. at grade) but in no case exceeding 3 inches (76 mm) above surrounding grade.

4. Locate objects outside the RSA if it is not essential for the object to reside within the RSA.
5. Do not install objects, including NAVAIDs not fixed-by-function, inside the standard RSA dimensions even when the RSA does not meet the dimensional standards.

3.9.1.5 **Construction.**

Comply with compaction criteria in Specification P-152, Excavation, Subgrade and Embankment, found in AC 150/5370-10. Refer to AC 150/5320-6 for design guidance for foundations, inlets, and manholes located with the RSA to support occasional loads by the most demanding aircraft.

3.9.2 Design Considerations.

3.9.2.1 **Non-Standard Runway Safety Areas.**

In accordance with FAA Order 5300.1, the FAA will not consider a “modification of standard” to address non-standard RSA dimensions. RSA dimensional standards remain in effect regardless of the presence of natural or man-made objects or surface conditions that preclude meeting full RSA standard dimensions.

1. While an EMAS system represents a supplemental measure that provides a level of safety equivalent to a standard RSA, the presence of an EMAS does not diminish or negate the standard RSA dimensional values.
2. Evaluate all practicable alternatives and opportunities to improve a non-standard RSA until it meets all standards for grade, construction, and object frangibility.
3. Identify on the ALP future development necessary to attain a standard RSA.
4. FAA Order 5200.8 explains the runway safety area determination process for assessing non-standard runway safety areas.

3.9.2.2 **NAVAIDs.**

As part of RSA design, consider the impact NAVAIDs have on the effectiveness of the RSA.

1. Evaluate practicable RSA construction at a grade that will preclude the need for non-frangible towers for portions of approach lighting systems or the localizer antenna array.
   a. Non-frangible towers pose a hazard risk to aircraft and may represent a potential interference source to LOC performance.

b. Construction to a lesser grade may allow installation on frangible or low impact resistant structures.

2. When practical, grade beyond the standard RSA dimensions to avoid abrupt drop-offs that can affect the location and performance of ILS components (glideslopes [GSs] and LOCs).

   a. GS facilities generally require a graded area in front of the antenna to serve as a reflective surface for the signal.

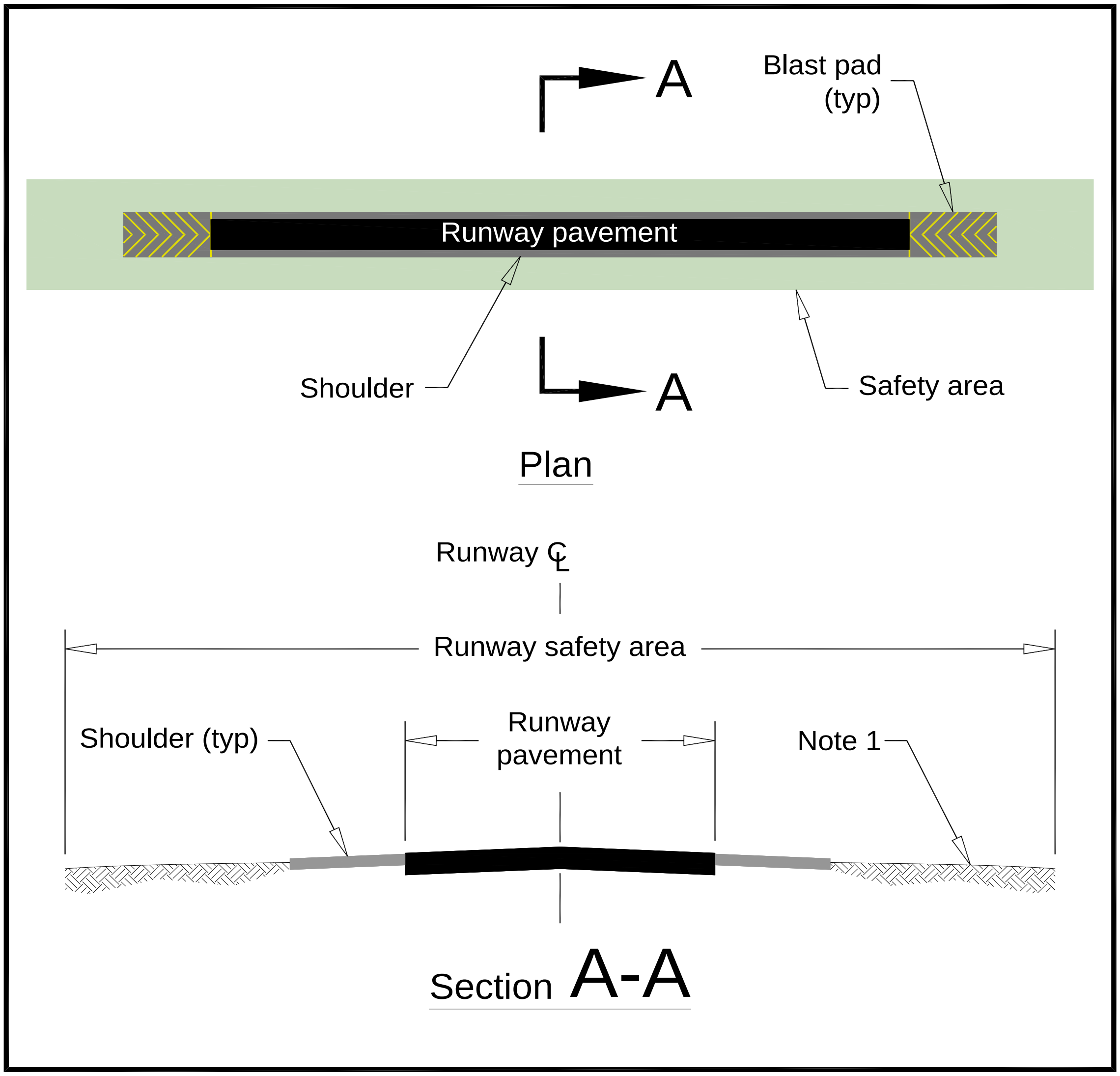
   b. Extend the RSA if needed to avoid placing the localizer within the RSA limits.

3.9.2.3 Engineered Materials Arresting Systems (EMAS).

The optimum RSA is one that meets the standards for dimensions and grade. When it is not practical to meet fully the dimensional standards for an RSA, the airport may consider various alternatives to achieve an acceptable level of safety. FAA Order 5200.8 addresses various factors to consider when evaluating the various alternatives. The installation of an EMAS system is an acceptable alternative when it is not practical to meet standard RSA dimensions or to implement other alternatives. A properly designed EMAS decelerates an aircraft during an excursion incident without damaging the landing gears thus providing an equivalent level of safety to a standard RSA. The presence of an EMAS system does not negate or diminish standard RSA dimensions. Refer to AC 150/5220-22 for guidance on planning, design, installation and maintenance of EMAS. Refer to FAA Order 5200.9 to determine the best practical and financially feasible alternative. Key design considerations for EMAS performance include:

1. Aircraft weight, landing gear configuration, tire pressure, and entry speed.
2. Stopping the “EMAS critical aircraft” upon exiting the runway at 70 knots is a primary design condition.
3. Application of a standard EMAS may maximize the available runway length.

Figure 3-16. Runway Safety Area (RSA)



Note 1: The width and length beyond the runway end vary per the Runway Design Code. See Appendix G.

3.10 Obstacle Free Zone (OFZ).

The OFZ is a design and an operational surface kept clear during operations. This clearing standard does not allow aircraft and other object penetrations, except for locating frangible NAVAIDs in the OFZ because of their function. OFZ surfaces cannot be modified. The OFZ, when applicable, is composed of four components:

1. the Runway OFZ (ROFZ),
2. the Precision Obstacle Free Zone (POFZ),
3. the inner-approach OFZ (IA-OFZ), and
4. the inner-transitional OFZ (IT-OFZ).

3.10.1 Recommended Practice.

Construct a runway to taxiway separation sufficient to protect the OFZ of a more demanding RDC for aircraft that, within reason, have occasional use at the airport.

3.10.2 Design Considerations.

1. Use the most demanding anticipated aircraft operation when selecting the applicable OFZ for runway design.
2. The OFZ for a specific aircraft operation may not be the same shape as that used for design purposes.
3. Procedures to protect the OFZ during operations by aircraft/operations more demanding than used for the design of the runway are beyond the scope of this AC. (Consultation with the appropriate offices of the FAA Office of Airports, Flight Technologies and Procedures Division (AFS-400), and/or ATO will identify any applicable adjustments to operational procedures.)
4. See Figure 3-17, Figure 3-18, Figure 3-19, and Figure 3-20 for various OFZ based on aircraft size and visibility minimums.

3.10.3 Runway Obstacle Free Zone (ROFZ).

The ROFZ is a defined volume of airspace centered on the runway centerline, whose base elevation is that of the highest runway elevation at that particular location. The ROFZ extends 200 feet (61 m) beyond each end of the runway.

3.10.3.1 **Standards.**

1. For operations by small aircraft:
    a. 300 feet (91 m) for runways with lower than 3/4 statute mile (1.2 km) approach visibility minimums.
    b. 250 feet (76 m) for operations on other runways by small aircraft with approach speeds of 50 knots or more.
    c. 120 feet (37 m) for operations on other runways by small aircraft with approach speeds of less than 50 knots.
2. 400 feet (122 m) for operations by large aircraft.

3.10.4 Inner-approach OFZ (IA-OFZ).

The inner-approach OFZ is a defined volume of airspace centered on the approach area. It applies only to runways with an ALS. The inner-approach OFZ begins 200 feet (61 m) from the runway threshold at the same elevation as the runway threshold and extends 200 feet (61 m) beyond the last light unit in the ALS. Its width is the same as the ROFZ and rises at a slope of 50 (horizontal) to 1 (vertical) from its beginning.

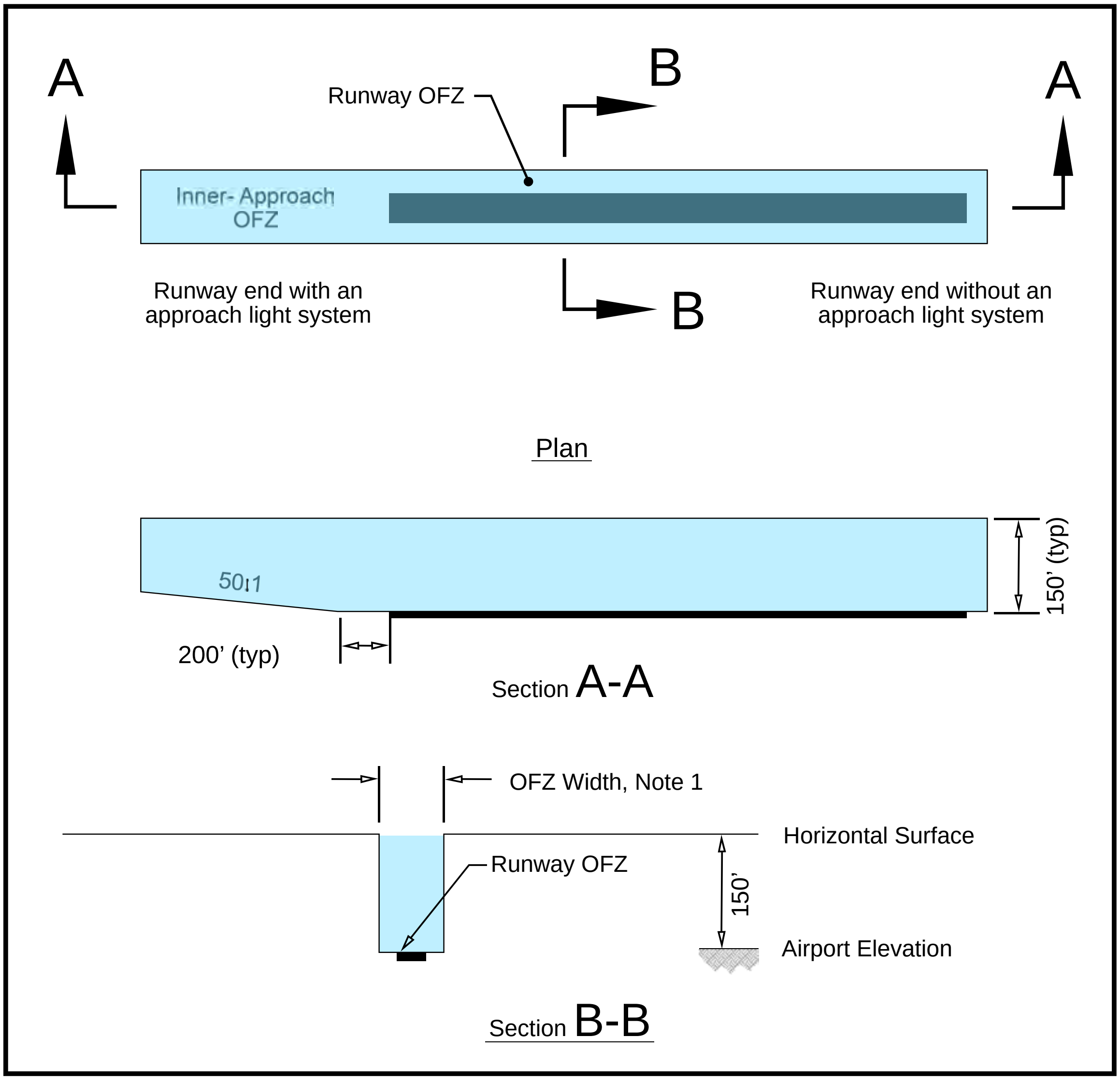
3.10.5 Inner-transitional OFZ (IT-OFZ).

The inner-transitional OFZ is a defined volume of airspace along the sides of the ROFZ and inner-approach OFZ. It applies only to runways with lower than 3/4 statute mile

(1.2 km) approach visibility minimums. Aircraft tails may not violate the inner-transitional OFZ. It is not acceptable to apply the OFZ criteria as support to decrease a runway-to-taxiway separation from the standard value.

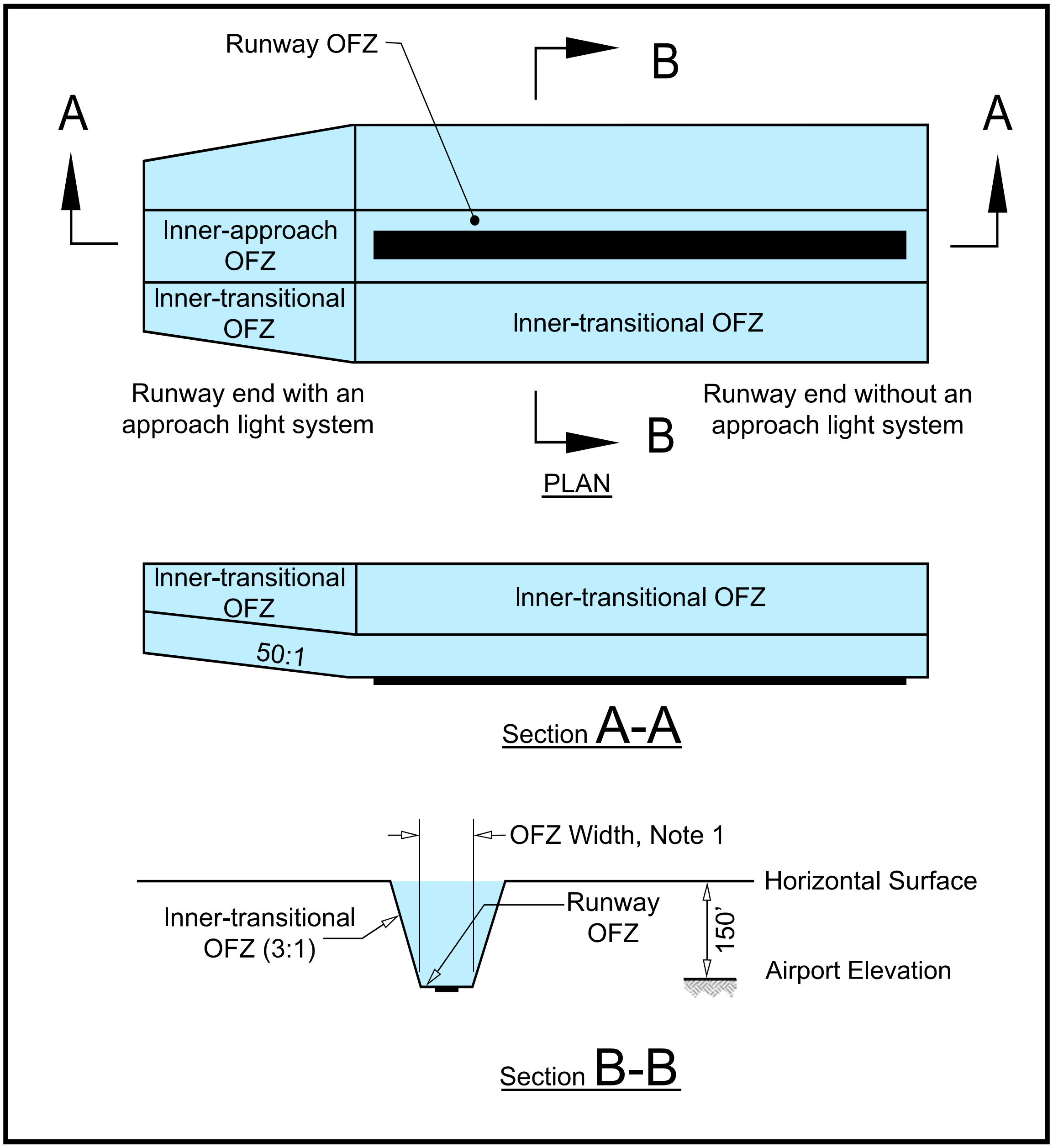
3.10.5.1 For operations on runways by small aircraft, the inner-transitional OFZ slopes 3 (horizontal) to 1 (vertical) out from the edges of the ROFZ and inner-approach OFZ to a height of 150 feet (46 m) above the established airport elevation.

Figure 3-17. Obstacle Free Zone (OFZ) for Visual Runways and Runways with Not Lower Than 3/4 Statute Mile (1.2 km) Approach Visibility Minimums



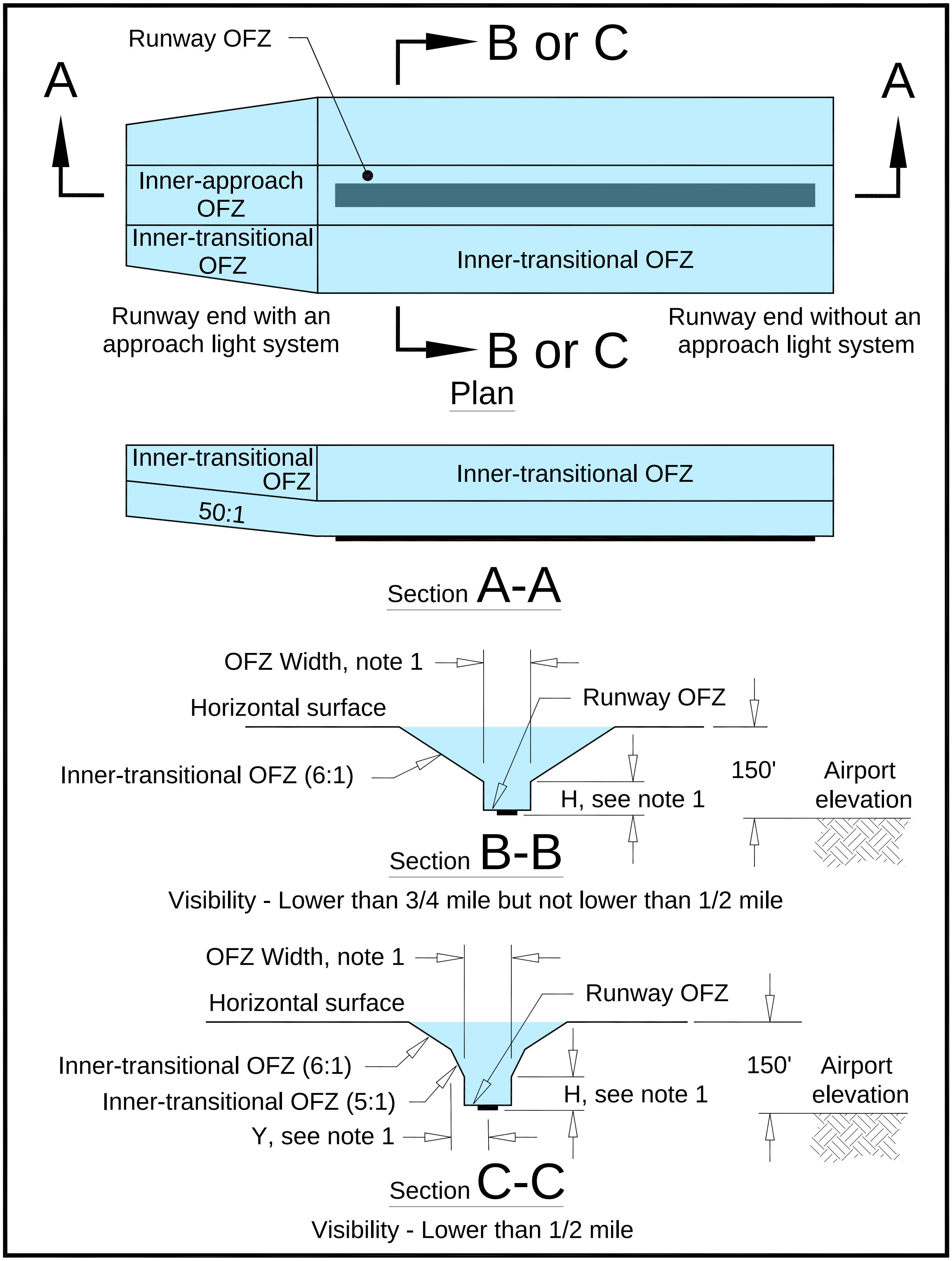
Note 1: Refer to paragraphs 3.10.3, 3.10.4, and 3.10.5 for dimensional values.

Figure 3-18. OFZ for Operations on Runways by Small Aircraft with Lower Than 3/4 Statute Mile (1.2 km) Approach Visibility Minimums



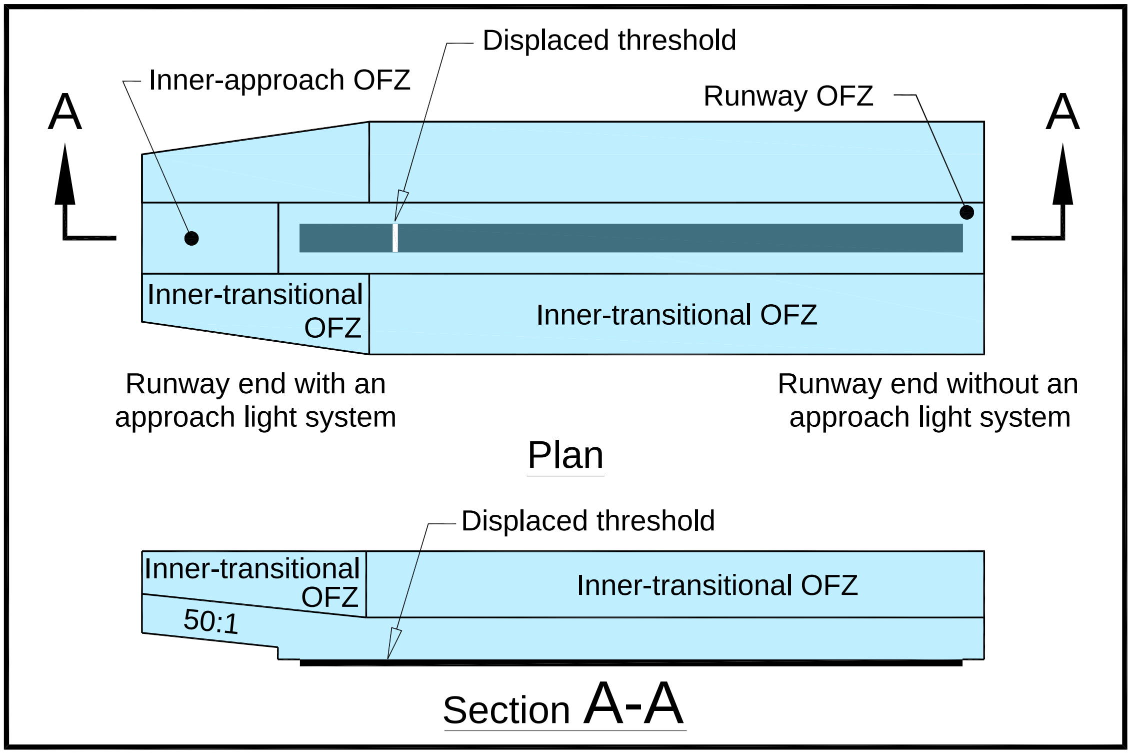
Note 1: Refer to paragraphs 3.10.3, 3.10.4, and 3.10.5 for dimensional values.

Figure 3-19. OFZ for Operations on Runways by Large Aircraft with Lower Than 3/4 Statute Mile (1.2 km) Approach Visibility Minimums



Note 1: Refer to paragraphs 3.10.3, 3.10.4, and 3.10.5 for dimensional values.

Figure 3-20. OFZ for Operations on Runways by Large Aircraft with Lower Than 3/4 Statute Mile (1.2 km) Approach Visibility Minimums and Displaced Threshold



Note 1: Refer to paragraphs 3.10.3, 3.10.4, and 3.10.5 for dimensional values.

3.10.5.2 For operations on runways by large aircraft, separate inner-transitional OFZ (IT-OFZ) criteria apply for runways with instrument approach procedures lower than ¾ mile but not lower than ½ mile.

1. For runways with instrument approach procedures with lower than ¾ mile but not lower than ½ mile, the IT-OFZ begins at the edges of the ROFZ and inner-approach OFZ, then rises vertically for a height "H," and then slopes 6 (horizontal) to 1 (vertical) out to a height of 150 feet (46 m) above the established airport elevation.

   a. In U.S. customary units,

      $H_{feet} = 61 - 0.094(S_{feet}) - 0.003(E_{feet})$.

   b. In SI units,

      $H_{meters} = 18.4 - 0.094(S_{meters}) - 0.003(E_{meters})$.

   c. S is equal to the most demanding wingspan of the RDC of the runway, and E is equal to the runway threshold elevation above sea level.

2. For runways with instrument approach procedure lower than ½ mile visibility, the IT-OFZ begins at the edges of the ROFZ and inner-

approach OFZ, then rises vertically for a height “H,” then slopes 5 (horizontal) to 1 (vertical) out to a distance “Y” from runway centerline, and then slopes 6 (horizontal) to 1 (vertical) out to a height of 150 feet (46 m) above the established airport elevation:

a. In U.S. customary units,

$H_{feet} = 53 - 0.13(S_{feet}) - 0.0022(E_{feet})$ and

$Y_{feet} = 440 + 1.08(S_{feet}) - 0.024(E_{feet})$.

b. In SI units,

$H_{meters} = 16 - 0.13(S_{meters}) - 0.0022(E_{meters})$ and

$Y_{meters} = 132 + 1.08(S_{meters}) - 0.024(E_{meters})$.

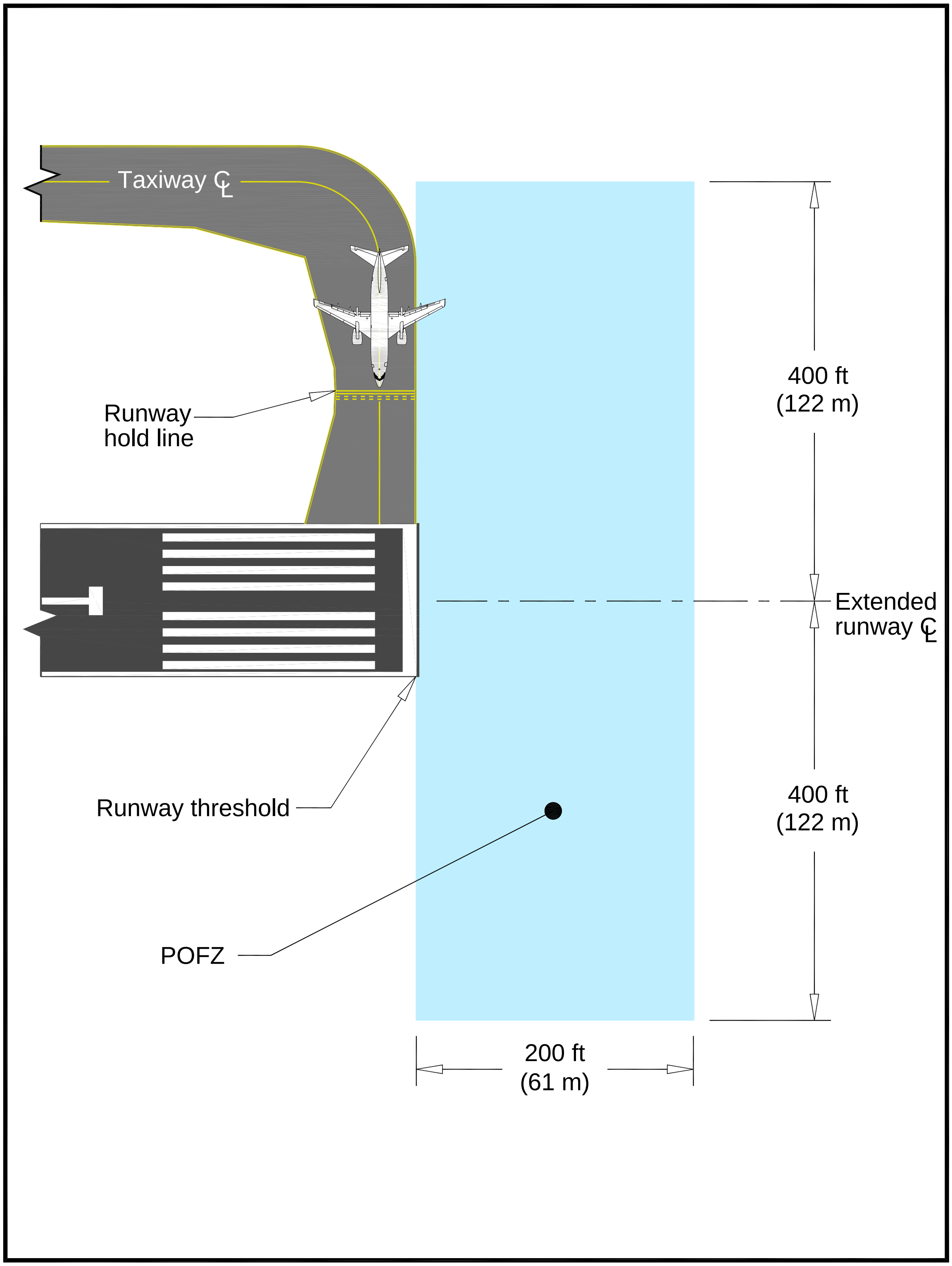
c. S is equal to the most demanding wingspan of the RDC of the runway and E is equal to the runway threshold elevation above sea level.

d. Beyond the distance “Y” from runway centerline, the inner-transitional CAT-II/III OFZ surface is identical to that for the CAT-I OFZ.

3.10.6 Precision Obstacle Free Zone (POFZ).

The POFZ is a volume of airspace above an area beginning at the threshold, at the threshold elevation, and centered on the extended runway centerline (200 feet [61 m] long by 800 feet [244 m] wide. See Figure 3-21.

Figure 3-21. Precision Obstacle Free Zone (POFZ) – No Displaced Threshold



Note: See paragraph 3.10.6.

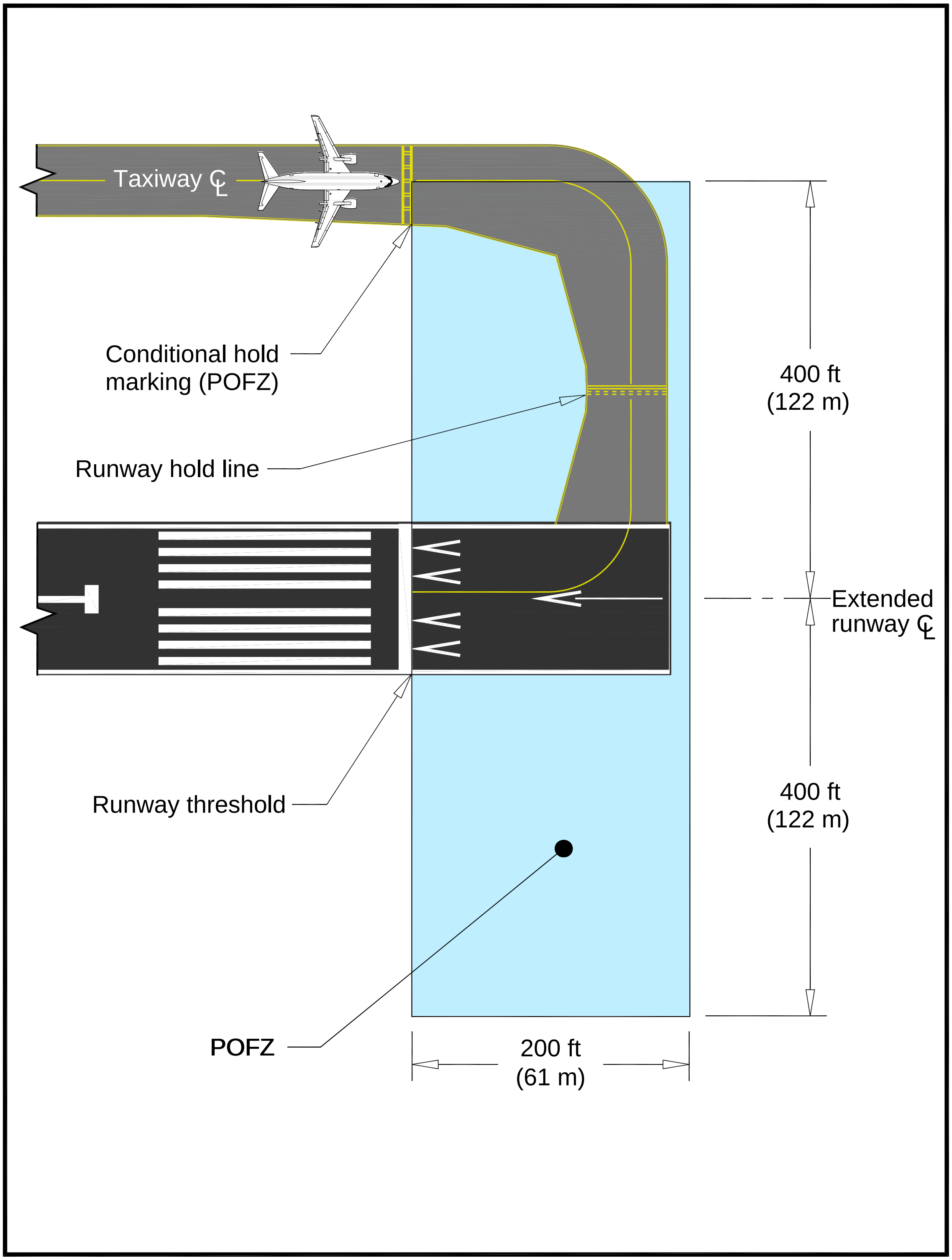
3.10.6.1 The surface is in effect only when all of the following operational conditions are met:

1. The approach includes vertical guidance.
2. The reported ceiling is below 250 feet (76 m) and visibility is less than 3/4 statute mile (1.2 km) (or Runway Visual Range [RVR] is below 4,000 feet [1219 m]).
3. An aircraft is on final approach within 2 miles (3.2 km) of the runway threshold.

3.10.6.2 When the POFZ is in effect, a wing of an aircraft holding on a taxiway may penetrate the POFZ; however, neither the fuselage nor the tail may penetrate the POFZ.

3.10.6.3 The POFZ is applicable at all runway thresholds including displaced thresholds. Refer to Figure 3-22.

2678 **Figure 3-22. POFZ – Displaced Threshold**



2679
2680 **Note 1:** Two hold lines are necessary, as the POFZ is only in effect during instrument meteorological
2681 conditions.

3.11 Runway Object Free Area (ROFA).

ROFA provides a measure of wingtip protection in the event of an aircraft excursion from the runway.

3.11.1 Standards.

1. The ROFA is symmetrical about the runway centerline. See Figure 3-33.
2. See Appendix G or the online Runway Design Standards Matrix Tool for standard dimensions of the ROFA.
3. Provide area clear of above-ground objects protruding above the nearest point of the RSA:
    a. For new runways, ensure terrain is no higher than the nearest point of the RSA within a distance from the edge of the RSA equal to one-half the most demanding wingspan of the RDC.
    b. Maintain area clear of parked aircraft, agricultural operations, and other non-essential activities.
4. Objects are allowed in the ROFA provided there is sufficient clearance (veritical and horizontal) between the object and the aircraft wing while the main gear is in the RSA.
5. Exceptions:
    a. It is acceptable to have objects in the ROFA for air navigation and aircraft ground maneuvering purposes per Table 6-1.
    b. For existing runways, it is permissible for the ROFA to have a positive grade lateral to the RSA, as shown in Figure 3-31, provided there is adequate drainage of the RSA.

3.11.2 Recommended Practices.

1. To the extent practical, make objects in the ROFA that exceed the elevation of the nearest point on the RSA comply with the same frangibility criteria as the RSA.
2. Preclude locating objects in a ROFA that can function equally outside of the ROFA.

3.11.3 Design Consideration.

When locating ditches in a ROFA, consider the impact future vegetation growth in the ditch may have on the adjacent RSA.

3.12 Runway Protection Zone (RPZ).

The RPZ is a public protection zone that serves to enhance the protection of people and property on the ground. Airport owner control of the land use in each runway RPZ is the optimum method of ensuring safety of the public in these areas. Acquisition of appropriate property interest (e.g. fee title, easement, etc.) offers a high degree of control. Zoning ordinances offer a lesser degree of control. The primary goals are to clear the RPZ areas of incompatible objects and activities and to ensure this area remains clear of such objects and activities.

1. The approach RPZ dimensions for a runway end are a function of the aircraft approach category and approach visibility minimum associated with the approach runway end.
2. The departure RPZ is a function of the aircraft approach category and departure procedures associated with the runway.
3. For a particular runway end, the more stringent RPZ (usually the approach) will govern the property interests and clearing for the airport owner.

3.12.1 Standards.

The RPZ is trapezoidal in shape and centered about the extended runway centerline. The RPZ may begin at a location other than 200 feet (61 m) beyond the end of the runway. When an RPZ begins at a location other than 200 feet (61 m) beyond the end of runway, two RPZs result, i.e. a departure RPZ and an approach RPZ. The two RPZs normally overlap (refer to Figure 3-23 and Figure 3-25).

3.12.1.1 Approach RPZ.

The approach RPZ extends from a point 200 feet (61 m) from the runway threshold, as shown in Figure 3-23, for a distance as prescribed in Appendix G or the online Runway Design Standards Matrix Tool.

3.12.1.2 Departure RPZ.

The departure RPZ begins 200 feet (61 m) beyond the runway end. If the Takeoff Run Available (TORA) and the runway end are not the same, it is 200 feet (61 m) beyond the far end of the TORA. Refer to Appendix G or the online Runway Design Standards Matrix Tool for dimensional standards.

1. For runways with an RDC for small aircraft in Aircraft Approach Categories A and B:
    a. Starting point: 200 feet (61 m) beyond the far end of TORA
    b. Length: 1,000 feet (305 m)
    c. Inner width: 250 feet (76 m)
    d. Outer width: 450 feet (137 m)
2. For runways with an RDC for large aircraft in Aircraft Approach Categories A and B:
    a. Starting point: 200 feet (61 m) beyond the far end of TORA
    b. Length: 1,000 feet (305 m)
    c. Inner width: 500 feet (152 m)
    d. Outer width: 700 feet (213 m)

3. For runways with an RDC for Aircraft Approach Categories C, D, and E:

    a. Starting point: 200 feet (61 m) beyond the far end of TORA

    b. Length: 1,700 feet (518 m)

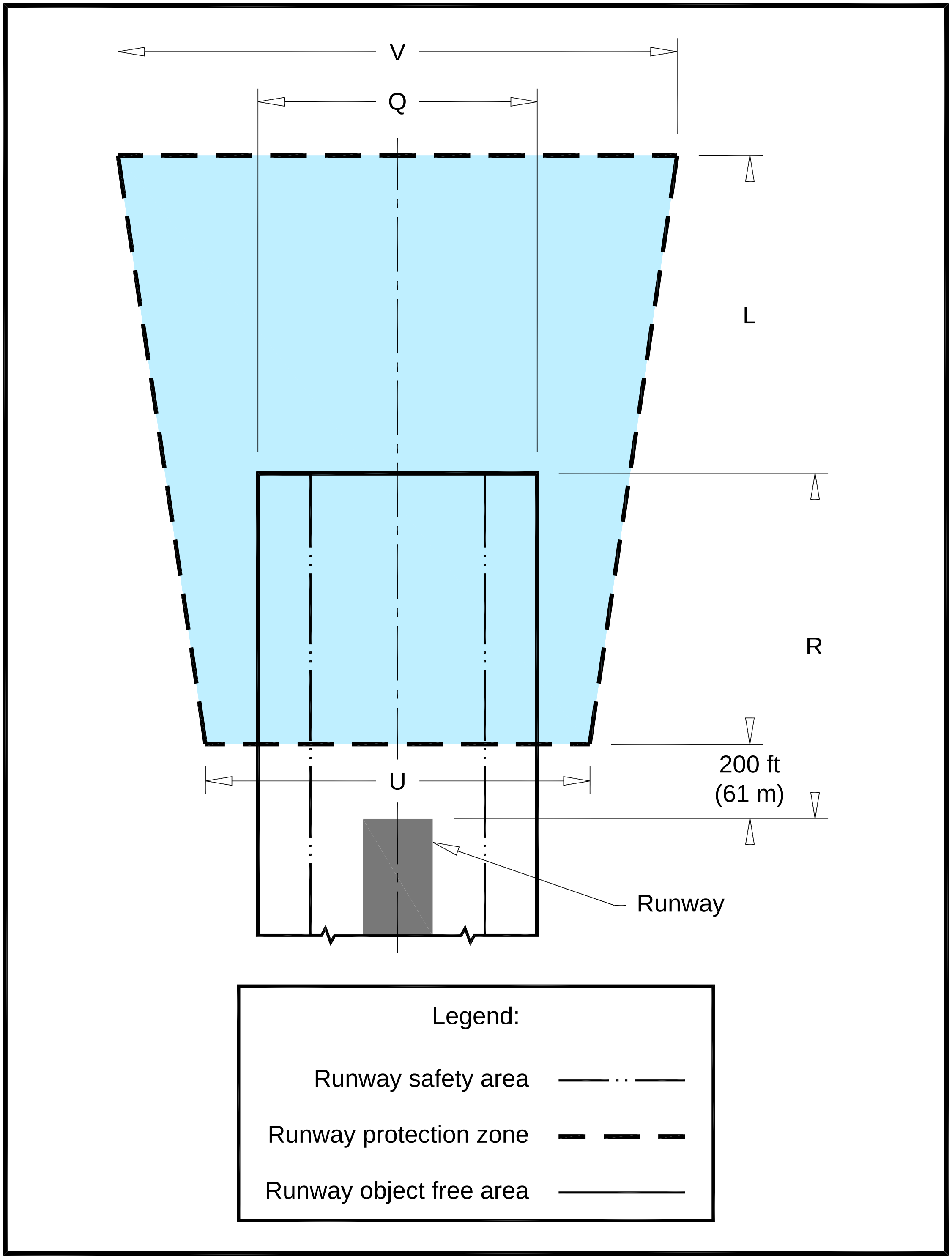
    c. Inner width: 500 feet (152 m)

    d. Outer width: 1,010 feet (308 m).

3.12.2 Design Considerations.

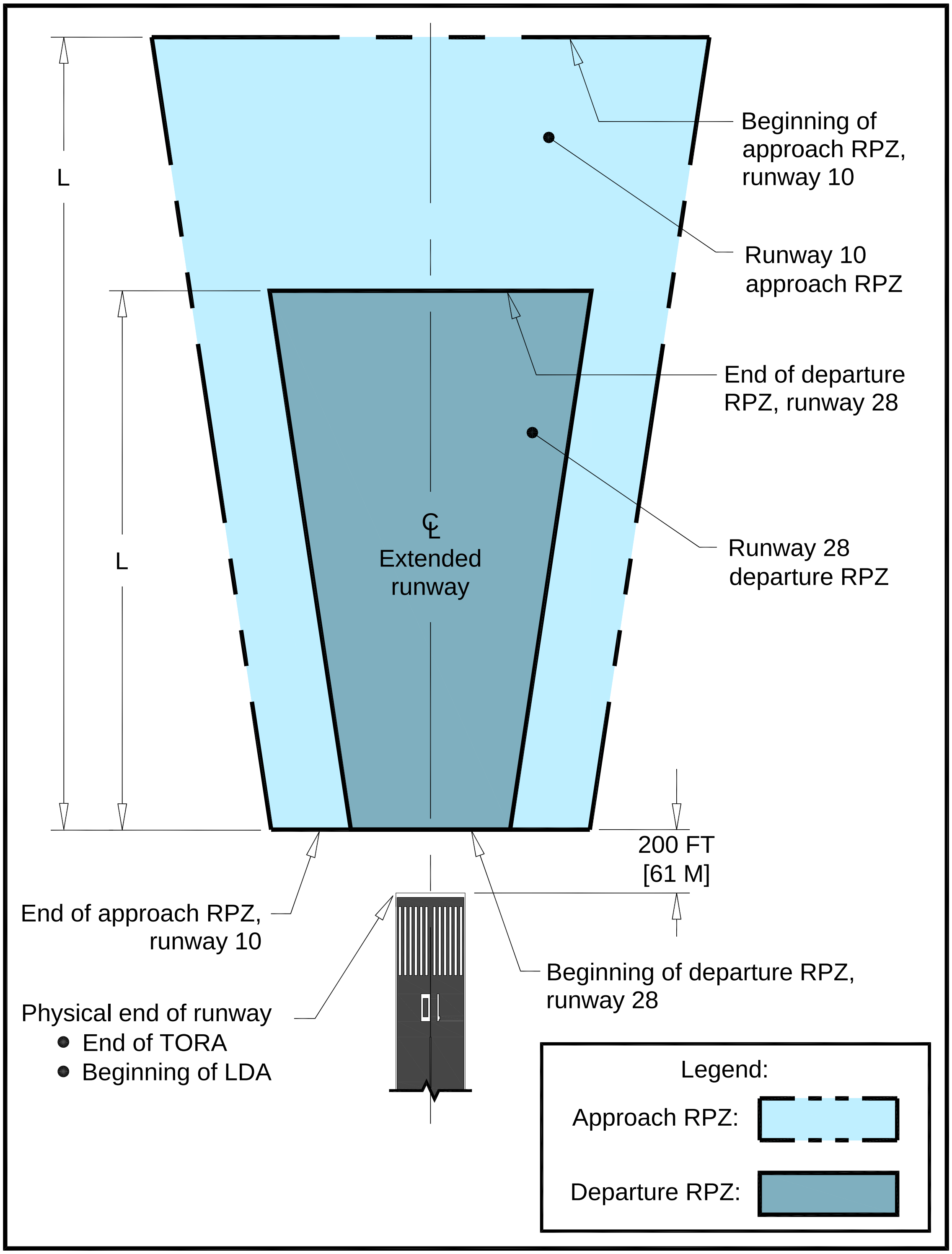
See Appendix I.

Figure 3-23. Runway Protection Zone (RPZ), Runway Object Free Area (ROFA) and Runway Safety Area (RSA)



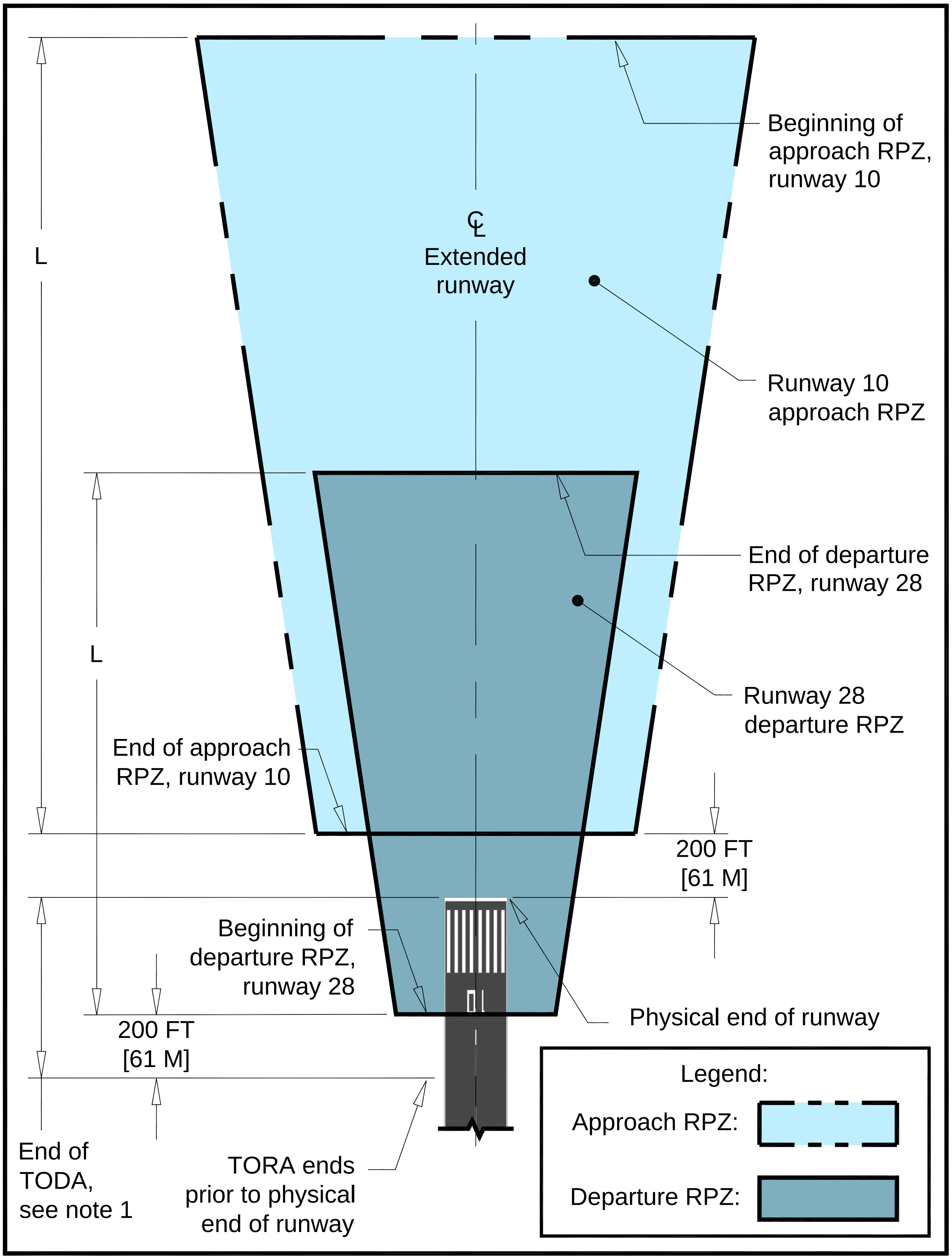
Note: See Appendix G or online Runway Design Standards Matrix Tool for dimensions.

Figure 3-24. Runway with all Declared Distances Equal to the Runway Length



Note: See Appendix G or online Runway Design Standards Matrix Tool for dimensions.

Figure 3-25. Approach and Departure RPZs Where the Takeoff Run Available (TORA) is less than the Takeoff Distance Available (TODA)



Note 1: See Appendix H for declared distances.
Note 2: See Appendix G or online Runway Design Standards Matrix Tool for dimensions.

3.13 Clearway.

The clearway (see Figure 3-26) is an area extending beyond the runway end available for completion of the takeoff operation of turbine-powered aircraft. A clearway increases the allowable aircraft operating takeoff weight without increasing runway length. The use of a clearway for takeoff computations requires compliance with the clearway definition of 14 CFR Part 1.

3.13.1 Standards.

The requirements in this paragraph originate from 14 CFR Part 1. These conditions must be met for a clearway to exist.

3.13.1.1 Dimensions.

The clearway must be at least 500 feet (152 m) wide symmetrically about the runway centerline. The length is no more than ½ the runway length.

3.13.1.2 Clearway Plane Slope.

The clearway plane slopes upward with a slope not greater than 1.25 percent (80:1).

3.13.1.3 Clearing.

No object or terrain may protrude through the clearway plane except for threshold lights no higher than 26 inches (66 cm) and located off the runway sides. The area over which the clearway lies need not be suitable for stopping aircraft in the event of an aborted takeoff.

3.13.1.4 Control.

A condition for standard clearways is the airport owner have suitable control of the underlying property. While direct ownership is not necessary, ownership offers the highest degree of control. The purpose of such control is to ensure that no fixed or movable object penetrates the clearway plane during a takeoff operation.

3.13.1.5 Notification.

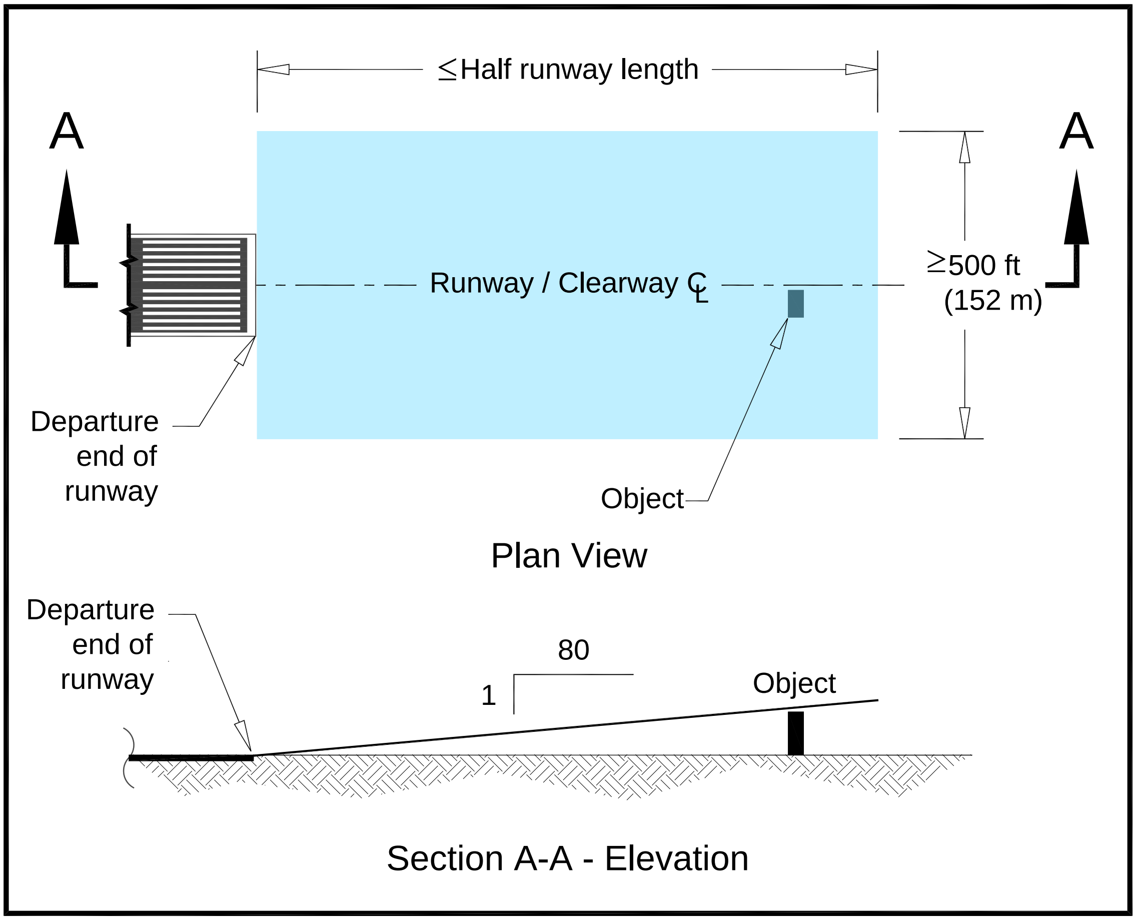
When providing a clearway:

1. Identify the clearway length and the declared distances, as specified in paragraph 3.13.1.1, and in the Chart Supplement (and in the Aeronautical Information Publication for international airports) for each operational direction.
2. Designate the clearway on the Airport Layout Plan (ALP) at those airports with an FAA-approved ALP.

3.13.1.6 Clearway Location.

Locate the clearway at the far end of TORA. The portion of the runway extending into the clearway is unavailable for takeoff run and takeoff distance computations.

Figure 3-26. Clearway



3.14 Stopway.

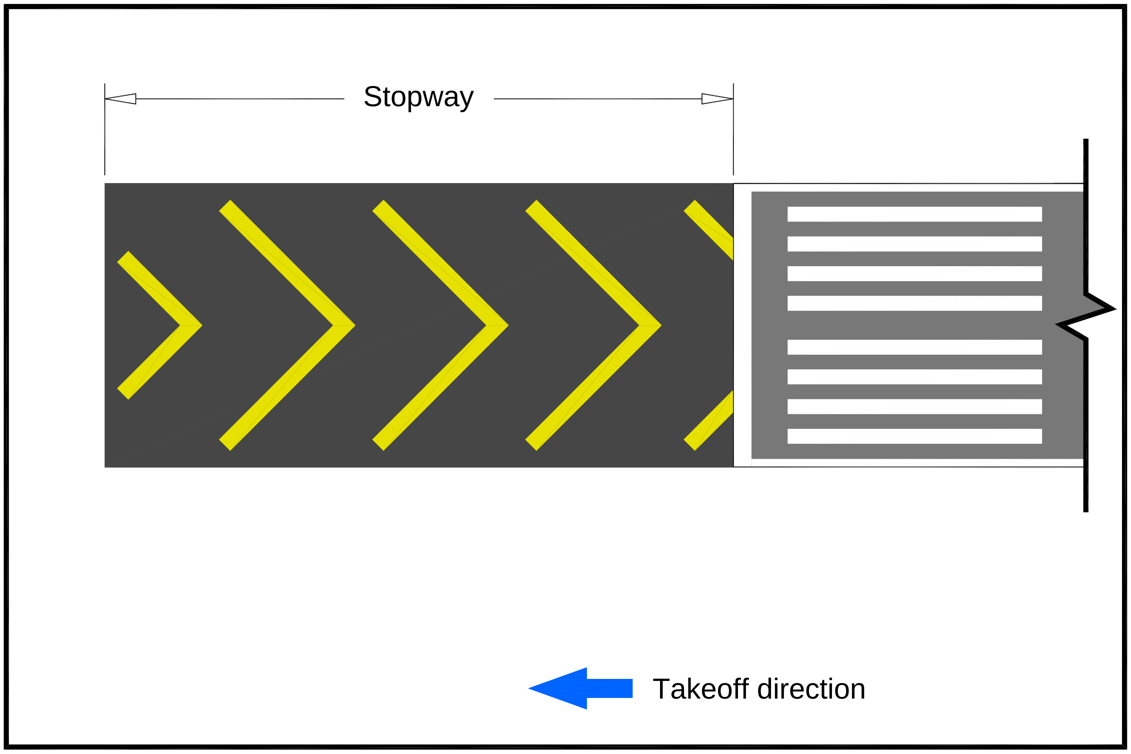
A stopway is an area beyond the takeoff runway located symmetrically about the extended runway centerline and designated by the airport owner for use in decelerating an aircraft during an aborted takeoff. (See Figure 3-27.) The presence of a blast pad does not mean a stopway exists. Refer to 14 CFR Part 1 for the criteria that establish a stopway.

3.14.1 Standards.

1. Width: At least as wide as the runway.
2. Surface strength:
    a. Able to support an aircraft during an aborted takeoff without causing structural damage to the aircraft.
    b. Refer to AC 150/5320-6 for pavement design standards for a stopway.

3. Publication: For each operational direction, provide the length and declared distances in the Chart Supplement (and in the Aeronautical Information Publication for international airports).
4. ALP: For federally obligated airports, depict the stopway on the FAA-approved ALP.

Figure 3-27. Stopway



Note 1: Width of stopway equals width of runway.
Note 2: See AC 150/5340-1 for stopway markings.

3.15 Surface Gradient.

Surface gradient is the rate of ascent or descent of an airport surface. The degree of surface gradient can have an effect on aircraft performance, pilot perception and economy of development. An upsloping runway impedes acceleration resulting in longer ground runs during a takeoff operation. A down sloping runway affects deceleration thus resulting in longer ground rollout during landing. The standards in this paragraph allow for economic design flexibility while establishing safe operation of aircraft during landing and takeoff operations. Some of the beneficial aspects provided by the gradient standards include:

1. Safe operation within aircraft structural limits.
2. Efficient drainage of surface water to reduce risk of aircraft hydroplaning.
3. Visual line-of-sight for pilot situational awareness.

4. Reduced risk of optical illusion effect due to runway and terrain slope.
5. Ride smoothness and comfort for aircraft passengers.

3.15.1 Standards for Longitudinal Gradient.

The longitudinal gradient standards for the centerline of runways and stopways vary per aircraft approach category.

3.15.1.1 **Aircraft Approach Categories A and B.**

Refer to Figure 3-29 and the following for standards applicable to Aircraft Approach Categories A and B.

1. The maximum longitudinal grade is ±2.0 percent.
2. The maximum allowable grade change is ±2.0 percent.
3. Vertical curves for longitudinal grade changes are parabolic.
   a. The minimum length of the vertical curve is 300 feet (91 m) for each 1.0 percent of change.
   b. A vertical curve is not necessary when the grade change is less than 0.40 percent.
4. The minimum allowable distance between the points of intersection of vertical curves is 250 feet (76 m) multiplied by the sum of the grade changes (in percent) associated with the two vertical curves.

3.15.1.2 **Aircraft Approach Categories C, D and E.**

Refer to Figure 3-30 and the following for standard applicable to Aircraft Approach Categories C, D and E.

1. The maximum longitudinal grade is ±1.50 percent:
   a. longitudinal grades do not exceed ±0.80 percent in the first and last quarter, or
   b. first and last 2,500 feet (762 m), whichever is less, of the runway length.
2. The maximum allowable grade change is ±1.50 percent; however, runway grade changes are not acceptable within the lesser of the following criteria:
   a. the first and last quarter of the runway length, or
   b. the first and last 2,500 feet (762 m) of the runway.
3. Vertical curves for longitudinal grade changes are parabolic. The length of the vertical curve is a minimum of 1,000 feet (305 m) for each 1.0 percent of change.
4. The minimum allowable distance between the points of intersection of vertical curves is 1,000 feet (305 m) multiplied by the sum of the grade changes (in percent) associated with the two vertical curves.

3.15.2 Standards for Transverse Gradients.

Transverse grades provide positive lateral drainage off runway pavement surfaces. Refer to Figure 3-31.

3.15.2.1 All Runways.

The standard configuration is a center crown with equal, constant transverse grades on either side.

3.15.2.2 Aircraft Approach Categories A and B.

Design transverse slope within a 1.0 percent to 2.0 percent range from center crown.

3.15.2.3 Aircraft Approach Categories C, D and E.

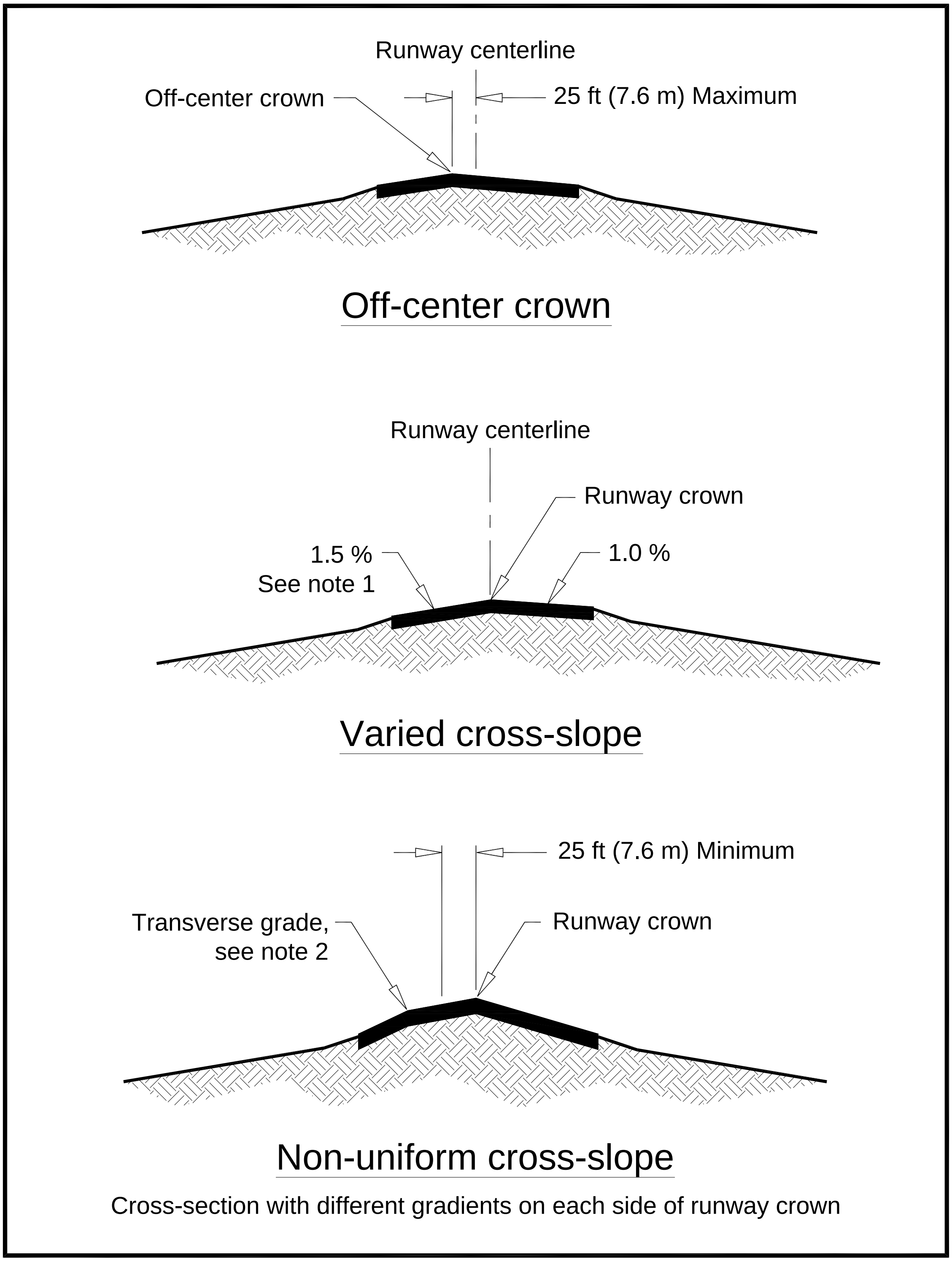
Design transverse slope within a 1.0 percent to 1.5 percent range from center crown.

3.15.2.4 Cross-Slope Variations.

The following configuration variances are acceptable methods to maintain positive drainage for site-specific runway conditions. Refer to Figure 3-28. Consider these variances when local site conditions are not suitable for application of the standard cross slope. This includes localized site conditions that limit runway edge elevations in order to match existing grades. Variances are also suitable for runway/runway intersections in order to provide a cross slope transition that creates positive surface drainage while allowing pilots to maintain direction control of the aircraft over a surface irregularity.

1. **Off-center crown:** A cross section with the crown off-set not more than 25 feet (7.6 m) from the centerline of the runway pavement.
2. **Varied cross-slope**: A cross section with different gradients on each side of the runway centerline.
3. **Non-uniform cross-slope:** A cross section with a transverse grade change of less than 0.5 percent located more than 25 feet (7.6 m) from the runway crown.

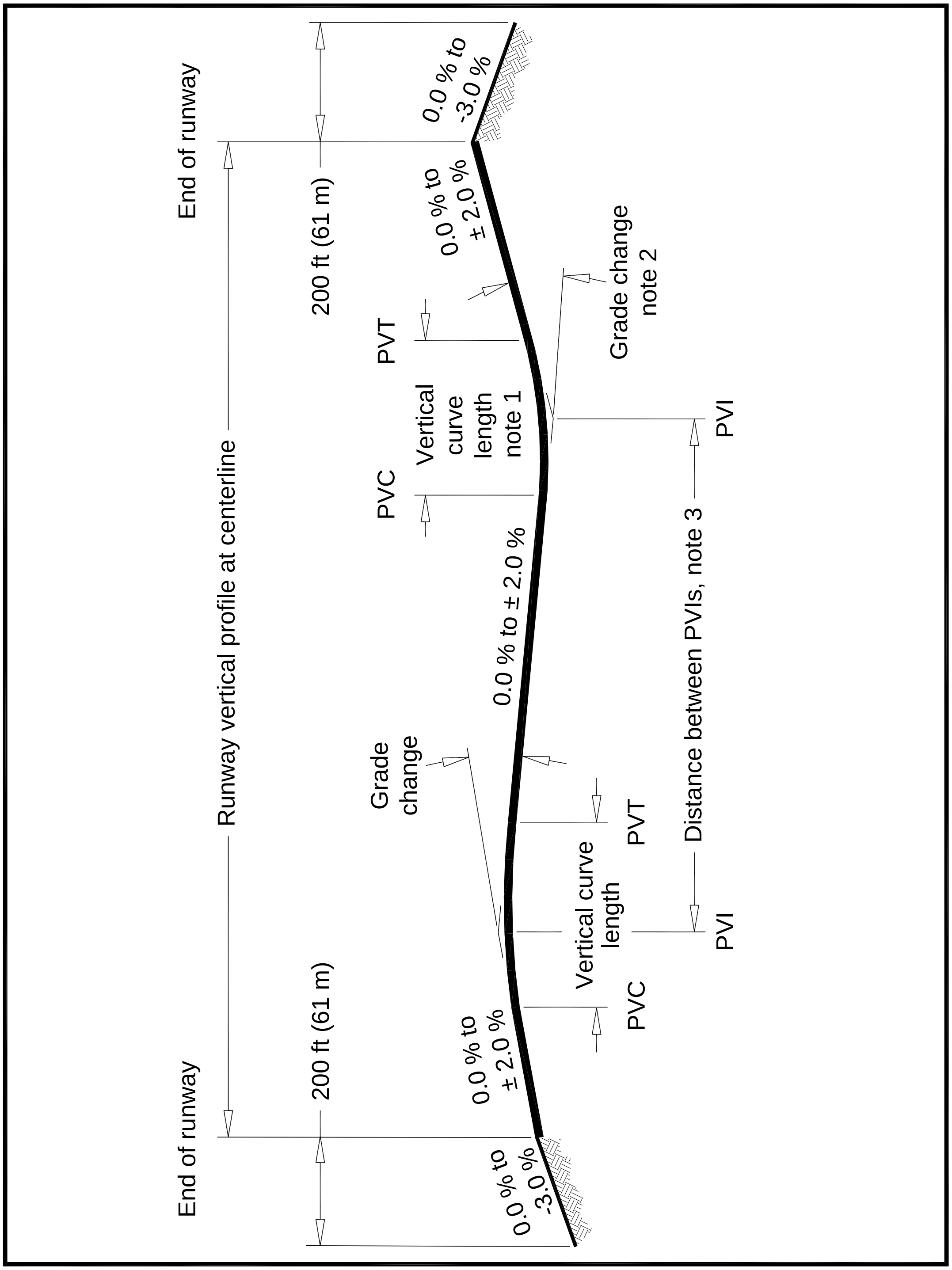
Figure 3-28. Alternate Runway Cross Sections



Note 1: Refer to Figure 3-31 and Table 3-5 for allowable transverse grades. The transverse grades shown here are for example illustrative purposes only.

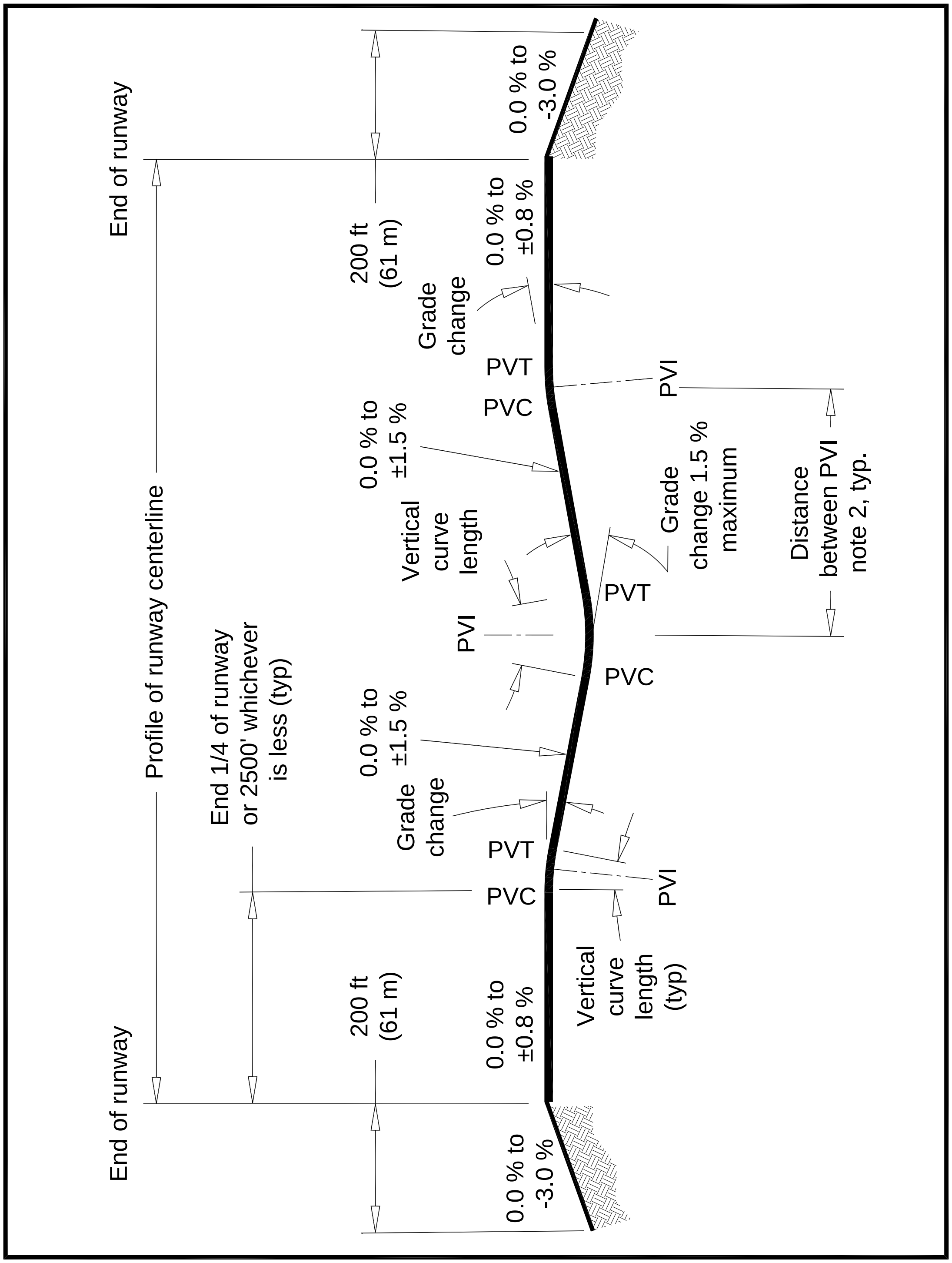
Note 2: A transverse grade change of less than 0.5% located more than 25 feet (7.6 m) from the runway crown. The runway crown is not necessarily the runway centerline.

Figure 3-29. Longitudinal Grade Limitations for Aircraft Approach Categories A and B



Note 1: Design length of vertical curves to be not be less than 300 ft (91 m) for each 1% grade change, except that no vertical curve is necessary when grade change is less than 0.4%.
Note 2: Do not design grade change at vertical curves greater than 2.0%
Note 3: Minimum distances between points of vertical intersection is 250 ft (76 m) multiplied by the sum of absolute grade changes.

Figure 3-30. Longitudinal Grade Limitations for Aircraft Approach Categories C, D, and E



Note 1: Minimum length of vertical curves equals 1,000 ft (305 m) multiplied by grade change percentage.
Note 2: The minimum vertical curve length is equal to 1,000 ft (305 m) multiplied by grade change.
Note 3: The standard minimum distance between points of vertical intersection is 1,000 ft (305 m) multiplied by the sum of the absolute grade changes.

3.15.3 Runway/Taxiway Intersections.

1. Maintain the surface gradient standards of the runway through intersections with taxiways.
2. Provide positive drainage off intersection pavement to prevent accumulation of surface water.

3.15.4 Runway/Runway Intersections.

Adjustments to runway transverse grades are necessary at runway/runway intersection in order to:

1. Maintain adequate surface drainage from the intersection pavement.
2. Provide a suitable longitudinal grade for both runways free of abrupt surface variations capable of impairing pilot directional control of aircraft.

3.15.4.1 **Standards.**

1. The surface gradient criteria for a higher category runway (e.g. primary runway) have precedence over a lower category runway (e.g. crosswind).
2. Provide positive drainage off intersection pavement that prevents accumulation of standing water on the intersection pavement.
3. Within the runway/runway intersection:
    a. Adjust the transverse grade of the higher category runway from the standards in Table 3-5 to provide a maximum 3-inch elevation difference between the runway crown and the edge of the runway.
    b. Adjust the transverse grade of the lower category runway to establish a constant transverse slope matching the elevation of the edge of pavement for the higher category runway.
4. Prior to the runway/runway intersection:
    a. For both runways, apply a transition from the standard transverse slope of Table 3-5 to the adjusted intersection transverse slope using a minimum intersection approach length of 150 ft length.

Table 3-5. Transverse Grades

Category	S-1 Runway (percent)	S-2 Shoulder (percent)	S-3 RSA Slope (percent)	S-4 OFA Slope (note 2)	S-5 Back Slope (Ratio)	D-1 Back Slope (feet/meter)
AAC-A	1.0% - 2.0%	1.5% - 5.0%	1.5% - 5.0%		-	-
AAC-B	1.0% - 2.0%	1.5% - 5.0%	1.5% - 5.0%		-	-
AAC-C	1.0% - 1.5%	1.5% - 5.0%	1.5% - 3.0%		-	-
AAC-D	1.0% - 1.5%	1.5% - 5.0%	1.5% - 3.0%		-	-
AAC-E	1.0% - 1.5%	1.5% - 5.0%	1.5% - 3.0%		-	-
ADG –I	-	-	-	≤ 0%	8:1	25 (7.6)
ADG-II	-	-	-	≤ 0%	8:1	40 (12.2)
ADG-III	-	-	-	≤ 0%	10:1	59 (18)
ADG-IV	-	-	-	≤ 0%	10:1	86 (26.2)
ADG-V	-	-	-	≤ 0%	16:1	107 (32.6)
ADG-VI	-	-	-	≤ 0%	16:1	131 (39.9)

Note 1: See Figure 3-31 and Figure 4-29.
Note 2: The S-4 slope relative to the RSA edge is negative to facilitate surface water drainage away from the RSA.
Note 3: S-5 and D-1 represent values for an acceptable back slope on the far side of the ROFA that provides adequate wingtip clearance.

3.15.4.2 **Allowable Modification.**

When necessary to accommodate the longitudinal grade conditions of a lower category runway, it is permissible to construct a constant-slope transverse grade on the higher category runway provided the intersection meets the following criteria:

1. A minimum transverse slope of 0.5 % is available to permit positive drainage across the higher category runway pavement.
2. The higher category runway has grooving per AC 150/5320-12.
3. The intersection does not create a bump capable of causing an aircraft to lose directional control.

3.15.4.3 **Design Considerations.**

The presence of surface variations at runway/runway intersections will have different effects depending on aircraft speed and the location of the surface variation on the runway. Consult with the appropriate FAA office to discuss options that pertain to a specific location. Consider the following:

1. When constructing a new runway that intersects another runway, include improvements to the existing runway to meet the criteria of this section.
2. When a change in aircraft type using the lower category runway occurs, consider the effect operation of higher speed aircraft will have at the runway/runway intersection.

3.15.4.4 **Implementation.**

1. For new construction and reconstruction of existing intersections, meet the standards of paragraph 3.15.4.1 or the allowable modifications of paragraph 3.15.4.2.
2. For existing conditions not meeting the standards of paragraph 3.15.4.1, assess the bump-roughness using Figure 2-3 of AC 150/5380-9 and determine if the existing condition falls within acceptable criteria for single bump events.
3. For conditions not falling within the acceptable range, develop a corrective action plan that leads to making necessary improvements when it becomes practical.
4. Conditions falling within the unacceptable range may require immediate corrective action such as runway closure, NOTAM issuance or aircraft restrictions.

3.15.5 RSA Grades.

The longitudinal and transverse gradient standards for RSAs are as follows and as illustrated in Figure 3-29, Figure 3-30, Figure 3-31, and Figure 3-32.

3.15.5.1 **Standards.**

1. Longitudinal grades, longitudinal grade changes, vertical curves, and distance between changes in grades for that part of the RSA between the runway ends are the same as the comparable standards for the runway and stopway.
2. For the first 200 feet (61 m) of the RSA beyond the runway ends, the longitudinal grade is between 0 and 3.0 percent, with any slope being downward from the ends.
3. Beyond the first 200 feet (61 m), the maximum allowable positive longitudinal grade is such that no part of the RSA penetrates any applicable approach surface or clearway plane.
4. The maximum allowable negative grade is 5.0 percent.
5. Limitations on longitudinal grade changes are plus or minus 2.0 percent per 100 feet (30 m).

6. Table 3-5 and Figure 3-31 show the maximum and minimum transverse grades for paved shoulders and for the RSA along the runway up to 200 feet (61 m) beyond the runway end.
7. For NAVAIDs located in the RSA, design the frangibility point of the equipment, including foundation and supports, to be no higher than 3 inches (76 mm) above the surrounding finished grade.

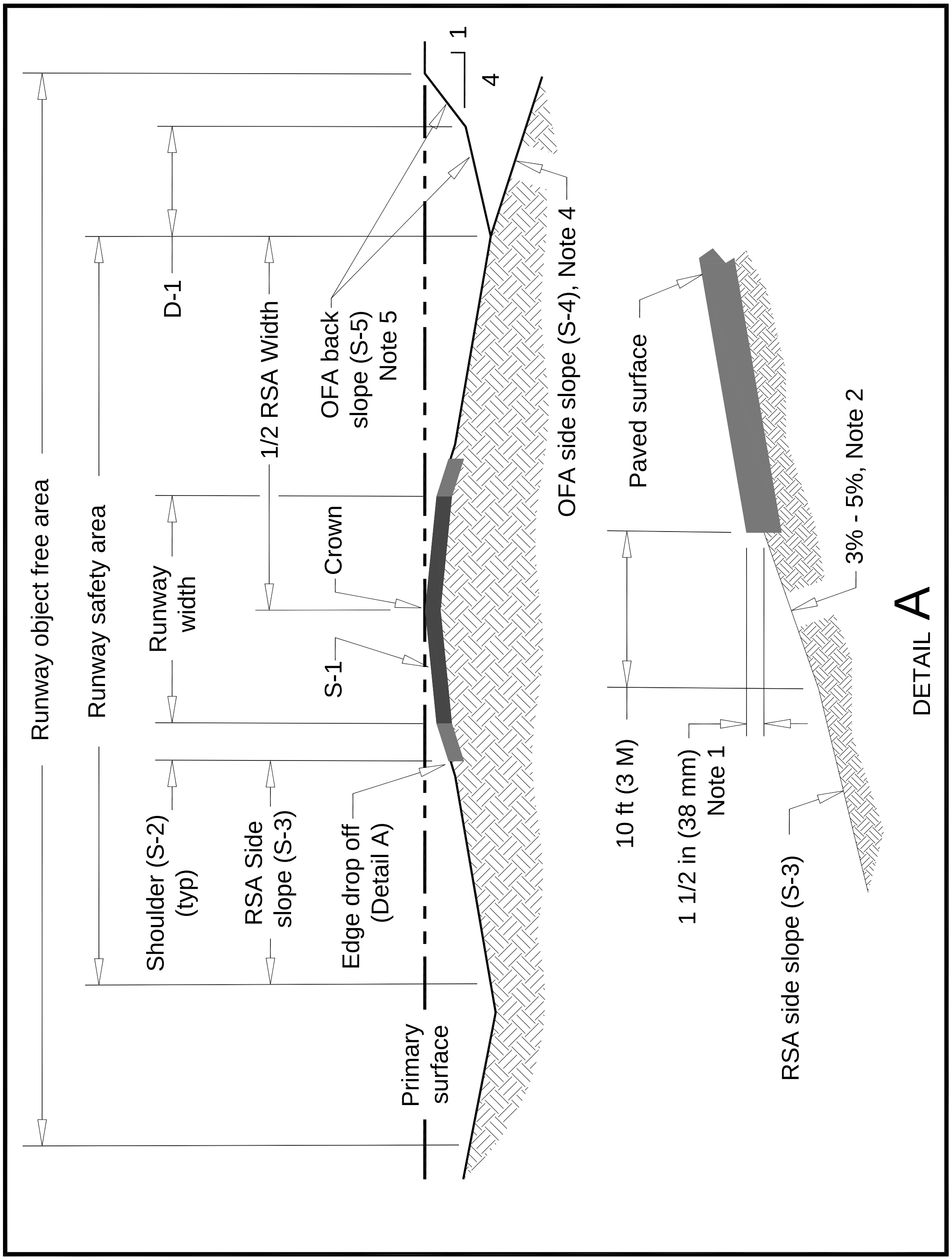
3.15.5.2 **Recommended Practices.**

1. Minimize the use of maximum grades.
2. Keep transverse grades to a minimum to facilitate local drainage conditions.
3. Use parabolic vertical curves to provide smooth transitions.

3.15.5.3 **Design Considerations.**

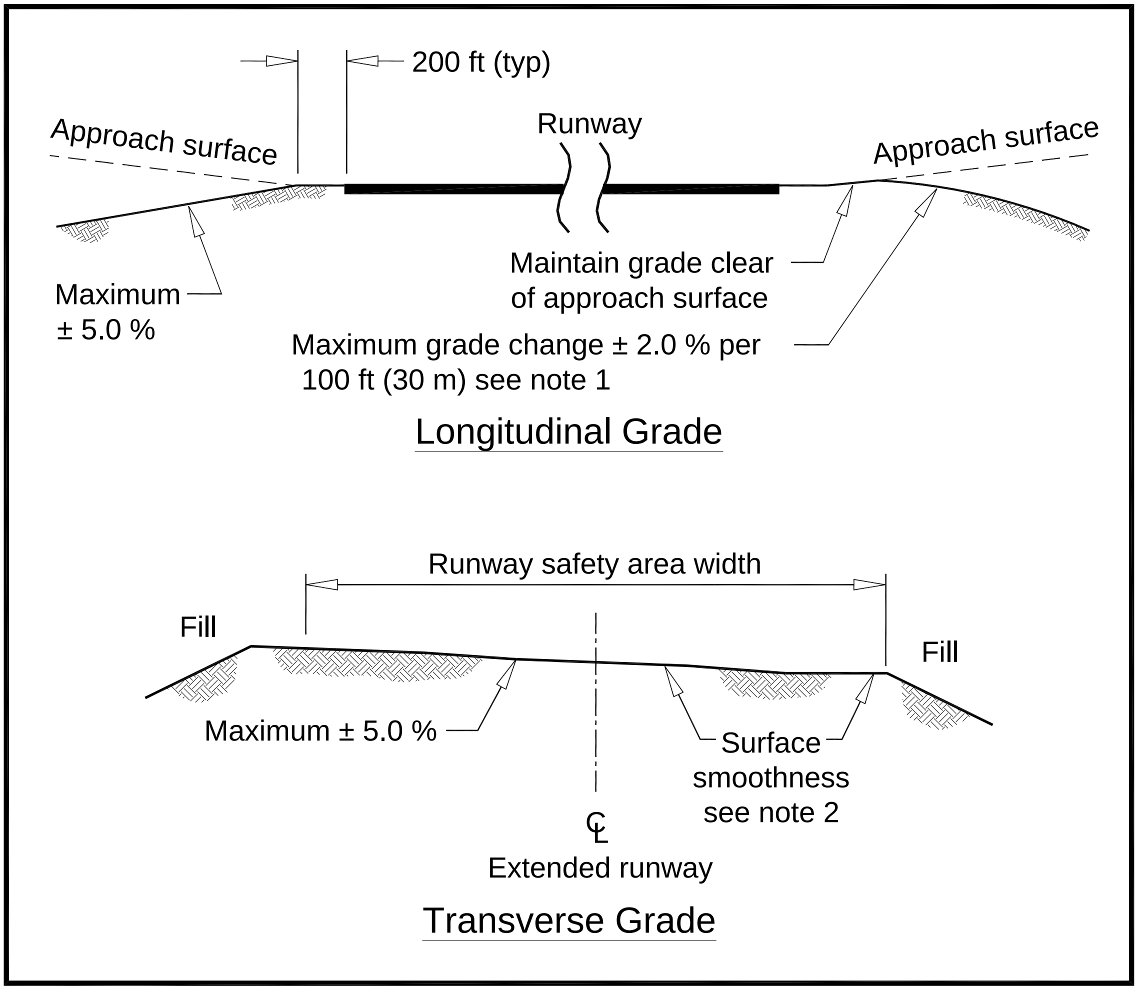
1. Consider drainage of water off top of foundation when establishing the height of the frangibility point relative to surrounding finish grade.
2. Other grading requirements for NAVAIDs located in the RSA may be more stringent than the standard stated in Table 3-5.

Figure 3-31. Transverse Grade Limitations



Note 1: Construct a 1.5 in (4 cm) ±½" (1.7 cm) drop between paved and unpaved surfaces.
Note 2: Maintain between a 3% -5.0% grade for 10 ft of unpaved surface adjacent to the paved surface.
Note 3: Slope S-2 applies when paved shoulders are present.
Note 4: S-4 is 0% or negative (unlimited) to drain water away from the RSA to the edge of the ROFA.
Note 5: A back slope (i.e. positive grade) is acceptable on the far side of the ROFA provided adequate wingtip clearance is available for ½ max wingspan of critical aircraft.

Figure 3-32. RSA Grade Limitations Beyond 200 feet (61 m) from the Runway End



Note 1: Use vertical curve to transition between longitudinal grade changes.
Note 2: Use gradual transition between transverse grade changes to allow a pilot to maintain control of aircraft traversing the safety area.

3.15.6 Surface Gradient Design Considerations.

1. Keep longitudinal grades and grade changes to a minimum.
2. Keep transverse grades to a minimum that allows positive drainage of water from pavement surfaces consistent with site-specific conditions.
3. Consider potential runway extensions and/or the future upgrade of the runway to a more stringent aircraft approach category when selecting the longitudinal and transverse grade of the runway.
4. If the approved ALP indicates extensions and/or upgrades, design grades to match to the ultimate plan.

3.16 Turf Runways.

Turf runways are used in many locations where traffic volume is low and aircraft wheel loading is light. Due to the nature of turf runways, landing, takeoff, and accelerate-stop distances are typically 20% longer than for paved runways. Refer to AC 150/5325-4 for additional information.

3.16.1 Standards.

3.16.1.1 Geometry.

Runway standards apply per Appendix G or the online Runway Design Standards Matrix Tool.

3.16.1.2 Grading.

1. Provide well drained turf surface capable of supporting the critical aircraft under wet conditions.
2. Provide at least a 2.0 percent slope away from the center of the runway for a minimum distance of 40 feet (12 m) on either side of the centerline of the landing strip.
3. Provide a 5.0 percent slope from that point to the edge of the RSA to provide rapid drainage.
4. Construct drainage swales with a maximum of a 3.0 percent slope parallel to the runway and outside of the RSA.

3.16.1.3 Compaction.

The compaction standards for turf runways are the same as the compaction standards for RSAs of paved runways.

3.16.1.4 Vertical Curves.

When longitudinal grade changes are necessary, do not exceed 3.0 percent change. Provide vertical curves with curve length equaling at least 300 feet (91 m) for each 1.0 percent change.

3.16.1.5 Thresholds.

Identify thresholds to ensure that airspace evaluation is valid for the runway. Ensure that approaches have clear 20:1 approach slopes starting at the threshold.

3.16.1.6 Landing Strip Boundary Markers.

1. The distance between markers is 200 feet - 400 feet (61 m - 122 m).
2. Locate boundary markers outside of the RSA.
3. Boundary marker equipment:
   a. Low mass cones, frangible reflectors, and Low Intensity Runway Lights (LIRL) may be used to mark the landing strip boundary.

b. Ensure higher mass items used for boundary markers are frangible.

3.16.1.7 Hold Markings.

Locate holding position markings to provide adequate runway clearance for holding aircraft.

3.16.1.8 Types of Turf.

Soil and climate are key factors for selection of grass types suitable for turf runway use.

1. Use grasses for airport turf with a deep, matted root system producing a dense, smooth surface cover with a minimum of top growth.
2. Select long-lived grasses that are durable, capable of spreading (e.g. rhizomes) and recover quickly from dormancy or heavy-use conditions.
3. Refrain from using short lived, shallow-rooted, weak sod species.
4. If seeding, time the planting to provide at least six weeks of favorable growing conditions to allow proper root development.
5. See AC 150/5370-10, Part 12 – Turfing, provides specification information on turf establishment.

3.17 Marking and Lighting.

Refer to AC 150/5340-1 for the current airport marking standards. Refer to the appropriate lighting ACs in the AC 150/5340 series and AC 150/5345 series for standards addressing airfield and runway lighting. A listing of these ACs is in paragraph 1.12.1.

3.18 Instrument Flight Procedures.

This paragraph applies to the establishment of new and revised authorized IFPs. Title 14 CFR Part 97 prescribes the criteria for instrument approach procedure development through incorporation of FAA Order 8260.3.

3.18.1 Background.

The overarching FAA strategy for navigation services is to provide pilots with vertical guidance on approach whenever possible. This results in more stabilized approaches and landings and ensures clearance from existing obstacles and terrain. IFPs improve flight safety even during visual conditions and nighttime. This paragraph identifies airport landing surface criteria to assist airport operators in their evaluation and preparation of the airport landing surface in support of a new or revised IFP. It also lists the airport data the FAA needs from the sponsor in order to conduct the airport airspace analysis specified in FAA Order JO 7400.2.

3.18.1.1 A favorable determination for IFR status is necessary for an airport to qualify for IFR operations (refer to CFR Part 157).

3.18.1.2 Use the requirements specified by FAA Order 8260.3 when planning for IFPs capable of achieving normal landing minimums. This order references FAA requirements, such as a safety analysis to determine the need for approach lighting and other visual enhancements to mitigate the effects of a difficult approach environment. This consideration applies regardless of whether or not the proposal involves a reduction in approach minimums.

3.18.1.3 For planning purposes, use Table 3-6 to determine the lowest obtainable minimums. Consideration of all pertinent factors ultimately determines the lowest minimums obtainable.

3.18.1.4 Lighting enhances the safety of an IFP. An ALS installation enhances the safety of an instrument procedure and may permit lower minimums. Installation of economy light systems such as Runway End Identifier Lights (REIL) or Precision Approach Path Indicator (PAPI) represent supplemental visual aids enhancing pilot situational awareness.

3.18.1.5 Under FAA Order 7110.41, additional requirements apply for certain types of Performance Based Navigation procedure requests, including Required Navigation Performance (RNP).

3.18.2 Prerequisite Actions.

3.18.2.1 **Instrument Runway Designation.**

In accordance with Part 157, it is necessary for an airport to submit FAA Form 7480-1 to change its status from VFR to IFR in order for the FAA to authorize a new IFP. For federally obligated airports, the airport updates their ALP in lieu of submitting the form. The FAA then conducts an aeronautical study and issues a determination. The FAA determination is a composite of the airspace review and findings, and indicates if the FAA supports IFR status.

3.18.2.2 **Airport Landing Surface.**

As a condition of FAA authorization for an IFP, the airport landing surface must meet the standards specified in Table 3-6 for each specified runway direction and have adequate airspace to support the IFP. For obligated NPIAS airports, the sponsor must provide a copy of the FAA-approved ALP showing the instrument procedure(s). For all other airports, submittal of an ALP facilitates the IFP development process.

3.18.3 Requesting an IFP.

Following establishment of a threshold and the appropriate approach surface, the following actions are necessary:

1. The airport operator or aircraft operator files a request with the FAA's Aeronautical Navigation Products (https://www.faa.gov/air_traffic/flight_info/aeronav/procedures/ifp_initiation/). Specify the runway direction, the desired approach minimums, whether proponent desires circling approach procedures and departure procedures.
2. The FAA:
   a. Validates, prioritizes, and designs the procedure, if approved by FAA under Order 8260.43.
   b. Designs the procedure (normally, LNAV, VNAV, and LPV minima are charted with any IFP request per the FAA's NAS Navigation Strategy)
   c. Develops IFR takeoff minima and/or procedures for all runway ends at an airport, unless otherwise requested by the airport (normally, at least one runway end will have IFR takeoff minima to support aircraft that depart under IFR).
   d. Performs a flight check
   e. Publishes the procedure for pilots.
3. When approach surfaces are entirely clear of obstacles the resulting procedure provides the optimum and most versatile situation for the pilot.
4. If not entirely clear, the mitigation measures determination are on a case-by-case basis, including:
   a. Higher instrument landing minimums,
   b. Higher than normal Glide Path Angles (GPAs),
   c. Installation of VGSIs,
   d. Non-standard Threshold Crossing Heights (TCHs), and
   e. Final approach offset.

3.18.4 Airport Aeronautical Surveys.

1. Use the standards identified in AC 150/5300-16, AC 150/5300-17, and AC 150/5300-18 to survey and compile the appropriate data to support the development of instrument procedures.
2. Provide vertically guided approaches whenever possible. For vertically guided approaches and all departures, complete surveys using the Vertically Guided Airport Airspace Analysis Survey criteria in AC 150/5300-18.
3. Providing pilots with vertical guidance results in more stabilized approaches and landings, so use the Non-Vertically Guided Airport Airspace Analysis Survey criteria in AC 150/5300-18 only in rare circumstances.
4. Absence of a survey does not preclude authorization to establish an instrument approach procedure to a runway but may restrict the procedure to daytime only operations.

Table 3-6. Criteria to Support Instrument Approach Procedure Development [1]

Standards	Visibility Minimums			
	< 3/4 statute mile	**3/4 to < 1 statute mile**	**≥ 1 statute mile straight-in**	**Circling [2] ≥ 1 statute mile**
HAT [3]	≤ 250 ft	≥ 250 ft	≥ 250 ft	≥ 350 ft
POFZ (PA & APV only)	Required	Not Required	Not Required	Not Required
IT-OFZ	Required	Not Required	Not Required	Not Required
ALP [4]	Required	Required	Required	Required
Minimum Runway Length	4,200 ft	3,200 ft [5]	3,200 ft [5]	3,200 ft [5]
Paved Surface	Required	Recommended [6]	Recommended [6]	Recommended [6]
Runway Markings (See AC 150/5340-1)	Precision	Non-precision	Non-precision	Visual
Holding Position Signs & Markings (See AC 150/5340-1, AC 150/5340-18)	Required	Required	Required	Required [6]
Runway Edge Lights [7]	HIRL or MIRL	HIRL or MIRL	MIRL or LIRL	MIRL or LIRL (Required only for night minimums)
Parallel Taxiway [8]	Required	Required	Recommended	Recommended
Approach Lights [9]	Required	Recommended [10]	Recommended [10]	Not Required
VGSI [11]	Recommended	Recommended	Recommended	Recommended
Applicable Runway Design Standards, (Reference online Runway Design Standards Matrix Tool or Appendix G)	Lower than 3/4 mile visibility minimums	Not lower than 3/4 mile visibility minimums	Not lower than 1 mile visibility minimums	Not lower than 1 mile visibility minimums
Obstacle Clearance Surface to be Met (Reference paragraph 3.5.1)	See Table 3-2 or Table 3-3	See Table 3-2 or Table 3-3	See Table 3-2 or Table 3-3	Table 3-1 or Table 3-2
Optimum Survey Type [12]	VGS	VGS	NVGS	NVGS [13]

Notes for Table 3-6:

Note 1: Visibility minimums and described standards are subject to the application of FAA Order 8260.3 (TERPS) and associated orders. For each level of visibility, meet or exceed the optimum conditions within the column.

Note 2: For runways authorized for circling, meet requirements for threshold siting (reference paragraph 3.4) and OFZ (reference paragraph 3.10).

Note 3: Height Above Airport (HAA) for circling. The HAT/HAA indicated is for planning purposes; actual obtainable HAT/HAA is determined by TERPS and may be higher due to obstacles or other requirements.

Note 4: An ALP is only required for obligated airports in the NPIAS; it is recommended for all others.

Note 5: Runways less than 3,200 ft are protected by 14 CFR Part 77 to a lesser extent. However, runways as short as 2,400 ft could support an instrument approach provided the lowest HAT is based on clearing any 200-ft (61 m) obstacle within the final approach segment.

Note 6: Unpaved runways require case-by-case evaluation by the IFP Validation Team (IVT).

Note 7: Runway edge lighting is required for night approach minimums. High intensity lights and an RVR touchdown zone sensor are required for RVR-based minimums.

Note 8: A full-length parallel taxiway leading to and from the thresholds is advisable to achieve the lowest possible minimums and minimizes the time aircraft are on the runway. Refer to the minimum visibility requirements on airport conditions in FAA Order 8260.3. Construction of a parallel taxiway, while advisable, is not a requirement for publication of an instrument approach procedure with visibility minima ≥ 1 statute mile.

Note 9: Not applicable to Performance Based Navigation procedures. The following standards is applicable to conventional ground-based procedures. A full approach light system (ALSF-1, ALSF-2, SSALR, or MALSR) is required for visibility < 3/4 statute mile. Intermediate (MALSF, MALS, SSALF, SSALS, SALS/SALSF) or Basic (ODALs) systems will result in higher visibility minimums. An ALSF-1 or ALSF-2 is required for CAT II/III ILS. HAT < 250 ft without MALSR, SSALR, or ALSF is permitted with visibility not less than ¾ SM.

Note 10: ODALS, MALS, SSALS, and SALS are acceptable. Approach lights are recommended where a visibility minima improvement of at least ¼ statute mile can be achieved.

Note 11: To preclude a non-standard instrument flight procedure, it is critical the instrument approach vertical descent angle (VDA) or glidepath angle (GPA) is coincident with the VGSI angle.

Note 12: See AC 150/5300-18 for Vertically Guided Survey (VGS) and non-Vertically Guided Survey (NVGS) requirements. When an AC 150/5300-18 VGS is not available, the equivalent legacy vertically guided (VG) surveys are ANAPV/LPV/PC, and PIR.

Note 13: Absence of a survey does not preclude authorization to establish circling to a runway but may result in the procedure being restricted to daytime only operations.

3.19 Jet Blast.

The effects of jet blast can cause erosion along runway shoulders and in some cases represent a blast force hazard to holding aircraft and vehicles. Mitigation measures such as paved shoulders, blast pads, and in some cases blast fences may be necessary. Refer to Chapter 6 for information on the effects and treatment of jet blast.

3.20 Runway Design Standards Matrix.

These are minimum separation standards and, if there is ample space, design the separation and hold line location at distances exceeding the minimum.

3.20.1 Runway to Taxiway.

See Appendix G and the online Runway Design Standards Matrix Tool for the minimum runway-to-taxiway separation standards based on ADG. These standards derive from landing and takeoff flight path profiles and physical characteristics of aircraft.

3.20.1.1 **Separation Based on ADG.**

The dimensions in Appendix G and the online Runway Design Standards Matrix Tool assume the same critical aircraft is using both the runway and taxiway. For example, if a taxiway serves larger aircraft (e.g. air carrier aircraft taxiing between the terminal and another runway), the basis for the runway-to-taxiway separation distance is the ADG of the larger aircraft.

3.20.1.2 **Separation Based on TDG.**

If there is a need for direction reversal between the runway and the parallel taxiway when using a high-speed exit, the basis for the separation distance may be a combination of the ADG and the TDG of the critical aircraft. Use Table 4-7, which provides the minimum and recommended separation distances between a runway and parallel taxiway and runways for turns based on TDG. The greater value from Appendix G (or the online Runway Design Standards Matrix Tool) and Table 4-7 determines the applicable separation value. See paragraph 4.8.4 for additional information on the effect of exit taxiway design on runway/taxiway separation. See paragraph 3.10 for additional information on OFZ recommended practices related to runway-to-taxiway separation.

3.20.2 Runway to Hold Line.

The standard runway to hold line separation derives from landing and takeoff profiles and physical performance characteristics of the critical aircraft.

3.20.2.1 For some aircraft and runway/taxiway geometries, the standard runway to hold line separation may be insufficient to hold aircraft perpendicular to the runway. Adjustments may be necessary to permit sufficient view of the runway environment including the extended centerline. See paragraph 4.8.1.1 for the standard for designing right-angle runway to taxiway intersections. See paragraph 4.6.2 for a recommended practice to attain a perpendicular holding position.

3.20.3 Runway to Taxiway.

3.20.3.1 **Separation Based on ADG.**

The dimensions in Appendix G and the online Runway Design Standards Matrix Tool assume the same critical aircraft uses both the runway and taxiway. For example, if a taxiway serves larger aircraft (e.g. air carrier aircraft taxiing between the terminal and another runway), the basis for the runway-to-taxiway separation distance is the ADG of the larger aircraft.

3.20.3.2 **Separation Based on TDG.**

If there is a need for direction reversal between the runway and the parallel taxiway when using a high-speed exit, the basis for the separation distance may be a combination of the ADG and the TDG of the critical aircraft. Use Table 4-7, which provides the minimum and recommended separation distances between a runway and parallel taxiway and runways for turns based on Taxiway Design Group. The greater value from Appendix G (or the online Runway Design Standards Matrix Tool) and Table 4-7 determines the applicable separation value. See paragraph 4.8.4 for additional information on the effect of exit taxiway design on runway/taxiway separation. See paragraph 3.10 for additional information on OFZ recommended practices related to runway-to-taxiway separation.

3.20.3.3 **Recommended Practices.**

When space is available without causing relocation of existing facilities and structures, an airport may apply the separation values of the next larger ADG aircraft when constructing or re-constructing a parallel taxiway. This will allow operation of more demanding aircraft without the need for:

1. Specific airport operational restrictions, or
2. Relocation of existing infrastructure when the larger ADG aircraft becomes the critical aircraft meeting regular use criteria.

3.20.4 Runway to Aircraft Parking Area.

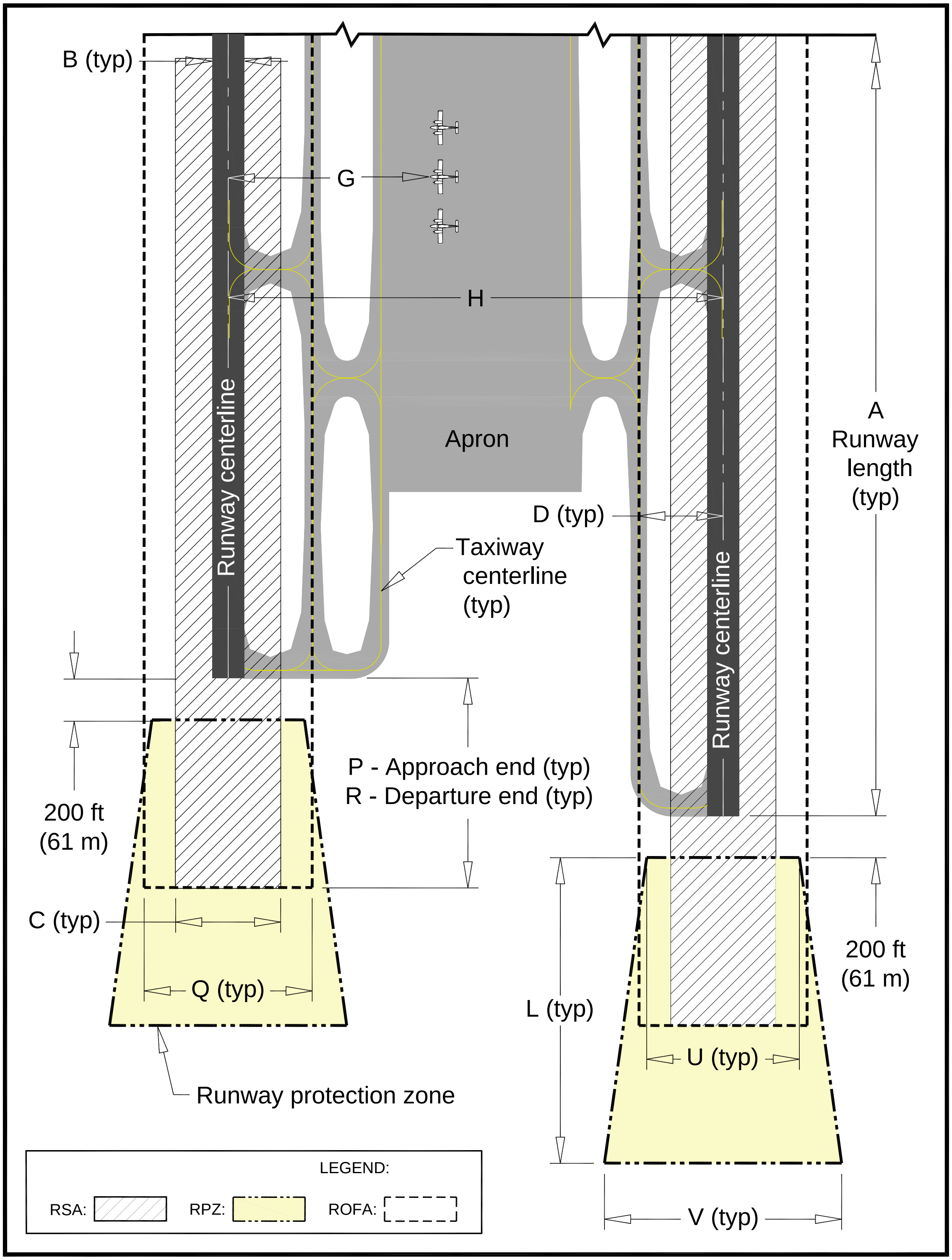
Locate aircraft parking areas to preclude any part of a parked aircraft (tail, wingtip, nose, etc.) from being within a ROFA or penetrating the OFZ. The optimum condition locates aircraft parking positions in a manner preventing the violation of an imaginary surface as defined in 14 CFR Part 77.

Table 3-7. Runway Design Standards Lookup Table

ADG	**AAC A**	**AAC B**	**AAC C**	**AAC D**	**AAC E**
I Small Aircraft	A-I Small aircraft	B-I Small aircraft	n/a	n/a	n/a
I	A-I	B-I	C-I	D-I	E-I
II Small Aircraft	A-II Small aircraft	B-II Small aircraft	n/a	n/a	n/a
II	A-II	B-II	C-II	D-II	E-II
III	A-III	B-III	C-III	D-III	E-III
IV	A-IV	B-IV	C-IV	D-IV	E-IV
V	n/a	n/a	C-V	D-V	E-V
VI	n/a	n/a	C-VI	D-VI	E-VI

Note 1: Links in this table navigate to the corresponding table in Appendix G.
Note 2: Alternatively, see the online Runway Design Standards Matrix Tool.

Figure 3-33. Airport Layout Example



Note: See Appendix G or online Runway Design Standards Matrix Tool for dimensions.

CHAPTER 4. Taxiway and Taxilane Design

4.1 General.

This chapter presents the airport design standards, recommended practices and design considerations for taxiways and taxilanes. It provides guidance to enhance safety and efficiency, including but not limited to:

1. Taxiway and taxilane dimensions, configuration and separation standards.
2. Taxiway turns and intersection design.
3. Surface gradients.

See Appendix J for additional taxiway design information and taxiway geometries with elevated runway incursion risk.

4.1.1 Design Criteria: Taxiways versus Taxilanes.

In general, the term "taxiway" as used in this chapter describes standards and recommended practices for both taxiways and taxilanes. Some of the design standards for taxiways and taxilanes vary given the different aircraft speeds and uses of taxiways versus taxilanes. Where there are differences between taxiway and taxilane design standards, the tables in this chapter will define these differences. Taxiways typically reside in movement areas, while taxilanes are more common in non-movement areas such as terminal apron areas.

4.1.1.1 Taxiway/Taxilane Differences.

The following standards are different between taxiways and taxilanes:

- Object Free Area (OFA)
- Centerline to centerline separation
- Centerline to fixed or movable object
- Wingtip clearance

4.1.1.2 Taxiway/Taxilane Similarities.

The following standards are equivalent between taxiways and taxilanes:

- Taxiway/taxilane safety area (TSA)
- Taxiway/taxilane width
- Taxiway/taxilane edge safety margin (TESM)
- Taxiway/taxilane shoulder width

4.1.2 Coordination.

An efficient taxiway system design requires knowledge of operational requirements. Coordinate with the airport's applicable stakeholders during the planning and design of taxiways:

- Airport Traffic Control Tower (ATCT) personnel
- Airlines and FBOs
- Other airport users

4.2 Taxiway Design Group (TDG).

The overall Main Gear Width (MGW) and the Cockpit to Main Gear Distance (CMG) determine the TDG classification. Establishing taxiway/taxilane fillet geometry involves determining the longest CMG, widest MGW theoretical airplane in the design TDG, and applying the TESM for the design TDG. See Figure 1-1, Figure 4-4 and paragraph 1.6. Some airplanes have special steering characteristics (e.g. steerable main gear). In such cases, use the "effective CMG" provided by the manufacturer.

4.3 Taxiway and Taxilane Design Method.

4.3.1 Taxiing Method.

Taxiways designed for cockpit over centerline steering enable rapid movement of traffic with minimal risk of aircraft excursions from the pavement surface. Judgmental oversteering, where the pilot intentionally steers the cockpit outside the marked centerline on turns, introduces excursion risk to a turning maneuver. The Taxiway Edge Safety Margin (TESM) provides allowance for wander from the centerline.

4.3.1.1 Standards.

Design taxiways for "cockpit over centerline" taxiing. Do not apply "judgmental oversteering" as a design technique to preclude provision of a standard fillet design.

4.3.1.2 Recommended Practice.

For new taxiway projects, upgrade other intersections along the associated route to eliminate the need for judgmental oversteering if it is practical to make such improvements at that time. The goal is to provide consistent "cockpit over centerline" taxiing throughout the airport.

4.3.2 Curve Design.

4.3.2.1 Standards.

1. For new taxiways, design taxiway centerline radii for turns of 90 degrees or more such that the maximum nose gear steering angle is close to but no more than 50 degrees to prevent excessive tire scrubbing.[2]
2. For new taxiways, design taxiway centerline radii for turns of less than 90 degrees such that the maximum nose gear steering angle allows the pilot to maintain an efficient speed in the turn.

[2] Where dimensions in this AC are based on nose gear steering angle, all calculations of nose gear steering angle assume that the nose gear is directly under or forward of the cockpit. Where the nose gear is aft of the cockpit, the actual nose gear steering angle will be slightly less. This conservative design allows for the slight slippage experienced by the nose gear in cornering.

3. Design the radius of the outer edge of the pavement to be equal to the centerline radius plus one-half of the straight segment taxiway width.

4.3.2.2 Recommended Practices.

1. For existing conditions, it is acceptable for the steering angle to be greater than 50 degrees.
2. For existing conditions where centerline lights are present, it is acceptable to retain the existing taxiway centerline.
3. The FAA Office of Airports Taxiway Fillet Design Tool, which calculates centerline radii for simple turns, is available on the FAA web site at: http://www.faa.gov/airports/engineering/airport_design/.

4.3.3 Three-Path Concept.

Complex intersections increase the possibility of pilot error and confusion, which can lead to a runway incursion. Proper airport design practices keep taxiway intersections simple by reducing the number of taxiways intersecting at a single location, thus allowing for proper placement of airfield markings, signage and lighting. The "three-path concept", formerly known as the "three-node" concept", means that a pilot has no more than three choices at an intersection – left, right and ahead. See Figure 4-1.

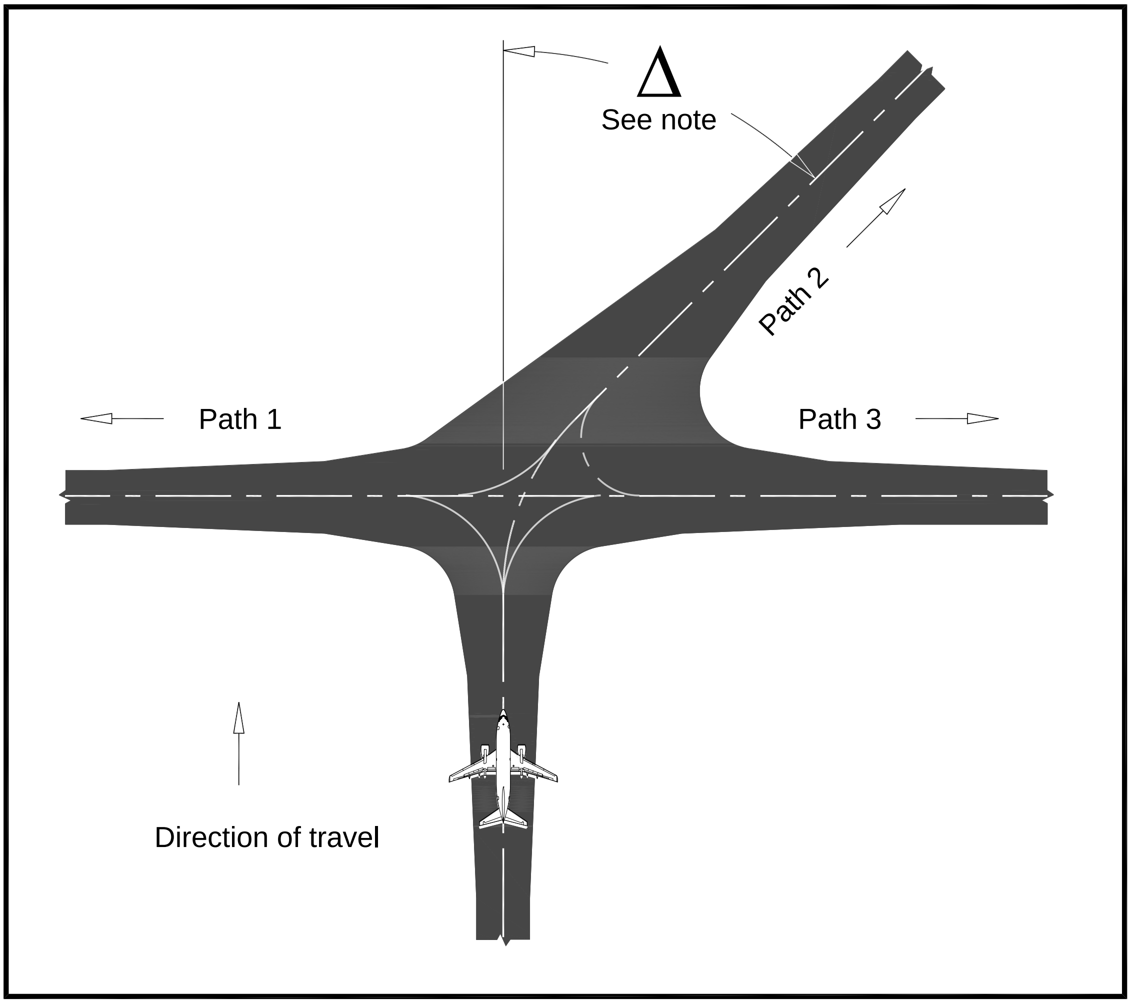
4.3.3.1 Standards.

1. Design all new taxiway intersections in accordance with the three-path concept.
2. For existing conditions not meeting the three-path concept, develop a plan to meet the standard in the future.

4.3.3.2 Recommended Practice.

Reconfigure all existing taxiway intersections (even those not designated as hot spots) in accordance with the three-path concept when the associated taxiway is subject to reconstruction or rehabilitation. See Figure 4-1.

Figure 4-1. Three-Path Concept Taxiway Intersection



Note: The angle (△) is measured from the initial direction of travel.

4.3.4 Channelized Taxiing.

Standard taxiway widths support visibility of airfield signage. Taxiway widths wider than standard result in signs being located further from the centerline; pilots may miss the signs due to excessive distance.

4.3.4.1 Standard.

1. Design new taxiway/taxiway and taxiway/runway intersections to meet standard taxiway widths.
2. For existing conditions comprising wide pavement areas, develop a plan to meet the standard.

4.3.4.2 **Recommended Practice.**

Reconfigure all existing taxiway intersections (even those not designated as hot spots) in accordance with paragraph 4.3.4.1 when the associated taxiway is subject to reconstruction or rehabilitation.

4.3.5 Runway Access from Apron.

Taxiways connecting an apron directly to a runway can lead to confusion by creating a false expectation of a parallel taxiway prior to a runway. This loss of situational awareness can result in a pilot entering a runway unknowingly thus resulting in a runway incursion.

4.3.5.1 **Standards.**

1. Design taxiways leading from an apron to a runway to make at least one turn between 75 and 90 degrees prior to reaching the runway hold line.
    a. For runways with a parallel taxiway, stagger the alignment of connecting taxiway and taxiways/taxilanes originating from the apron. See Figure 4-2.
    b. For runways without a parallel taxiway, provide a no-taxi island on the apron aligned with the connecting taxiway to the runway. See Figure 4-3.
2. For existing conditions with direct access from an apron to a runway:
    a. Develop a plan (e.g. ALP) to meet the standard when it becomes practical to make such improvements.
    b. Reconfigure existing direct-access taxiways, including those not designated as hot spots, when the associated taxiway is subject to reconstruction.

4.3.5.2 **Recommended Practices.**

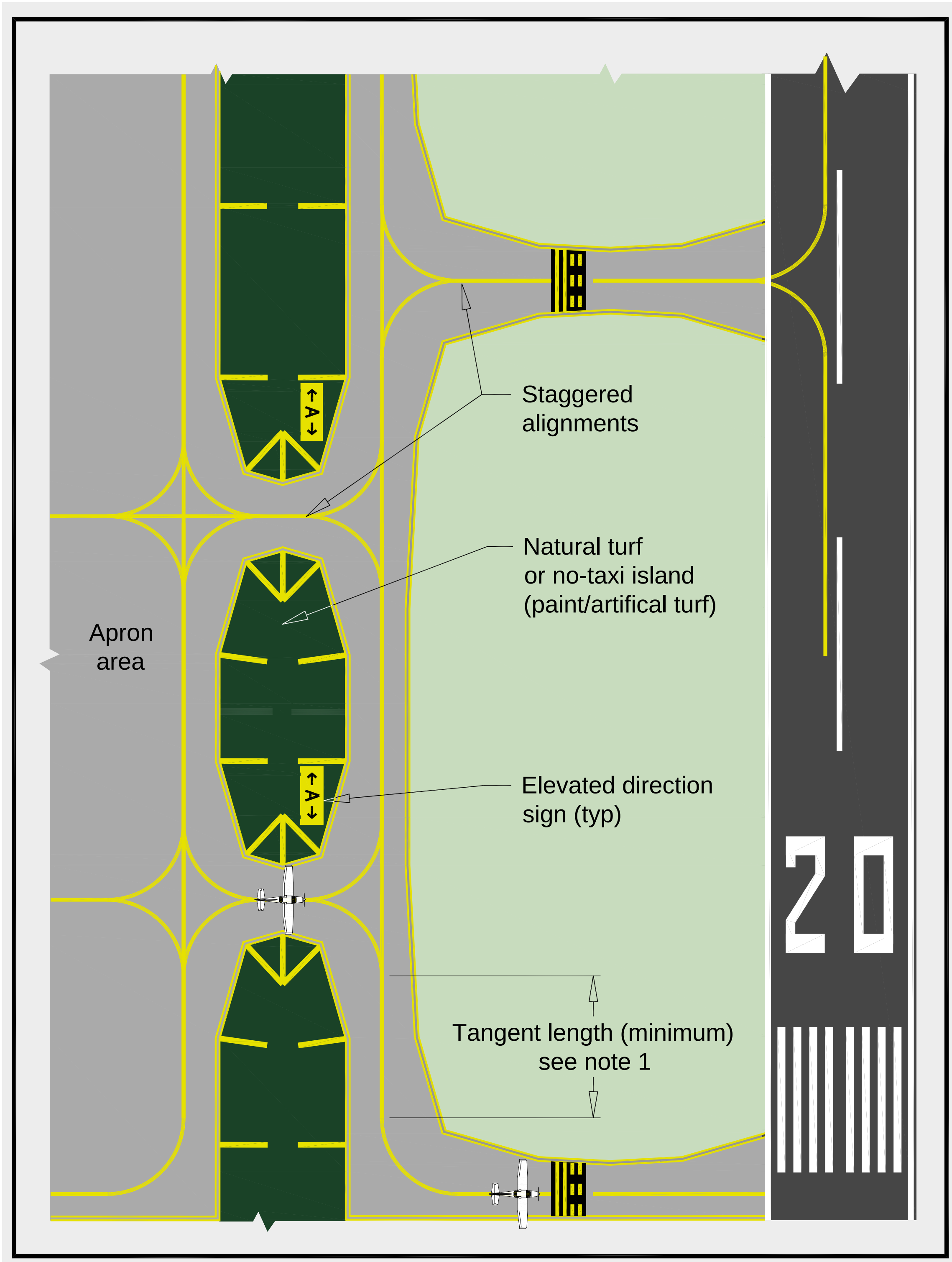
1. To the extent practical, design taxi routes between the apron and runway ends to include a turn onto a parallel taxiway and a second turn onto a connecting taxiway leading to the runway.
2. Design the taxi route between the apron and the runway to include the following:
    a. a turning movement from the apron taxiway/taxilane to the parallel taxiway.
    b. a turning movement from the parallel taxiway to the connecting taxiway at an angle between 75 and 90 degrees.
    c. a holding position that allows the critical aircraft to hold 90 degrees, plus or minus 15 degrees, to the runway centerline.

3. Provide a minimum tangent length between the connecting taxiway and runway entrance taxiway so that the pilot, after turning onto the parallel taxiway, has sufficient time and distance to align the fuselage along the parallel taxiway centerline to provide a clear view of clearly see the taxiway signs indicating the entrance to the runway.
4. During taxiway rehabilitation projects, evaluate the feasibility of reconfiguring existing direct-access taxiways (even those not designated as hot spots) in accordance with paragraph 4.3.5.1.

4.3.5.3 Design Considerations.

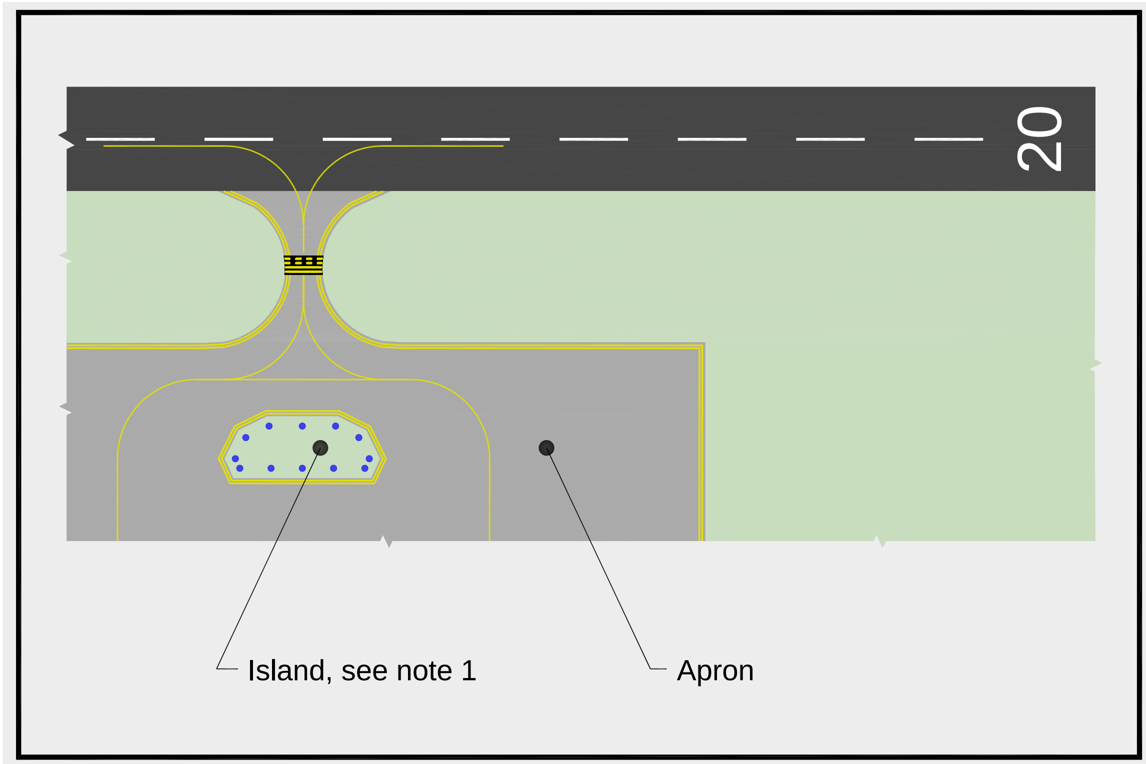
1. Evaluate whether an increase to the standard runway to taxiway separation is necessary to allow the critical aircraft to hold 90 degrees, plus or minus 15 degrees, to the runway centerline per paragraph 3.20.3.
2. Consider providing a partial parallel taxiway if the existing runway does not have a parallel taxiway.

Figure 4-2. Apron-Taxiway Transition



Note 1: See paragraph 4.3.5.2.

Figure 4-3. Apron-Runway Transition



Note 1: Turf or paved no taxi island with edge lights/reflectors.

4.3.6 Hot Spots.

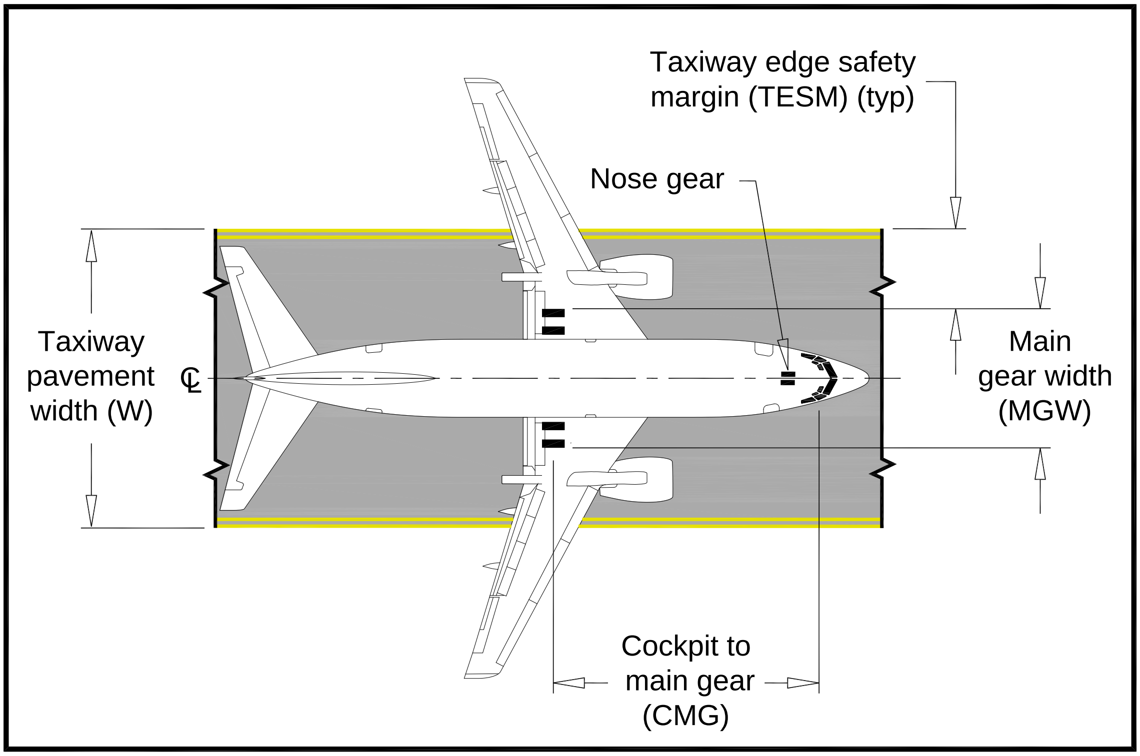
4.3.6.1 Standards.

1. Reconfigure hot spots identified in the FAA Airport Diagrams when the associated runway or taxiway is subject to reconstruction or rehabilitation.
2. Correct other non-standard taxiway design elements as soon as practicable.

4.4 Straight Segment Taxiway/Taxilane Width.

Taxiway width standards derive from aircraft TDG classifications. The minimum width for straight segments ensures that the standard TESM is available for possible aircraft wander (see Figure 4-4). See Table 4-2 for minimum width for straight segments. See paragraph 4.7 for guidance on fillet design.

Figure 4-4. Taxiway Edge Safety Margin (TESM) – Straight Segment



Note 1: See Table 4-2 for pavement width and TESM values.
Note 2: See Appendix A for CMG and MGW data.

4.5 Taxiway/Taxilane Clearance.

4.5.1 Taxiway/Taxilane Separations.

Pilots need ample wingtip clearance due to the pilots' limited visual range of their aircraft's wingtips. Wingtip clearance values ensure an acceptable level of safety when one airplane on a parallel taxiway wanders off the taxiway centerline toward an airplane on the adjacent taxiways. See Figure 4-5. The ADG of the critical aircraft determines the minimum separation distance between a taxiway/taxilane centerline and fixed or moveable objects.

4.5.1.1 Standards.

Table 4-1 lists standard minimum separation standards by ADG considering:

1. Wingspan dimensions of the critical aircraft in each ADG.
2. A lateral deviation allowance to provide protection in the event of deviation from the taxiway centerline.
3. A safety buffer allowance to provide for wingtip clearance in the event of deviation from the taxiway centerline.

4.5.1.2 **Recommended Practices.**

When space is available without causing relocation of existing facilities and structures, an airport may apply the separation values of the next larger ADG aircraft when constructing or re-constructing a taxiway or taxilane. This will allow operation of more demanding aircraft without the need for:

1. Specific airport operational restrictions, or
2. Relocation of existing infrastructure when the larger ADG aircraft becomes the critical aircraft meeting regular use criteria.

4.5.1.3 **Design Considerations.**

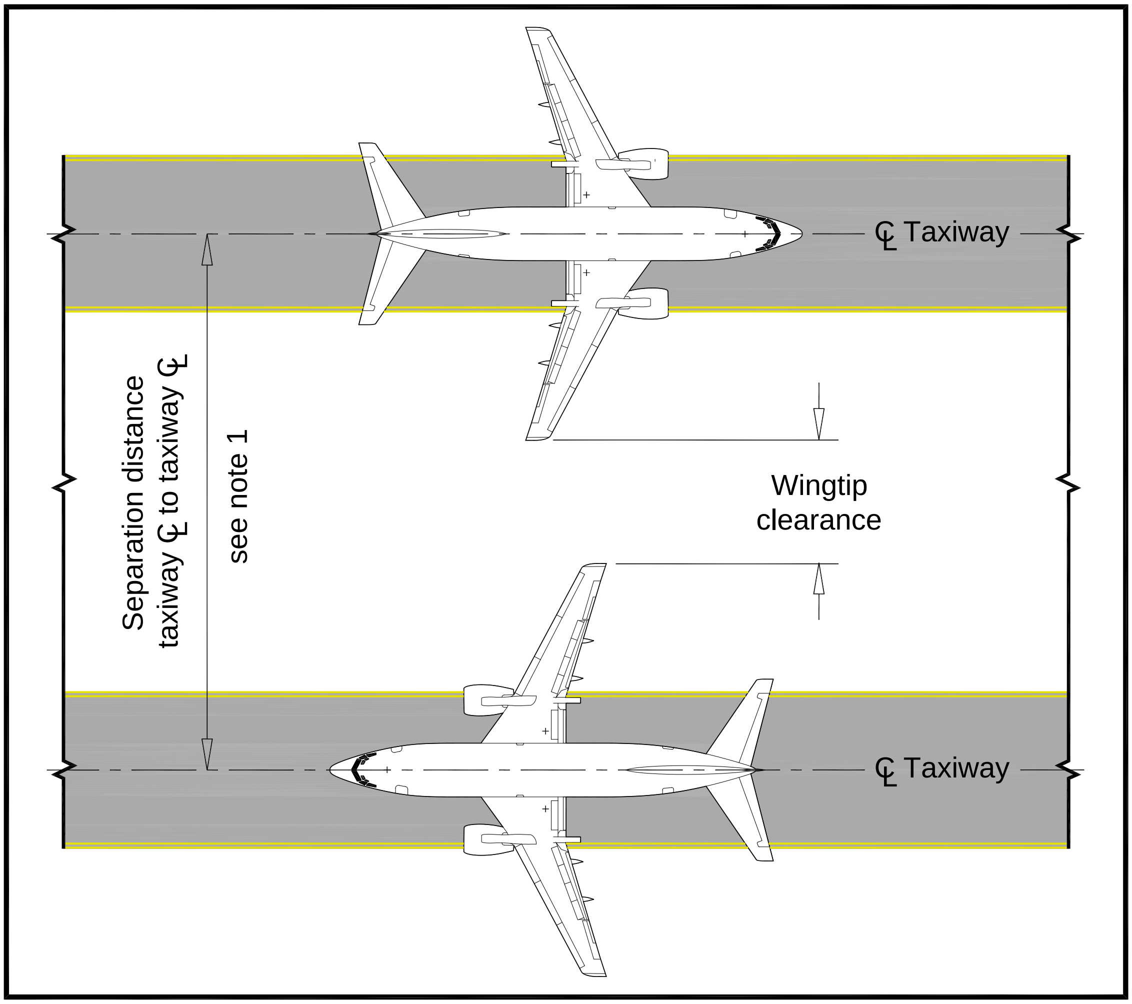
The minimum distance between centerlines of parallel taxiways or taxilanes may be a function of the critical aircraft TDG due to turning and fillet geometry requirements.

4.5.2 Parallel Taxiways/Taxilanes for Dissimilar ADGs.

For parallel taxiways/taxilanes serving dissimilar ADGs, determine the necessary distance between centerlines by applying the following method:

1. Establish the OFA dimension of the more demanding ADG.
2. Establish the wingspan of the lesser ADG.
3. Determine the composite taxiway separation value by adding one-half the OFA of the more demanding ADG to one-half the wingspan of the lesser ADG.
4. Example:
   a. One-half of ADG III TOFA is 85.5 ft (26 m).
   b. One-half of ADG II wingspan is 39.5 (12 m).
   c. Composite separation distance is 125 ft (38 m).

3550 **Figure 4-5. Wingtip Clearance – Parallel Taxiways/Taxilanes**



3551
3552 **Note 1:** See Table 4-1 for standard separation distances between parallel taxiways and parallel taxilanes.

Table 4-1. Design Standards Based on Airplane Design Group (ADG)

Item	ADG					
	I	II	III	IV	V	VI
Taxiway and Taxilane Protection						
TSA	49 ft (15 m)	79 ft (24 m)	118 ft (36 m)	171 ft (52 m)	214 ft (65 m)	262 ft (80 m)
Taxiway OFA [2]	89 ft (27 m)	124 ft (38 m)	171 ft (52 m)	243 ft (74 m)	285 ft (87 m)	335 ft (102 m)
Taxilane OFA [2]	79 ft (24 m)	110 ft (34 m)	158 ft (48 m)	224 ft (68 m)	270 ft (82 m)	322 ft (98 m)
Taxiway and Taxilane Separation						
Taxiway centerline to parallel taxiway centerline [1]	70 ft (21.5 m)	105 ft (32 m)	144 ft (44 m)	207 ft (63 m)	249 ft (76 m)	298 ft (91 m)
Taxiway centerline to fixed or movable object [2]	45 ft (14 m)	62 ft (19 m)	86 ft (26 m)	121 ft (37 m)	142 ft (43.5 m)	168 ft (51 m)
Taxilane centerline to parallel taxilane centerline [1]	64 ft (20 m)	94 ft (29 m)	138 ft (42 m)	198 ft (60 m)	242 ft (74 m)	292 ft (89 m)
Taxilane centerline to fixed or movable object [2]	40 ft (12 m)	55 ft (17 m)	79 ft (24 m)	112 ft (34 m)	135 ft (41 m)	161 ft (49 m)
Wingtip Clearance						
Taxiway wingtip clearance	20 ft (6 m)	23 ft (7 m)	27 ft (8 m)	36 ft (11 m)	36 ft (11 m)	36 ft (11 m)
Taxilane wingtip clearance	15 ft (4.5 m)	16 ft (5 m)	20 ft (6 m)	27 ft (8 m)	28 ft (8.5 m)	30 ft (9 m)

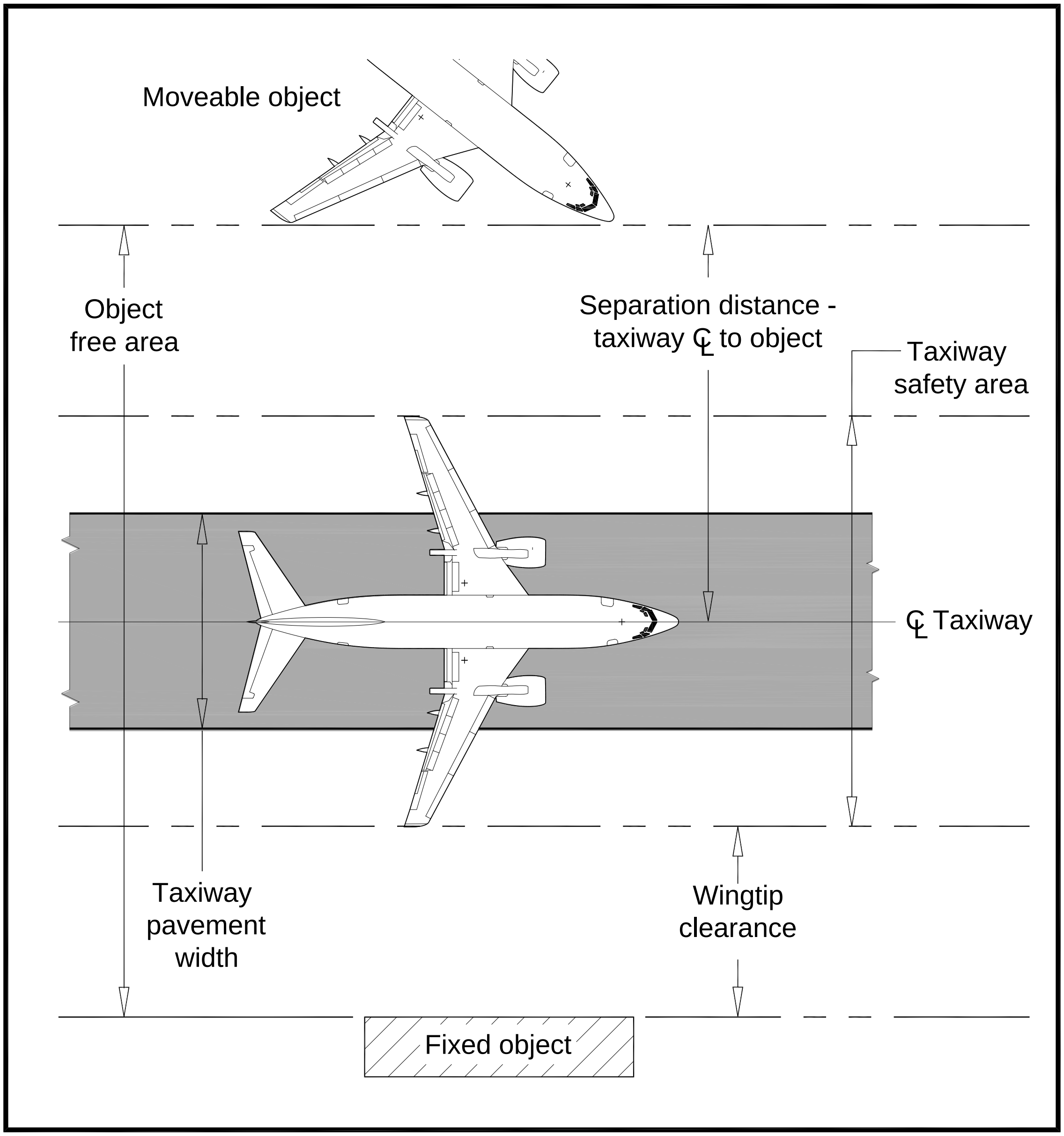
Note 1: See Figure 4-5.
Note 2: See Figure 4-6.

Table 4-2. Design Standards Based on Taxiway Design Group (TDG)

Item	TDG							
	1A	1B	2A	2B	3	4	5	6
Taxiway/Taxilane Width	25 ft (7.5 m)	25 ft (7.5 m)	35 ft (10.5 m)	35 ft (10.5 m)	50 ft (15 m)	50 ft (15 m)	75 ft (23 m)	75 ft (23 m)
Taxiway Edge Safety Margin	5 ft (1.5 m)	5 ft (1.5 m)	7.5 ft (2 m)	7.5 ft (2 m)	10 ft (3 m)	10 ft (3 m)	14 ft (4.25 m)	14 ft (4.25 m)
Taxiway Shoulder Width	10 ft (3 m)	10 ft (3 m)	15 ft (3 m)	15 ft (3 m)	20 ft (6 m)	20 ft (6 m)	30 ft (9 m)	30 ft (9 m)
Taxiway/Taxilane Centerline to Parallel Taxiway/Taxilane Centerline w/ 180 Degree Turn	See Table 4-8 and Table 4-9.							

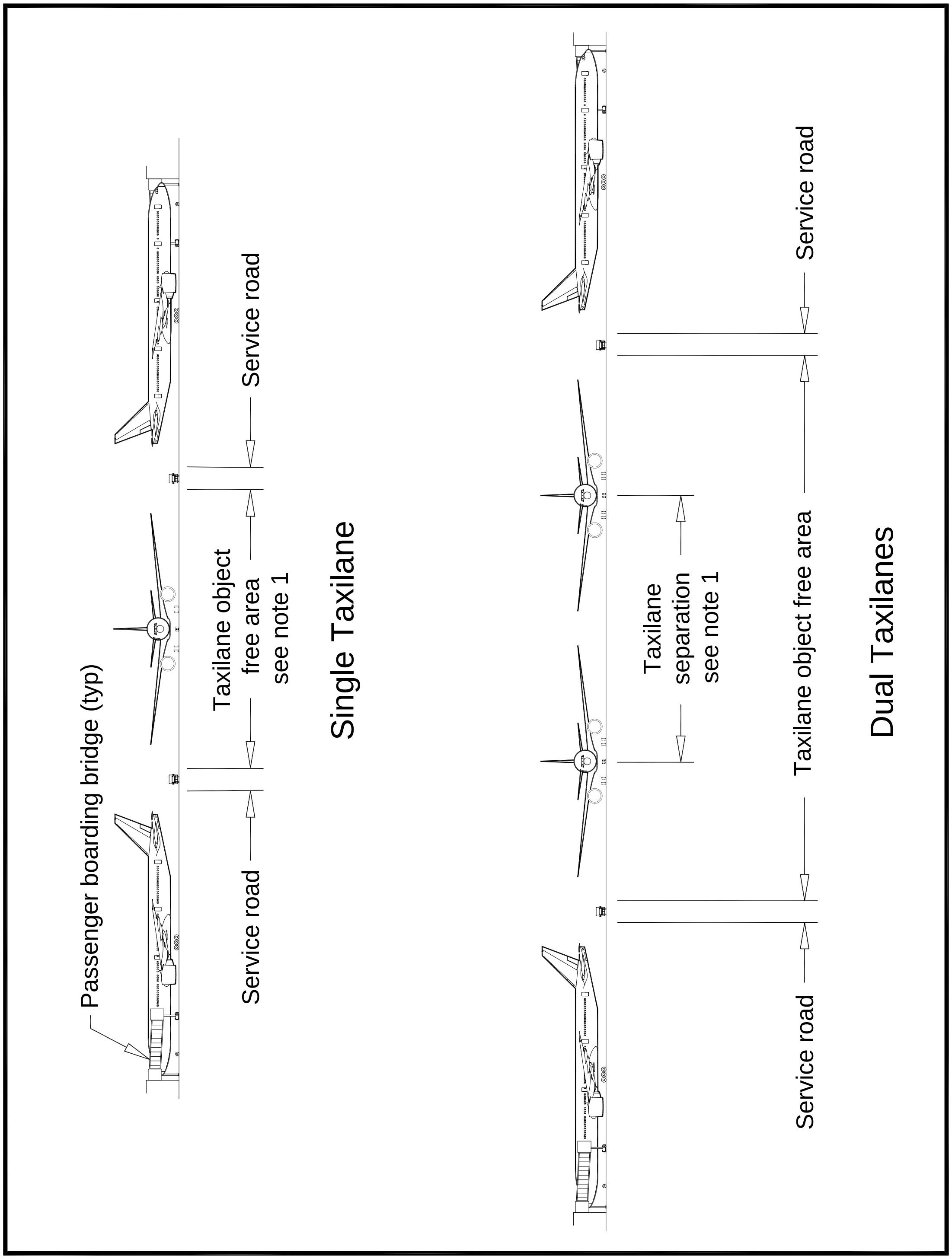
Note: See Figure 4-4.

Figure 4-6. Wingtip Clearance from Taxiway



Note 1: Refer to Table 4-1 for standard separation distances between parallel taxiways.

Figure 4-7. Taxilane Separations and Clearances



Note 1: Refer to Table 4-1 for standard taxilane OFA and standard separation distances between parallel taxilanes.

4.5.3 Taxiway/Taxilane Safety Area (TSA).

The TSA is a defined surface prepared to support the occasional passage of aircraft and ARFF equipment.

4.5.3.1 **Standards.**

1. The TSA width equals the maximum wingspan of the ADG. See Table 4-1.
2. The TSA is symmetrical about the taxiway/taxilane centerline on straight segments.
   a. The TSA increases in width at intersections and turns by extending for a distance of (TSA Width – W)/2 from the taxiway/taxilane edge, based on the fillet design (see Figure 4-9) where W is the taxiway width.
3. Clear and grade the TSA to remove potentially hazardous ruts, humps, depressions, or other surface variations.
4. Prevent accumulation of surface water by grading the TSA to drain away from taxiway pavement, or using flush grated catch basins.
5. Design the TSA to be capable, under dry conditions, of supporting snow removal equipment, ARFF equipment, and the occasional passage of aircraft without causing structural damage to the aircraft.
   a. See AC 150/5370-10, Item P-152, Excavation, Subgrade and Embankment specifications for compaction specification criteria.
   b. Design structures including, but not limited to, manholes, handholes, and grates to support the occasional passage of aircraft and ARFF equipment.
6. The TSA is free of objects, except for objects that need to be located in the TSA because of their function.
   a. Design objects higher than 3 inches (76 mm) above grade on low impact resistant (LIR) supports (frangible mounted structures) of the lowest practical height with the frangible point no higher than 3 inches (76 mm) above the grade.
   b. Design other objects, such as manholes, to meet grade or not exceed a height of 3 inches (76 mm) above grade.

4.5.4 Taxiway and Taxilane Object Free Area (TOFA).

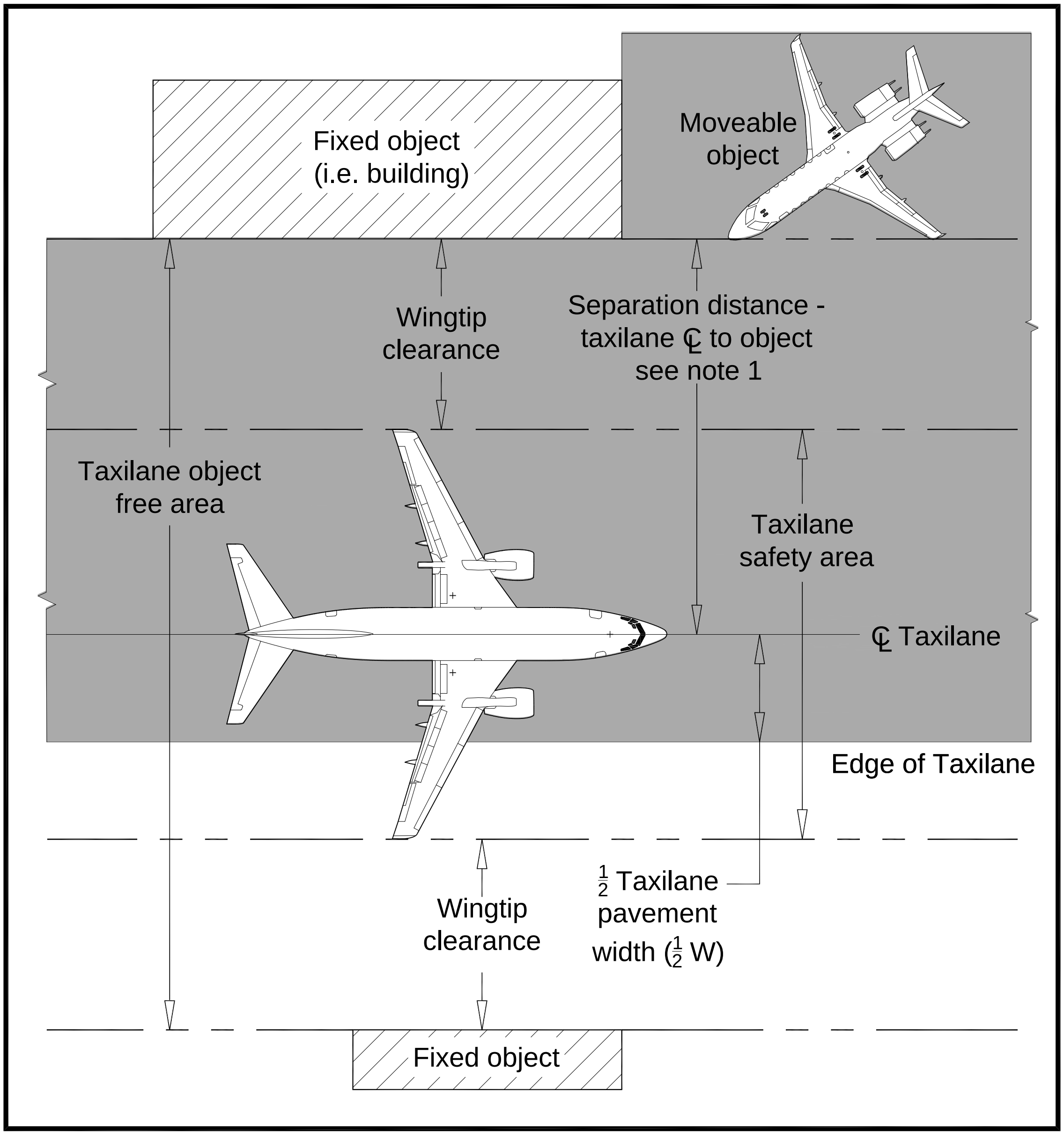
The TOFA is an area adjacent to the TSA that is clear of objects not fixed-by-function to provide vertical and horizontal wingtip clearance. Applying the taxiway/taxilane centerline to object separation values in Table 4-1 to both sides of the centerline establishes the taxiway/taxilane Object Free Area (OFA). See Figure 4-6.

4.5.4.1 Standards.

Table 4-1 specifies the standard dimensions for TOFAs. A standard TOFA is:

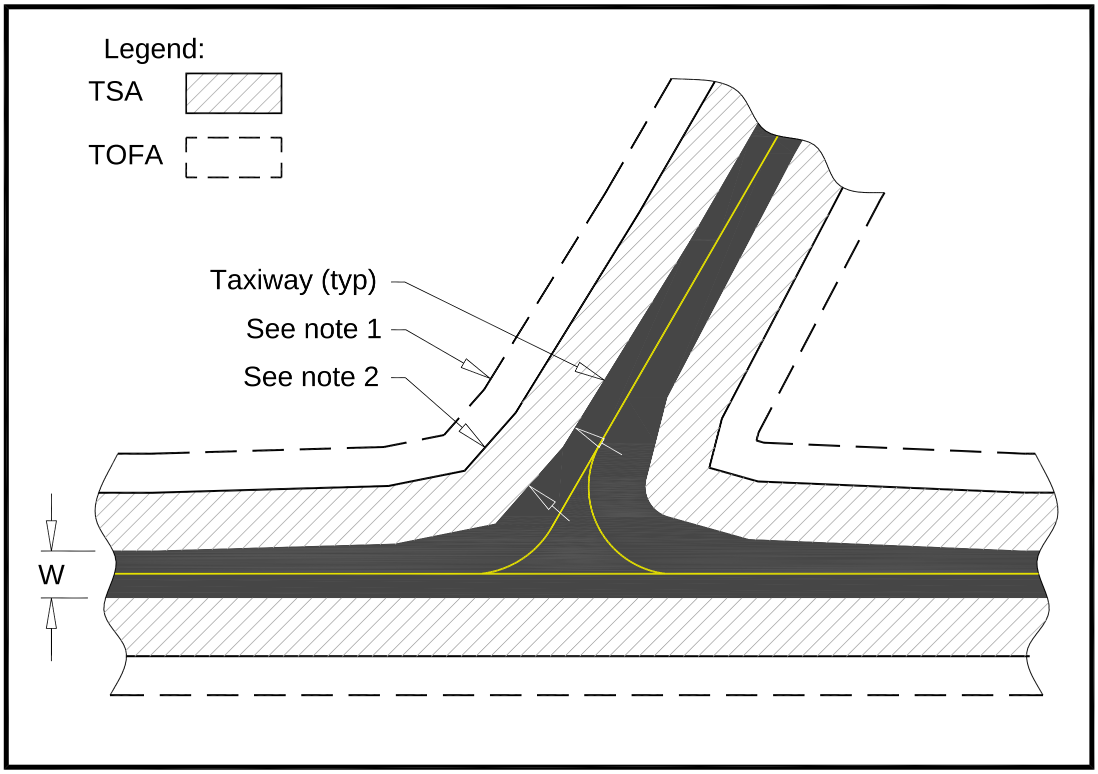
1. Symmetrical about the taxiway and taxilane centerlines as shown in Figure 4-6 and Figure 4-8.
2. Cleared of roads used by baggage carts, fuel trucks, and other service vehicles, parked aircraft, and other objects, except for objects that need to be located in the TOFA for air navigation or aircraft ground maneuvering purposes.
    a. Vehicles may operate within the TOFA provided they give right of way to oncoming aircraft by either maintaining a safe distance ahead or behind the aircraft or by exiting the TOFA to let the aircraft pass.
    b. Provide vehicular exiting areas along the outside of the TOFA where required.
3. Increase in width at intersections and turns.
    a. TOFA clearing standards are met for a distance of (TOFA Width – W)/2 feet from the taxiway edge, based on the fillet design, where W is the taxiway width. (See Figure 4-9.)

Figure 4-8. Wingtip Clearance from Apron Taxilane



Note 1: Refer to Table 4-1 for standard separation distances between parallel taxilanes.

Figure 4-9. TSA and TOFA at Taxiway Intersections



Note 1: (TOFA Width - W)/2
Note 2: (TSA Width - W)/2

4.6 Parallel Taxiways.

A parallel taxiway eliminates using the runway for taxiing, thus increasing runway capacity and protecting the runway under low visibility conditions. A dual parallel taxiway provides the ability for airplanes to taxi behind an airplane holding at a runway hold line.

4.6.1 Standards.

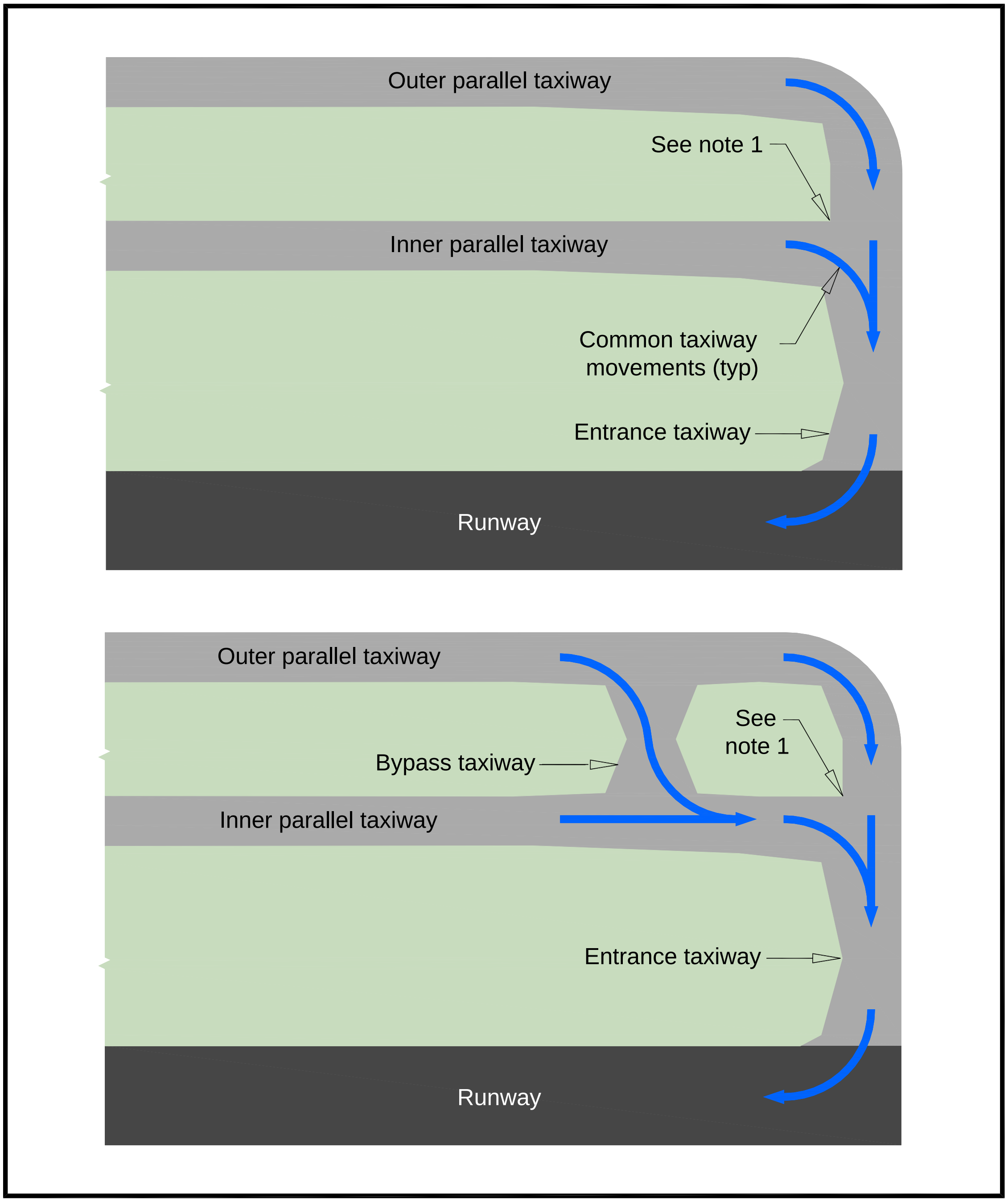
1. Provide a full-length parallel taxiway, or equivalent taxi path, for instrument approach procedures with visibility minimums below one mile.
2. Between dual parallel taxiways, provide fillets only for common turning movements (see Figure 4-10).

4.6.2 Recommended Practices.

1. Provide a full-length parallel taxiway, or equivalent taxi path, for all runways with published instrument approaches (excluding circling approaches).
2. Consider the use of multiple parallel taxiways to provide additional access paths to runway ends at airports with high-density traffic.
3. See FAA Order 5090.3 for relevant planning criteria.

4. A dual parallel taxiway (see Figure 4-10) need not extend the full length of runway.

Figure 4-10. Parallel Taxiways



Note 1: Providing a centerline radius marking and fillet for the uncommon turn from the connecting taxiway to the inner parallel can create a risk for a taxiway departure. Refer to paragraph 4.6 for additional guidance on reducing this risk.

5. To avoid risk of take-offs from the inner parallel taxiway as well as to facilitate maneuvering of snow removal equipment, limit the fillet pavement from the connecting taxiway to the inner parallel taxiway to a 30-foot radius.

6. Provide a parallel taxiway offset at runways ends to mitigate potential risks of wrong surface landings on the taxiway by establishing a discontinuity in the taxiway alignment. See Figure 4-11. Design a 50-foot to 100-foot taxiway offset within 1,500 feet of the runway end in conformance with curve criteria of paragraph 4.3.2. Benefits of this practice include:

   a. Mitigation of potential risks of taxiway landings by establishing a discontinuity in the taxiway alignment.

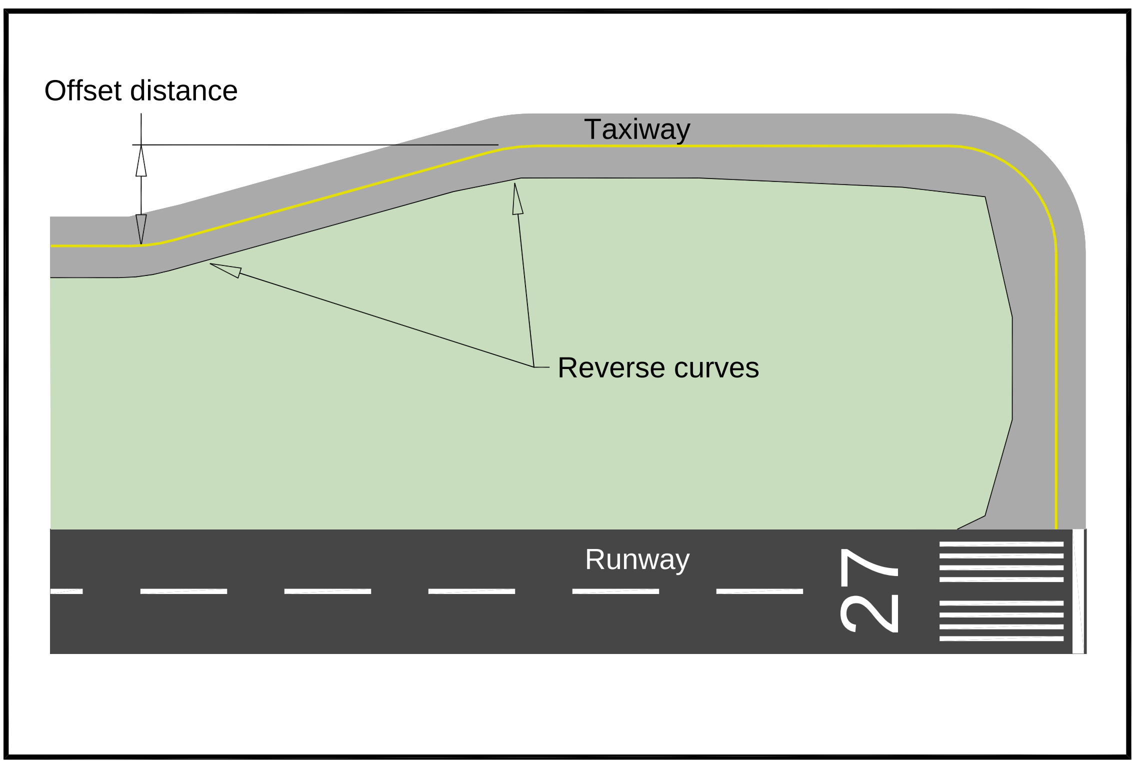
   b. Additional wingtip clearance from parallel taxiway to aircraft holding at a bypass taxiway location. See Figure 4-10.

   c. Facilitation of perpendicular aircraft holding position relative to the runway centerline

   d. Facilitation of NAVAIDs (Glide Slope) and visual aids (wind cones) installations at the approach end of the runway.

7. See paragraph 4.8.5.3, item 5, and online Runway Design Standards Matrix Tool (alternately Appendix G) regarding runway to taxiway separation standards.

Figure 4-11. Parallel Taxiway Offset



4.7 **Taxiway Fillet Design.**

Apply these standards and recommended practices to intersections involving taxiways, taxilanes, and/or aprons.

4.7.1 Standards.

1. Design fillets to maintain the applicable TESM throughout the turning movement.
2. To allow for the asymptotic nature of an airplane realigning with the taxiway centerline when exiting a turn, the taper may end at a point where the distance from the centerline to the outside of the main gear is equal to one half of the straight segment taxiway width plus 6 inches (15 cm).

4.7.2 Recommended Practices.

4.7.2.1 Design pavement fillets at intersections to accommodate the entire selected TDG, while minimizing excess pavement.

4.7.2.2 See Appendix J for guidance on the design of pavement fillets, including the Taxiway Intersection Dimensions by TDG tables. The FAA Office of Airports online Taxiway Fillet Design Tool, which calculates fillet dimensions for simple turns, is available on the FAA web site at: http://www.faa.gov/airports/engineering/airport_design/.

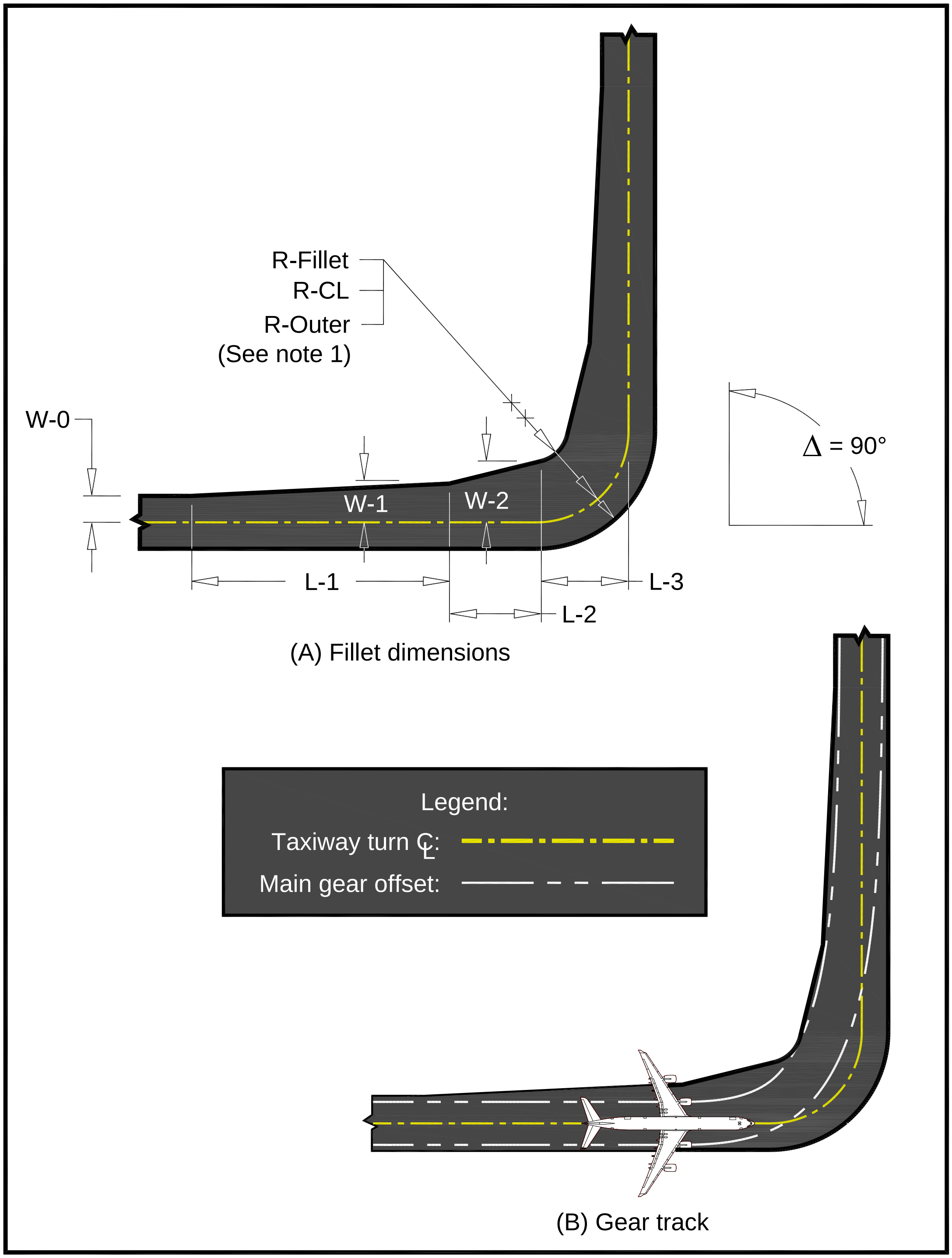
4.7.2.3 See Figure 4-12, Figure 4-13, and Figure 4-14 for illustrated dimensions used to provide the minimum pavement necessary for taxiway fillets.

4.7.2.4 The standard fillets designed using the online Taxiway Fillet Design Tool assume the airplane aligns with the taxiway centerline at the start of a turn.

4.7.2.5 The Taxiway Fillet Design Tool for Multiple Turns calculates minimum turn radii and is available at http://www.faa.gov/airports/engineering/airport_design/.

4.7.2.6 Fillets designed to a specific airplane using CAD software are accepted after review via a modification of standard process.

Figure 4-12. Taxiway Turn – 90 Degree Delta

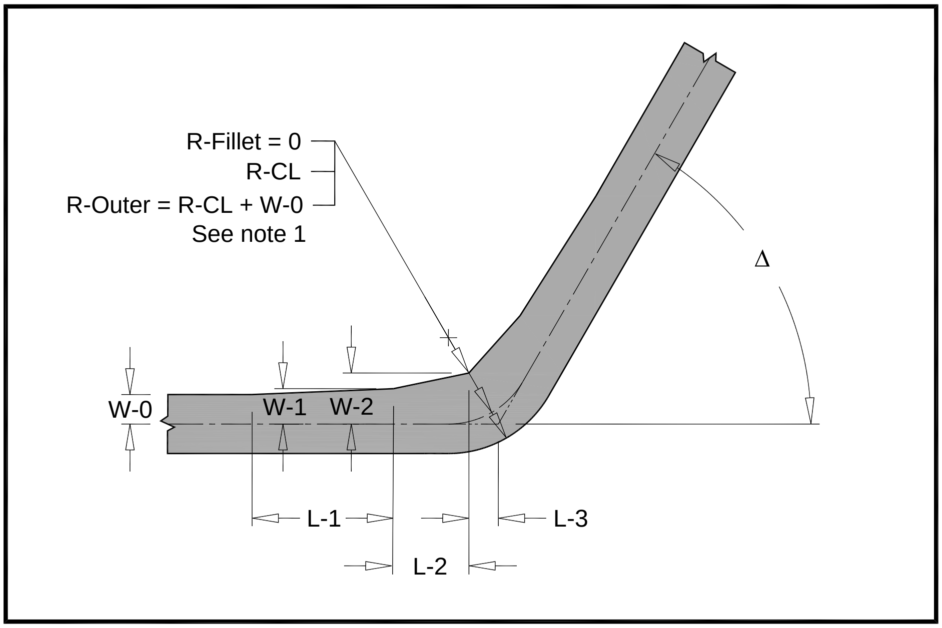


Note 1: Radii of the fillet and the taxiway centerline are not concentric. The radii of the centerline and the outer pavement edge are concentric.

Note 2: Offsets are shown in one direction, but offsets, and therefore fillets, are symmetrical.

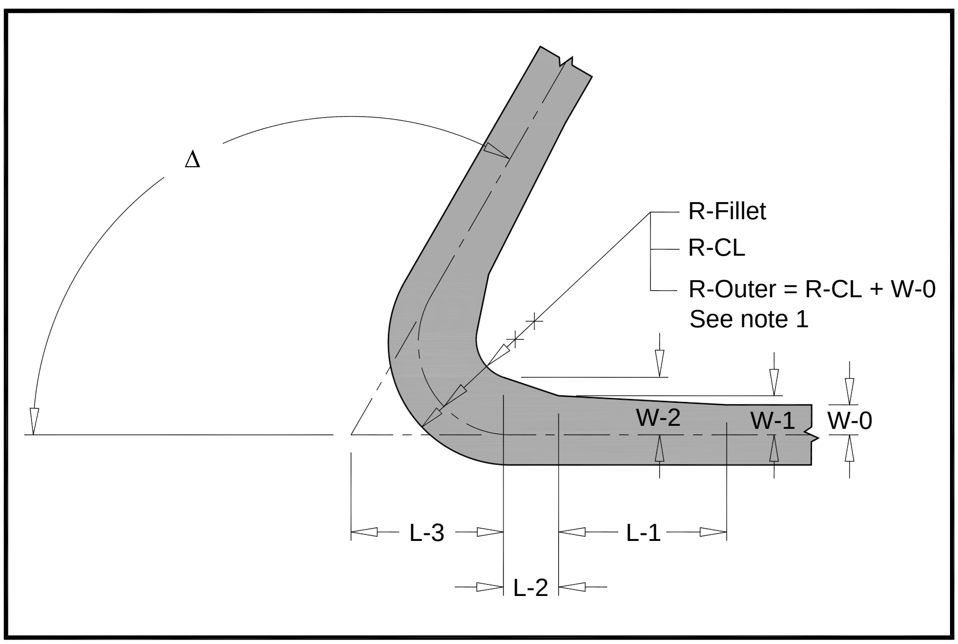
Note 3: Variables used in this figure relate to the online Taxiway Fillet Design Tool.

Figure 4-13. Taxiway Turn – less than 90 Degree Delta



Note 1: Radii of the fillet and the taxiway centerline are not concentric. The radii of the centerline and the outer pavement edge are concentric.
Note 2: The design TDG establishes the dimensional values. See Appendix J.
Note 3: Variables used in this figure relate to the use of the online Taxiway Fillet Design Tool.

Figure 4-14. Taxiway Turn – greater than 90 Degree Delta



Note 1: Radii of the fillet and the taxiway centerline are not concentric. The radii of the centerline and the outer pavement edge are concentric.
Note 2: The design TDG establishes the dimensional values. See Appendix J.
Note 3: Variables used in this figure relate to the use of the online Taxiway Fillet Design Tool.

4.7.3 Design Considerations.

Obtuse angle turns require a much larger fillet to maintain the TESM. See Appendix J for details.

4.7.3.1 When turns are close enough such that the lead-in (see dimension L-1) from one turn overlaps the lead-in to another turn, the airplane is not aligned with the taxiway centerline at the start of the subsequent turn. Such conditions often occur at right-angle runway exits/entrances where the ADG determines runway-to-taxiway separation but the TDG controls the taxiway design.

4.7.3.2 Design intersections and associated fillets by modelling the critical TDG airplane movements using CAD software.

4.7.3.3 Fillet improvements may allow the airport to maintain the current location of taxiway centerline and lights for turns.

4.7.3.4 Consider constructability and snow removal operations:

1. Construct slightly more pavement than the minimum to simplify paving operations while maintaining the TESM.
2. Justify a non-zero fillet radius.
3. Adjust fillet taper points to accommodate the location of concrete pavement joints.

4.8 Runway/Taxiway Intersections.

4.8.1 Right-angle taxiways provide the best visual perspective to a pilot approaching an intersection with the runway to observe aircraft in both the left and right directions. They also provide the optimum orientation of the runway holding position signs to maximize conspicuity to pilots.

4.8.1.1 **Standards.**

1. Design right-angle intersections for runway/taxiway intersections, except where there is a need for high-speed exit taxiways.
2. If a true 90-degree angle with the runway is not practicable, it is acceptable to adjust the angle such that the critical airplane is ±15 degrees from a 90-degree angle when at the hold line.
3. For opposite direction acute angle exit taxiways in close proximity, provide sufficient separation between the exits to limit a large expanse of pavement and allow standard locations for signs and marking.

4.8.1.2 Recommended Practices.

1. Increase the taxiway-to-runway separation for a segment of the parallel taxiway as depicted in Figure 4-15 to allow for a 90-angle angle.
2. Design acute angle exit taxiways at an angle less than 45 degrees from the runway centerline.
3. Limit runway crossings to the outer thirds of the runway, keeping the high-energy area of the runway clear so a pilot can maneuver to avoid a potential collision.
4. Minimize the number of runway crossings:
   a. to that necessary for efficient movement of aircraft.
   b. to reduce the number of potential conflict points with crossing aircraft operations.
5. Design a runway/taxiway intersection such that the sight distance along a runway from an intersecting taxiway is sufficient to allow a taxiing aircraft to safely enter or cross the runway.

4.8.1.3 Design Considerations.

1. Multiple intersecting taxiways with acute angles cause pilot confusion and poor visibility of signs due to:
   a. increased distance from centerline.
   b. non-standard positioning of signs.
2. Right-angle intersections provide:
   a. a pilot with the best view of the runway and the approach ends.
   b. the optimum orientation of the runway holding position signs.

4.8.2 Entrance Taxiways.

4.8.2.1 Standards.

1. Curve the outer edge of an entrance taxiways located at runways ends.
2. When multiple parallel taxiways extend to the end of the runway, curve the outer edge of the outer parallel taxiway.
3. See Figure 4-15 for a standard entrance taxiway layout.

4.8.2.2 Recommended Practices.

1. Design entrance taxiways to serve each runway end.
2. For fillet design, locate the point of tangency of the taxiway centerline curve at the runway centerline.

a. Entrance taxiways do not provide direct access from an apron (see Figure 4-2 and paragraph J.5.7.

b. Each entrance taxiway has its own taxiway designator, markings and elevated signage.

4.8.2.3 Design Considerations.

1. Two standard 90 degree turns:

   a. Resulting in a steering angle of 50 degrees or less:

      i. Design a runway entrance taxiway as two standard 90 degree turns symmetrical about a line midway between the runway and taxiway centerlines.

   b. Resulting in a steering angle of more than 50 degrees:

      i. Increase the turn radius and fillets.

      ii. Table 4-3 and Table 4-4 provide dimensions that may be used for common combinations of ADG, TDG, and runway to taxiways separation where the design requires other than two standard 90 degree turns.

      iii. An example of this condition is a right-angle runway exit or entrance where the runway to taxiway separation applies ADG-IV criteria but the taxiway design uses TDG 6 criteria.

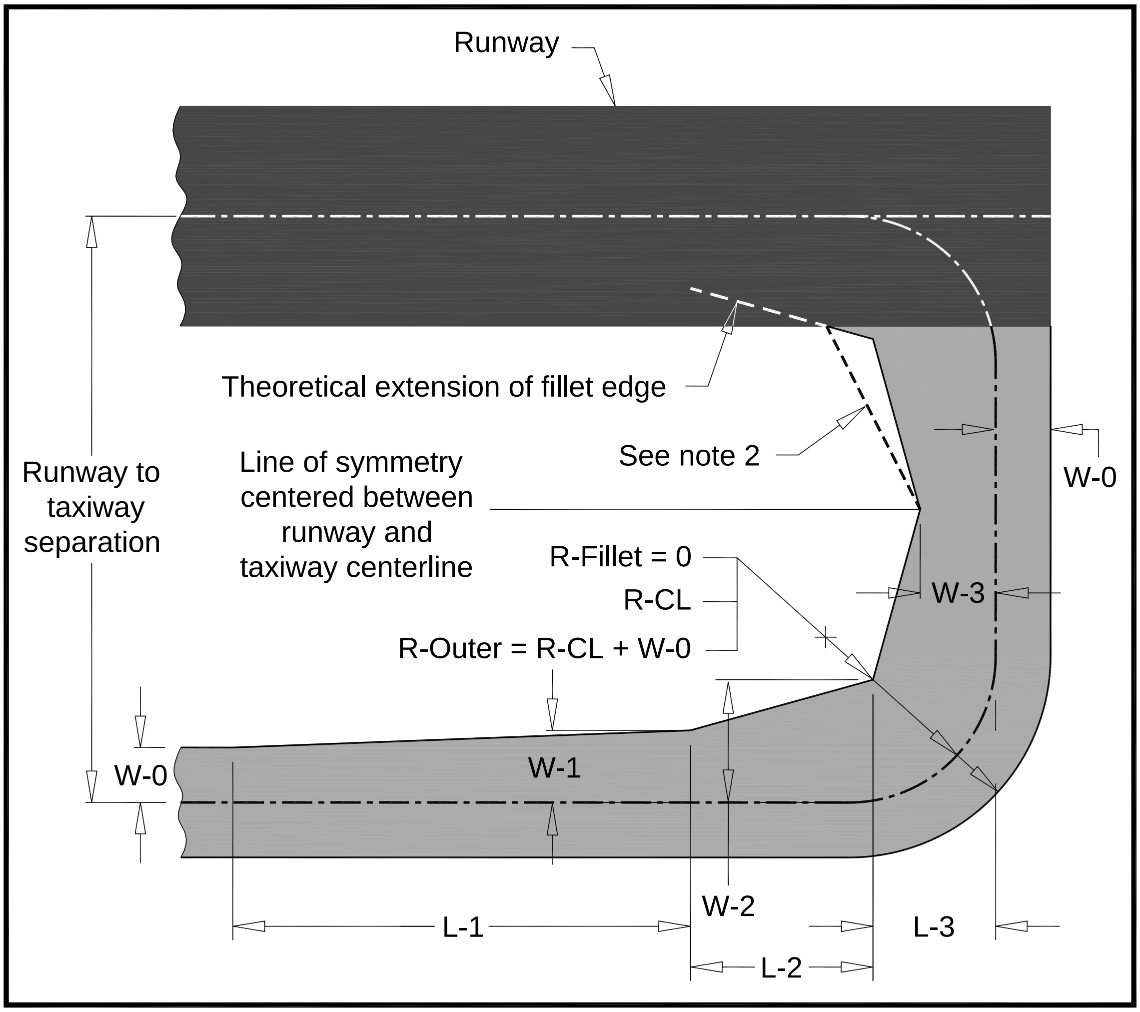
      iv. Drawings of common combinations of TDG and runway to taxiway separation, with acceptable fillet design are available in DXF format on the FAA web site at http://www.faa.gov/airports/engineering/airport_design/.

2. Design the entrance taxiway width based on Table 4-2. Design the centerline radius and minimum fillet dimensions with the design TDG as shown in the tables in paragraph J.3.

3. A displaced threshold may cause the location of the holding position to reside on the parallel taxiway to keep aircraft out of the Precision Obstacle Free Zone (POFZ) and approach surfaces.

4. Entrance taxiways also serve as the final exit taxiway for operations in the opposite direction.

Figure 4-15. Entrance Taxiway



Note 1: Radii of the fillet and the taxiway centerline are not concentric. The radii of the centerline and the outer pavement edge are concentric.

Note 2: It is allowable to design a single fillet edge as shown to avoid a short and narrow fillet pavement section near the runway edge.

Note 3: Refer to Table 4-3, Table 4-4 and Appendix J for dimensional values.

Table 4-3. Dimensions for Runway Entrance/Exit Taxiways with TDG 1A, 1B, 2A, or 2B (Where the Two 90-Degree Turns are Nonstandard)

Dimension	TDG															
(see Figure 4-15)	1A	1B					2A					2B				
Runway Centerline to Taxiway Centerline Distance (ft)	150	240	250	300	350	400	240	250	300	350	400	240	250	300	350	400
W-0 (ft)	12.5	12.5	12.5	12.5	12.5	12.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
W-1 (ft)	21	18	18	18	18	18	18	23	23	23	23	26	26	26	26	26
W-2 (ft)	21	31	31	31	31	31	31	35	35	35	35	50	50	49	49	48
W-3 (ft)	13	15	15	14	13	13	15	20	19	18	18	27	27	24	22	21
L-1 (ft)	52	94	94	94	94	94	94	91	91	91	91	178	179	177	177	176
L-2 (ft)	0	47	47	47	47	47	47	45	45	45	45	84	84	85	85	84
L-3 (ft)	21	31	31	31	31	31	31	35	35	35	35	50	50	49	49	48
R-Fillet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-CL (ft)	19	37	37	37	37	37	37	37	37	37	37	65	65	62	61	60
R-Outer	31.5	49.5	49.5	49.5	49.5	49.5	54.5	54.5	54.5	54.5	54.5	82.5	82.5	79.5	78.5	77.5

Note: Use two standard 90 degree turns for combinations of TDG and common runway to taxiway separation not shown in this table.

Table 4-4. Dimensions for Runway Entrance/Exit Taxiways with TDG 3, 4, 5, or 6 (Where the Two 90-Degree Turns are Nonstandard)

Dimension	TDG														
(see Figure 4-15)	3			4					5			6			
Runway Centerline to Taxiway Centerline Distance (ft)	300	350	400	300	350	400	450	500	400	450	500	400	450	500	550
W-0 (ft)	25	25	25	25	25	25	25	25	37.5	37.5	37.5	37.5	37.5	37.5	37.5
W-1 (ft)	33	33	33	37	37	36	36	36	49	48	48	51	51	51	50
W-2 (ft)	55	54	54	80	77	75	74	74	84	83	83	102	100	98	97
W-3 (ft)	31	29	28	49	42	38	35	33	50	47	45	63	57	53	50
L-1 (ft)	173	172	172	315	310	307	305	305	301	299	298	408	405	403	401
L-2 (ft)	82	83	83	140	140	140	140	140	137	136	138	180	180	180	180
L-3 (ft)	55	54	54	80	77	75	74	74	84	83	83	102	100	98	97
R-Fillet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-CL (ft)	62	61	60	110	102	98	95	94	98	95	94	133	126	122	120
R-Outer	87	86	85	135	127	123	120	119	135.5	132.5	131.5	170.5	163.5	159.5	157.5

Note: Use two standard 90 degree turns for combinations of TDG and common runway to taxiway separation not shown in this table.

4.8.3 Bypass Taxiways.

At busy airports, ATC routinely needs to reshuffle the sequence of aircraft near the departure runway end in order to maintain optimum runway capacity. Bypass taxiways located near runway ends provide flexibility of runway operations by permitting necessary ground maneuvering based on clearance sequence.

4.8.3.1 Standards.

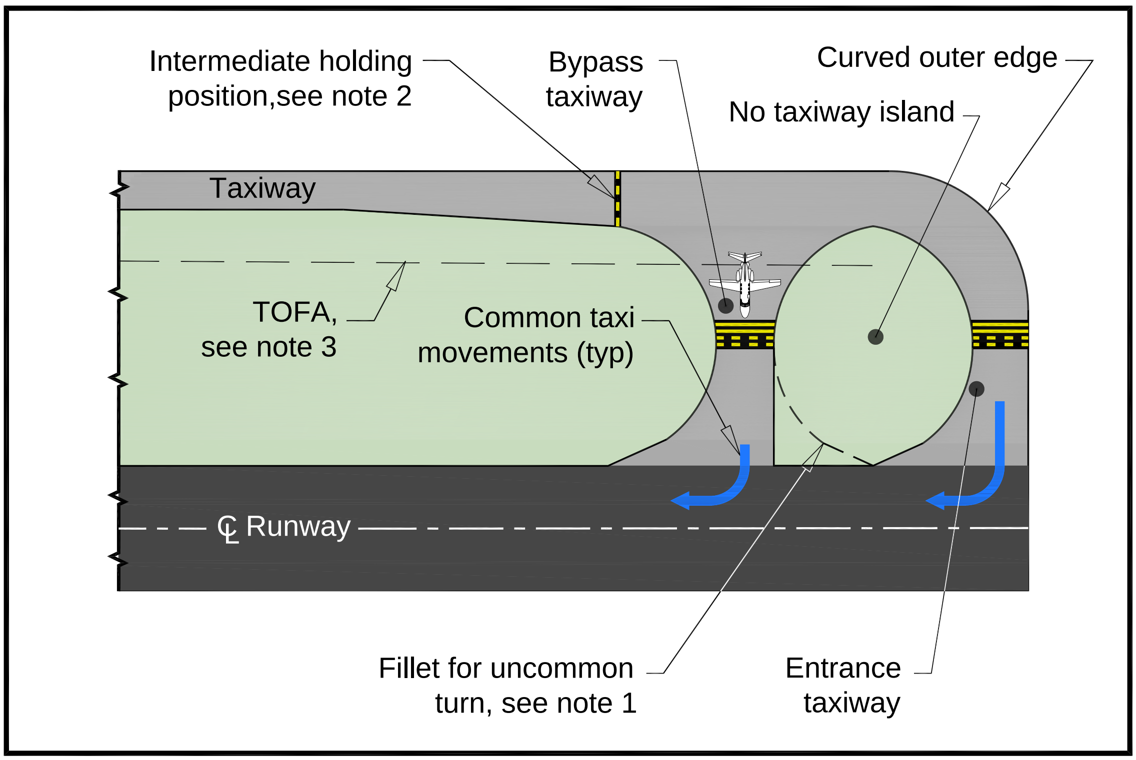
1. Conform to the standard taxiway widths and separation for the specific ADG and TDG, as shown in Table 4-1 and Table 4-2.
2. For existing conditions, mark, sign, and light paved islands between the entrance taxiway and the bypass taxiway to identify the area as closed to aircraft (see AC 150/5340-1).

3. For new design, install turf (natural or artificial) to create the no-taxi island between bypass taxiway(s) and the entrance taxiways. See Figure 4-20 and Figure 4-10.

4.8.3.2 **Recommended Practices.**

1. Provide the fillet between the bypass taxiway and entrance taxiway only when there is a recurring operational need for this turning movement, as shown in Figure 4-20.
2. Consult with local ATC to assess if one or more bypass taxiways on a runway end are worthwhile for optimum departure capacity.
3. Provide bypass taxiways at towered airports with regular IFR operations.

Figure 4-16. Bypass Taxiway Bay Configuration



Note 1: The turn from the near end of the runway to the bypass taxiway is an uncommon operation. See paragraph 4.8.3.2.

Note 2: Install an intermediate holding position marking (i.e. Pattern C) prior to the bypass taxiway if any part of a holding aircraft encroaches upon the taxiway object free area.

Note 3: For unobstructed taxi operations on the parallel taxiway, consider an off-set parallel taxiway per figure 4-10 to preclude a holding aircraft from encroaching upon the TOFA.

4.8.4 Exit Taxiways.

Exit taxiways permit free flow to the parallel taxiway or to a point where the aircraft is completely clear of the hold line.

4.8.4.1 Recommended Practices.

1. Design right-angle exit taxiways to provide for flexible operations in both directions and as a runway crossing point.
2. Figure 4-19 illustrates a configuration for a right-angle exit taxiway, which can be designed by creating a mirror image of an entrance taxiway about the exit taxiway centerline. For configurations other than those with two standard 90-degree turns, see Table 4-3 and Table 4-4.
3. Assess exit taxiway locations impact on runway occupancy time and capacity.
   a. The Runway Exit Design Interactive Model (REDIM) is the preferred quantitative method for determining the location and mix of high speed and right-angle runway exits.
   b. Fast-time simulation modeling, used alone, is not a reliable means of locating exit taxiways.
   c. Alternatively, for airports with an elevation under 2000 feet MSL, Table 4-5 and Table 4-6 provide for cumulative distributions of exit usage by AAC and ADG.

4.8.4.2 Design Considerations.

1. Exit taxiways, including high speed exit taxiways, may be located in the middle third of a runway to optimize runway capacity provided there is no accompanying crossing taxiway associated with the exit taxiway.
2. An acute angle exit taxiway is not suitable as a runway entrance or runway crossing point, as it provides a pilot with a diminished viewing range in one direction.
3. Runway exit taxiways classify as either “right angle” or “acute angle” taxiways.
   a. The application of a right-angled exit taxiway versus acute-angled exit taxiway is a function of the existing and anticipated traffic in the interest of reducing runway occupancy time.
   b. Acute angle taxiway turns require the pilot landing in the opposite direction to slow down considerably on the runway to negotiate the greater than 90-degree turn, resulting in additional runway occupancy time.
   c. See paragraph 4.8.5 for guidance on high speed exit taxiways.
4. The type of exit taxiway influences runway to parallel taxiway separation.
   a. FAA Airports’ online Runway Design Standards Matrix Tool provides runway/taxiway separations based on ADG.

b. Minimum turn radii based on TDG may affect runway/taxiway separation distance.

5. For existing runway/taxiway separations, it may not be possible to combine a standard high-speed 30-degree angle exit (see paragraph 4.8.5) with a subsequent 150-degree reverse turn while maintaining a nose gear steering angle of no more than 50 degrees.

6. Design tools related to exit taxiways are available at: http://www.faa.gov/airports/engineering/airport_design.

Table 4-5. ADG Cumulative Runway Exit

	ADG I	ADG I	ADG II	ADG II	ADG III	ADG III	ADG IV	ADG IV	ADG V	ADG V	ADG VI	ADG VI
	Acute Angle	Right Angle	Acute Angle	Right Angle	Acute Angle	Right Angle	Acute Angle	Right Angle	Acute Angle	Right Angle	Acute Angle	Right Angle
Distance (ft)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)
0	0	0	0	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0	0	0	0
1000	0.002	0	0	0.06	0	0	0	0	0	0	0	0
1500	0.954	0.124	0	0.18	0	0	0	0	0	0	0	0
2000	9.93	3.988	0.13	0.84	0	0.01	0	0	0	0	0	0
2500	34.22	21.338	0.24	1.99	0	0.05	0	0.01	0	0	0	0
3000	66.682	52.602	0.68	5.8	0.08	0.31	0.01	0.04	0	0	0	0
3500	89.288	81.23	3.51	12.83	1.61	1.42	0.58	0.34	0.14	0.06	0	0
4000	97.892	95.64	7.61	23.93	3.32	6.19	1.1	1.79	0.26	0.09	0.14	0
4500	99.734	99.382	24.74	40.03	16.22	16.85	6.39	6.07	2.12	0.46	0.27	0.02
5000	99.984	99.954	43.5	63.57	30.64	29.15	23.54	16.32	7.94	5.23	1.51	0.22
5500	100	100	58.73	72.14	44.51	43.03	37.68	30.94	17.5	7.87	6.56	0.74
6000	100	100	77.18	83.59	65.13	62.5	58.81	42.63	35.57	12.98	13.84	1.16
6500	100	100	88.18	89.85	83.38	77.37	77.91	59.55	67.25	33.3	54.39	5.07
7000	100	100	91.51	92.64	89.46	85.68	91.39	69.67	80.55	44.85	67.05	15.8
7500	100	100	97.67	95.94	96.97	91.49	97.08	77.9	92.67	59.12	79.08	33.1
8000	100	100	98.09	96.42	98.43	93.28	98.68	82.73	97.35	67.61	95.89	45.17
8500	100	100	98.15	97.56	98.77	95.09	99.62	87.74	99.43	76.17	99.7	66.23
9000	100	100	98.5	98.12	98.89	96.78	99.68	92.69	99.44	89.94	99.7	89.71
9500	100	100	100	98.4	100	97.37	99.99	94.17	99.9	92.61	99.96	93.37
10000	100	100	100	99.34	100	98.63	99.99	97.24	99.91	97.7	99.96	96.03
10500	100	100	100	99.43	100	98.97	100	97.54	100	98.32	99.98	96.86
11000	100	100	100	100	100	100	100	100	100	100	100	100

Table 4-6. AAC Cumulative Runway Exit Probability

	AAC A	AAC A	AAC B	AAC B	AAC C	AAC C	AAC D	AAC D	AAC E	AAC E
	Acute Angle	Right Angle	Acute Angle	Right Angle	Acute Angle	Right Angle	Acute Angle	Right Angle	Acute Angle	Right Angle
Distance (ft)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)	Prob (%)
0	0	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0	0
1000	0.112	0	0.002	0	0	0	0	0	0	0
1500	4.214	0.446	0.696	0.01	0	0	0	0	0	0
2000	22.402	7.626	8.752	1.606	0	0	0	0	0	0
2500	54.844	31.032	32.618	13.652	0.01	0.04	0	0	0	0
3000	83.508	64.94	64.94	42.652	0.06	0.36	0	0.04	0	0.04
3500	97.002	89.712	87.324	73.286	1.2	1.3	0.27	0.16	0.27	0.16
4000	99.72	98.464	96.436	91.204	3.35	7.56	0.83	1.95	0.83	1.95
4500	99.996	99.914	99.116	97.756	16.32	19.2	7.37	5.72	7.37	5.72
5000	100	99.996	99.86	99.538	33.1	35.08	16.78	11.88	16.78	11.88
5500	100	100	99.984	99.902	47.38	48.83	30.66	22.3	30.66	22.3
6000	100	100	100	99.992	67.49	66.13	53.95	39.55	53.95	39.55
6500	100	100	100	100	83.88	78.74	78.33	58.89	78.33	58.89
7000	100	100	100	100	89.94	86.02	86.93	69.47	86.93	69.47
7500	100	100	100	100	96.98	91.32	96.15	79.55	96.15	79.55
8000	100	100	100	100	98.34	92.99	98.05	84.23	98.05	84.23
8500	100	100	100	100	98.64	94.93	98.85	88.53	98.85	88.53
9000	100	100	100	100	98.82	96.82	98.94	93.52	98.94	93.52
9500	100	100	100	100	100	97.41	99.99	94.82	99.99	94.82
10000	100	100	100	100	100	98.71	99.99	97.89	99.99	97.89
10500	100	100	100	100	100	98.96	100	98.44	100	98.44
11000	100	100	100	100	100	100	100	100	100	100

4.8.5 High-Speed Exit Taxiways.

A specific runway exit taxiway that forms a 30-degree angle with the runway centerline. Also commonly referred to as a "high-speed" exit taxiway. High-speed exits enhance runway capacity by reducing runway occupancy time.

4.8.5.1 **Standards.**

1. A high-speed exit provides direct access to a parallel taxiway closest to the runway.
2. The radius of the high-speed exit from the runway is 1500 feet (457 m).

4.8.5.2 **Recommended Practices.**

To improve pilot recognition and acceptance of an exit taxiway, provide enhancements such as:

1. High intensity taxiway centerline lights
2. Widening the exit taxiway throat
3. Provide high speed exits to reduce runway occupancy time when runway operations meet criteria established in FAA Order 5090.5.

4.8.5.3 **Design Considerations.**

1. A high-speed exit that provides direct access to the outer of two parallel taxiways or to an apron introduces safety risks.
2. Ideally, aircraft exiting the runway via a high-speed exit taxiway continue on the parallel taxiway in the landing direction.
3. When it is necessary for aircraft to reverse taxiing direction after exiting a runway with a single parallel taxiway, consider:
    a. providing an additional 90-degree exit taxiway beyond the high-speed exit to provide two 90-degree turns
    b. providing a second parallel taxiway with crossover taxiways (Figure 4-21), or
    c. providing additional pavement, as shown in Figure 4-18.
4. Reference Table 4-7 for guidance on reverse turns between runways and parallel taxiways using the greater dimension based on ADG or TDG.
    a. If a reverse turn is necessary when the runway to taxiway separation is less than shown in Table 4-7 either decrease the initial exit angle and/or use a radius that will require a nose gear steering angle of more than 50 degrees for longer aircraft and increase pavement fillets. (See paragraph 4.7 for guidance on fillet design.)

b. Design the fillet for the reverse turn considering that the aircraft movement on the exit taxiway is in the exiting direction only.

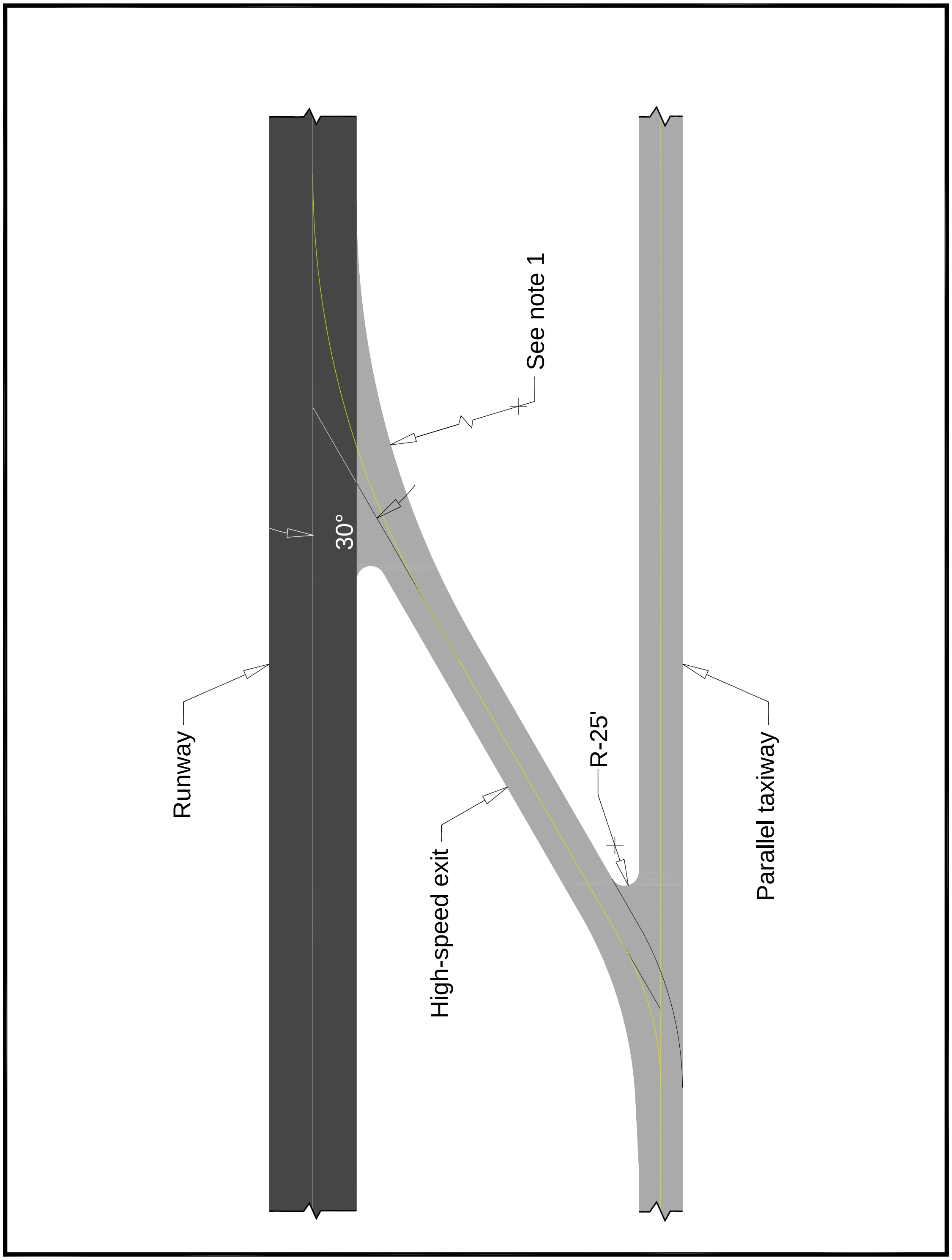
5. Provide sufficient spacing between opposite direction high-speed exit taxiways to avoid wide expanses of pavement at the runway-taxiway intersection and to allow for the standard location of signs, marking, and lighting. See Figure 4-19.

6. Figure 4-15 and other drawings in DXF format showing common combinations of ADG, TDG, and runway to taxiway separation distance are available on the FAA web site at: http://www.faa.gov/airports/engineering/airport_design/.

Table 4-7. Runway to Taxiway Separation for Reverse Turns from a High-Speed Exit Based on Taxiway Design Group (TDG)

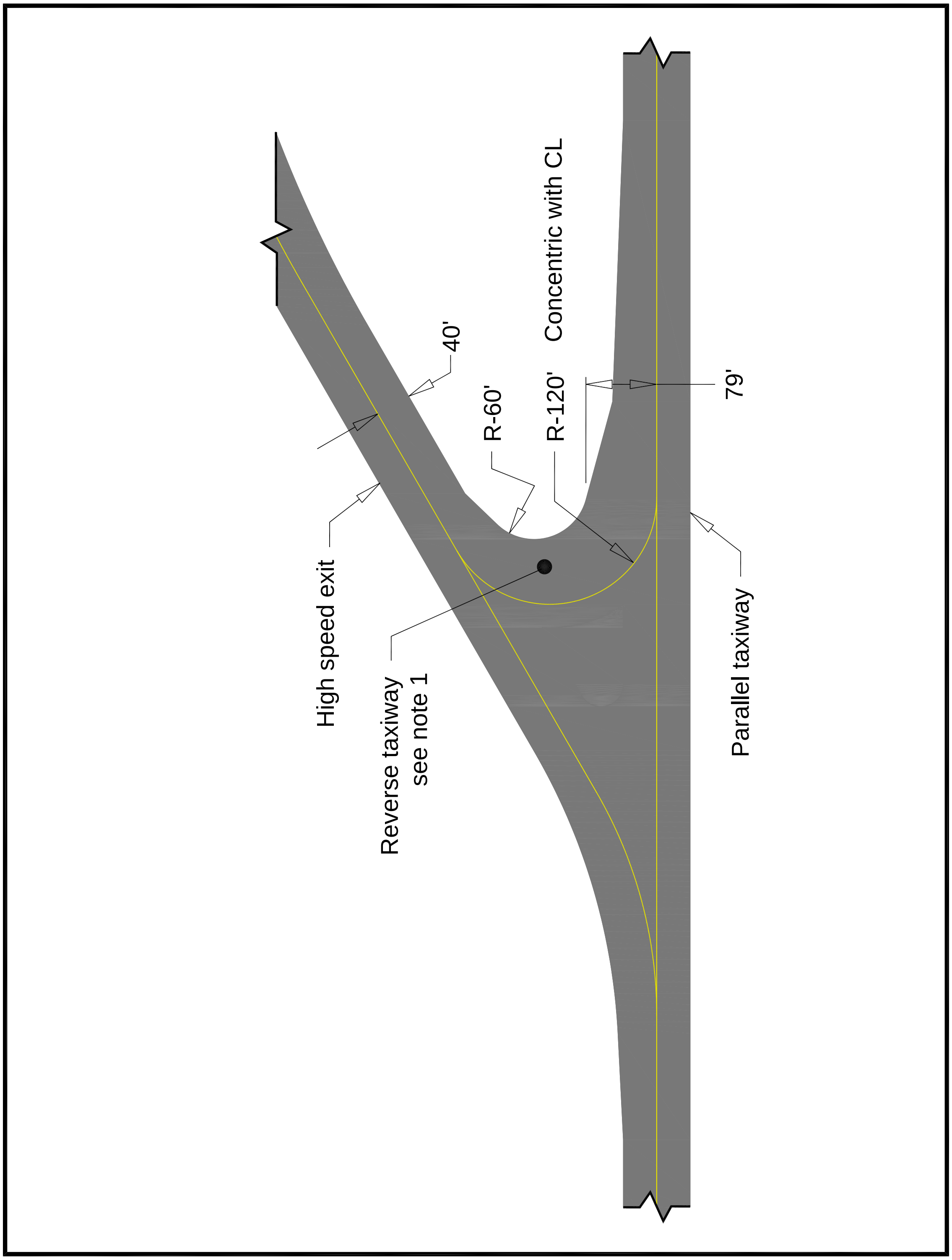
Runway Centerline to Taxiway/ Taxilane Centerline	**TDG**							
	1A	**1B**	**2A**	**2B**	**3**	**4**	**5**	**6**
Minimum separation	250 ft (76 m)	293 ft (89 m)	293 ft (89 m)	349 ft (106 m)	349 ft (106 m)	427 ft (130 m)	427 ft (130 m)	483 ft (147 m)
Recommended separation	250 ft (76 m)	300 ft (91 m)	300 ft (91 m)	350 ft (107 m)	350 ft (107 m)	450 ft (137 m)	450 ft (137 m)	600 ft (183 m)
Radius for 150-degree turn after 30-degree exit	24 degrees	49 degrees	49 degrees	79 degrees	79 degrees	121 degrees	121 degrees	151 degrees
Minimum distance calculated	246 ft (75 m)	292 ft (89 m)	292 ft (89 m)	348 ft (106 m)	348 ft (106 m)	427 ft (130 m)	427 ft (130 m)	483 ft (147 m)

3960 **Figure 4-17. High-Speed Exit – TDG 5**



3961
3962 **Note 1:** Radius equals 1500 ft (457 m).

Figure 4-18. High-Speed Exit – Reverse Turn



Note 1: See paragraph 4.8.5.3, item 4.

Figure 4-19. Right-Angled Exit Taxiway

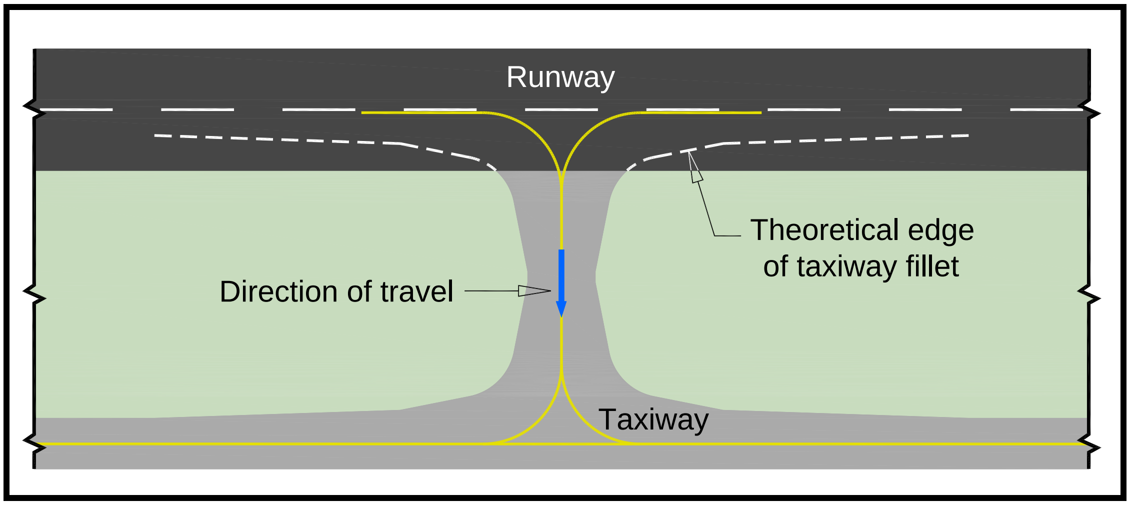
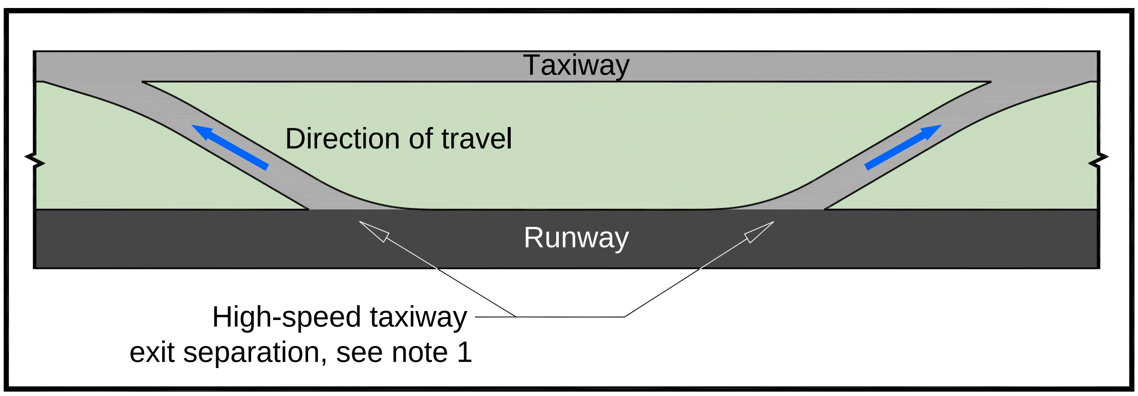


Figure 4-20. High-Speed Exit Separation



Note 1: See paragraph 4.8.5.3, item 5.

4.8.6 Crossover Taxiways.

Crossover taxiways, sometimes called "connector" or "transverse" taxiways, between parallel taxiways increase flexibility.

4.8.6.1 Standards.

1. When there is no reverse turn, design the taxiway to taxiway separation distance between parallel taxiways to be the greater of:
   a. Separation value based on ADG per Table 4-1.
   b. Twice the radius of a standard 90-degree turn.
2. When there is an operational need for a direction or reversal turn, design the minimum distance between parallel taxiways based on TDG (see Table 4-5 and Figure 4-16).

4.8.6.2 Design Considerations.

1. In cases where the separation is based on ADG, a steering angle of more than 50 degrees may result from combining two 90 degree turns designed according to paragraphs J.2 and J.3.
2. Table 4-7 provides dimensions used in Figure 4-21 for common combinations of ADG and TDG for crossover taxiways where steering angles may be kept to no more than 50 degrees.

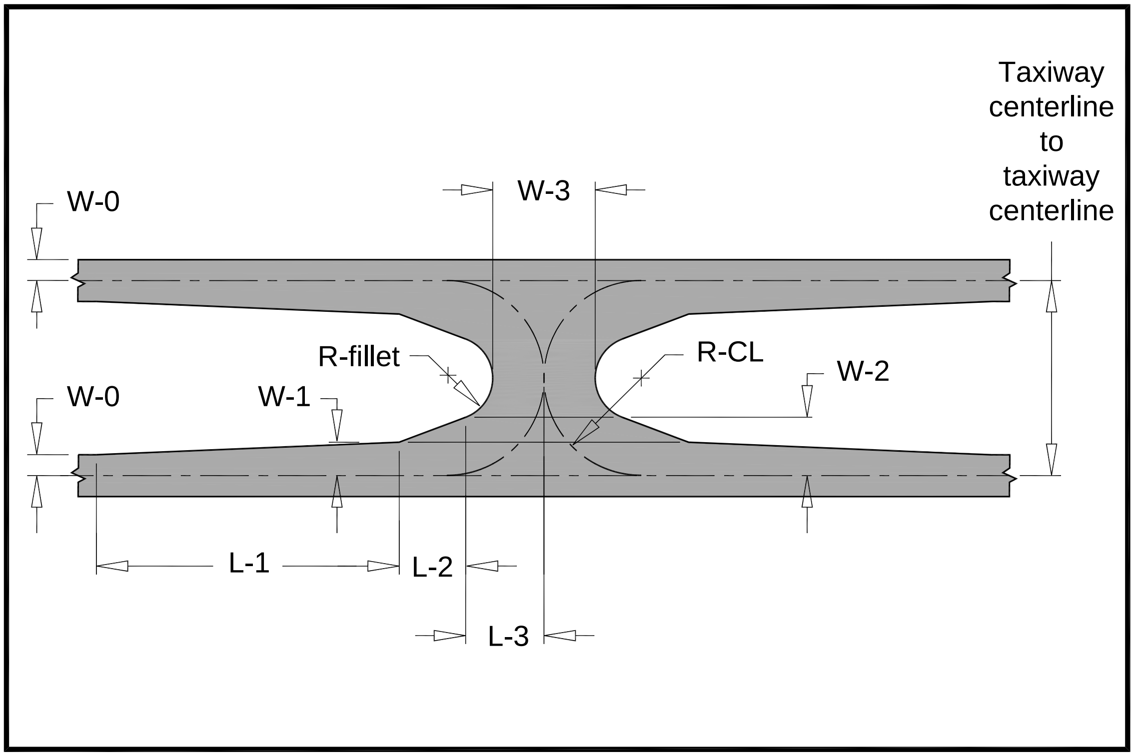
4.8.6.3 Recommended Practices.

1. Design the taxiway system to minimize the need for direction reversal between taxiways (180-degree turns).
2. If it is not feasible to increase the separation between existing parallel taxiways, it is acceptable to design to a steering angle of more than 50 degrees.

Table 4-8. Crossover Taxiways with Direction Reversal Between Taxiways Based on TDG

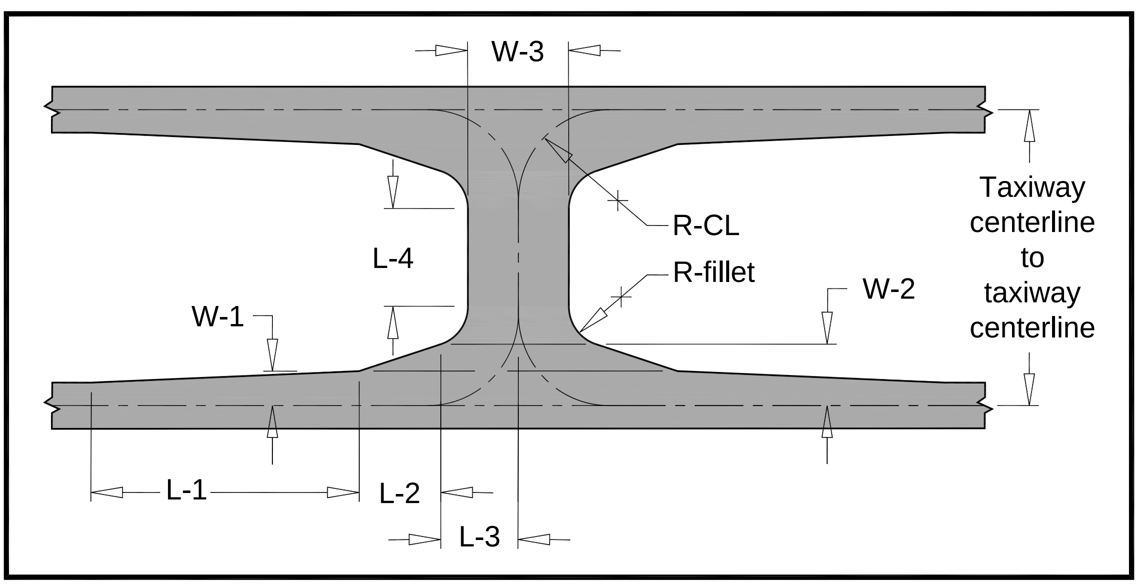
Dimension	TDG							
(See Figure 4-21)	**1A**	**1B**	**2A**	**2B**	**3**	**4**	**5**	**6**
Taxiway Centerline to Centerline Distance	50	100	100	162	162	250	250	312
W-0 (ft)	12.5	12.5	17.5	17.5	25	25	37.5	37.5
W-1 (ft)	12.5	12.5	17.5	17.5	25	25	37.5	37.5
W-2 (ft)	25	19	24	27	34	38	50	53
W-3 (ft)	25	37	40	57	63	86	95	112
L-1 (ft)	42	58	68	88	103	131	150	176
L-2 (ft)	58	101	99	188	185	324	318	424
L-3 (ft)	0	47	46	84	82	139	136	177
R-Fillet (ft)	21	37	40	57	63	86	95	112
R-CL (ft)	25	50	50	81	81	125	125	156
R-Outer	37.5	62.5	67.5	98.5	106	150	162.5	193.5

Figure 4-21. Crossover Taxiway where Direction Reversal is Needed Based on TDG



Note: Refer to Table 4-8 for dimensional values.

Figure 4-22. Crossover Taxiway where Direction Reversal is Needed Based on ADG

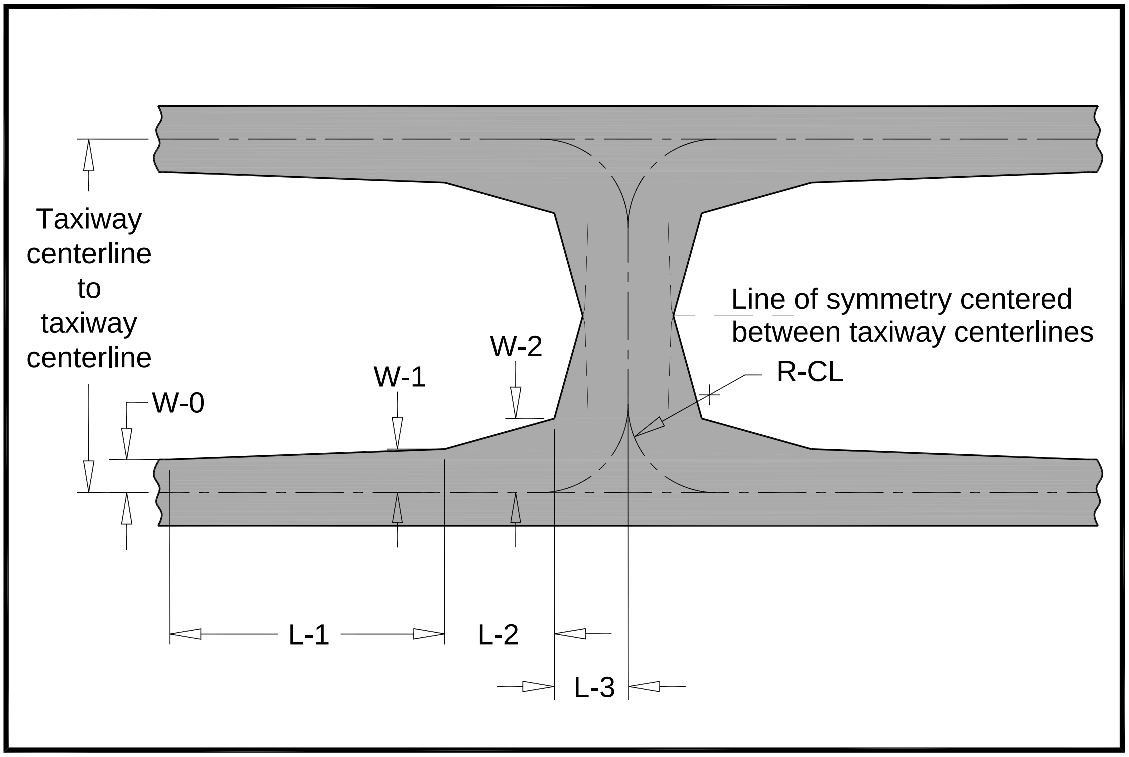


Note: Refer to Table 4-9 for dimensional values.

Table 4-9. Crossover Taxiways with Direction Reversal Between Taxiways Based on ADG

Dimension (see Figure 4-22)	**TDG**																	
	1A	1B		2A		2B			3		4			5		6		
	ADG																	
	II	II	III	II	III	II	III	IV	III	IV	III	IV	V	IV	V	IV	V	VI
Taxiway Centerline to Centerline Distance	70	105	144	105	144	105	144	207	144	207	144	207	249	207	249	207	249	298
W-0 (ft)	12.5	12.5	12.5	17.5	17.5	17.5	17.5	17.5	25	25	25	25	25	37.5	37.5	37.5	37.5	37.5
W-1 (ft)	21	19	18	24	23	28	27	26	34	33	40	39	38	50	50	54	53	53
W-2 (ft)	21	36	33	39	36	61	57	52	63	57	95	87	87	96	95	118	114	112
W-3 (ft)	32	53	38	63	47	137	95	61	110	77	241	149	131	177	157	267	207	181
L-1 (ft)	53	100	95	98	93	192	189	181	186	177	334	325	323	319	318	432	426	424
L-2 (ft)	0	47	47	46	45	83	84	85	82	83	137	138	139	136	136	175	177	177
L-3 (ft)	21	36	33	39	36	61	57	52	63	57	95	87	87	96	95	118	114	112
L-4 (ft)	28	9	62	9	62	0	0	69	0	69	0	0	0	0	0	0	0	0
R-Fillet (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-CL (ft)	21	48	41	48	41	52.5	72	69	72	103.5	124.5	103.5	124.5	103.5	124.5	103.5	124.5	149
Steering Angle (degrees)	50	50	50	50	50	77	57	50	57	50	85	61	50	61	50	76	63	52

Figure 4-23. Crossover Taxiway Without Direction Reversal Between Taxiways



Note 1: See Appendix J for dimensional values.

4.9 Holding Bays for Runway Ends.

Providing holding bays instead of bypass taxiways enhance capacity. Holding bays provide a space for queuing of aircraft awaiting departure clearance. Holding bays also permit aircraft receiving clearance to bypass other aircraft to the runway takeoff position.

4.9.1 Standards.

1. Locate holding bays to keep aircraft out of the Obstacle Free Zone (OFZ), POFZ, Runway Safety Area (RSA), and Instrument Landing Systems (ILS) critical areas.
2. Design the geometry per the applicable ADG and TDG standards.

4.9.2 Recommended Practices.

1. Provide a holding bay when runway operations meet criteria established in FAA Order 5090.5.
2. Design holding bays to allow independent aircraft movements to bypass one another to taxi to the runway based on the design ADG. See Figure 4-24.
3. Islands, either grass or properly marked pavement, between the parking positions provide visual cues to pilots that assist them with situational awareness. See Figure 4-24.

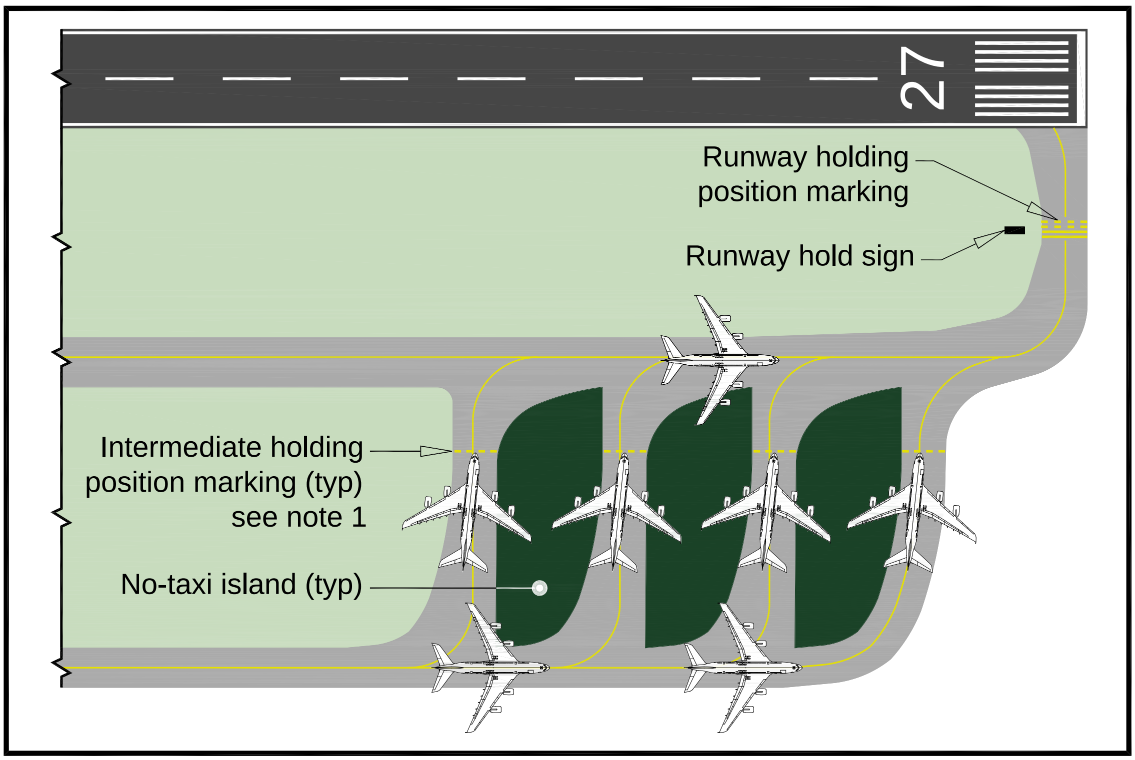
4. The alternate holding bay configuration consisting of a queuing taxiway and an access taxiway (see Figure 4-25) can provide an acceptable level of safety and efficiency provided:

   a. There is adequate TOFA separation between the marked centerlines of the connecting taxiways based on ADG of critical aircraft.

   b. Spacing of intermediate holding positions allows sufficient wingtip clearance between an aircraft turning onto a connecting taxiway and the aircraft holding ahead of the turning aircraft.

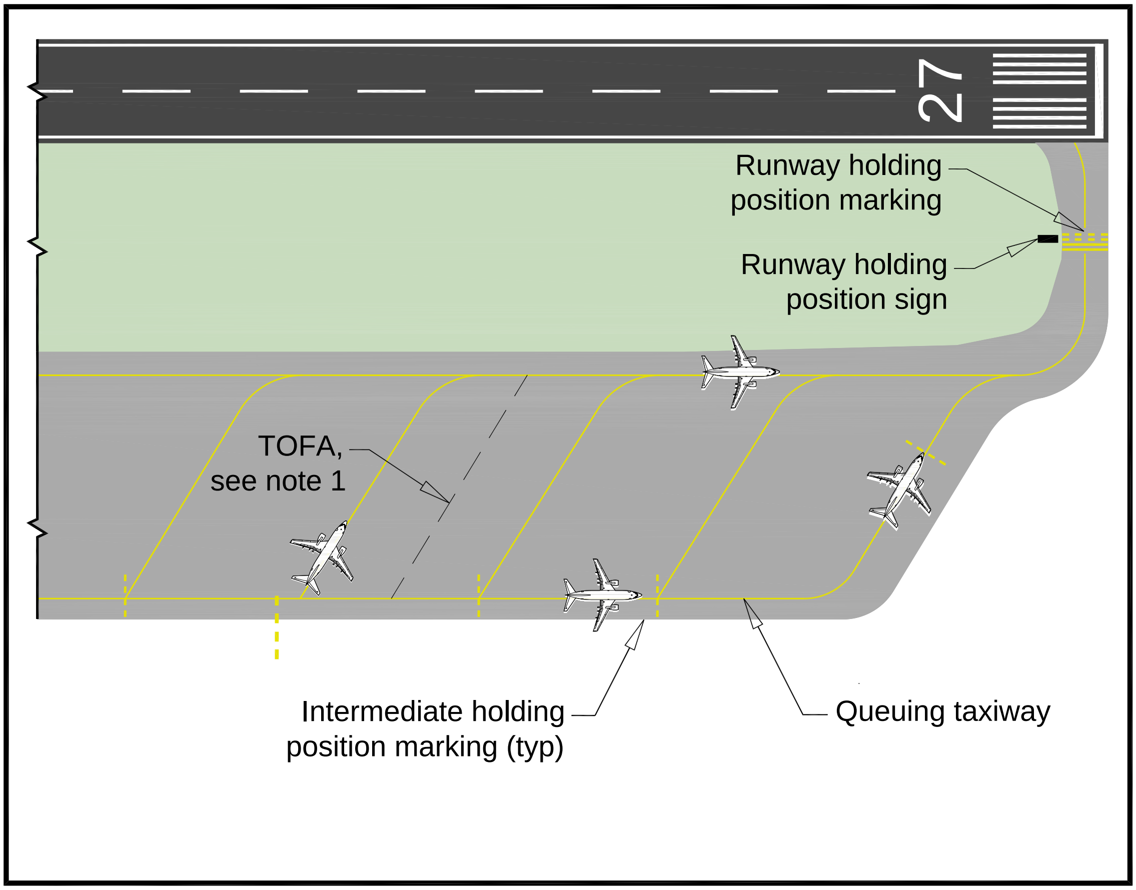
   c. The airport and ATCT develop a standard operating procedure addressing the use of the queuing taxiway in a manner that establishes an acceptable level of safety.

Figure 4-24. Holding Bay Configuration



Note 1: Locate intermediate hold lines at the outer limit of the inner taxiway object free area.

Figure 4-25. Holding Bay – Alternate Configuration



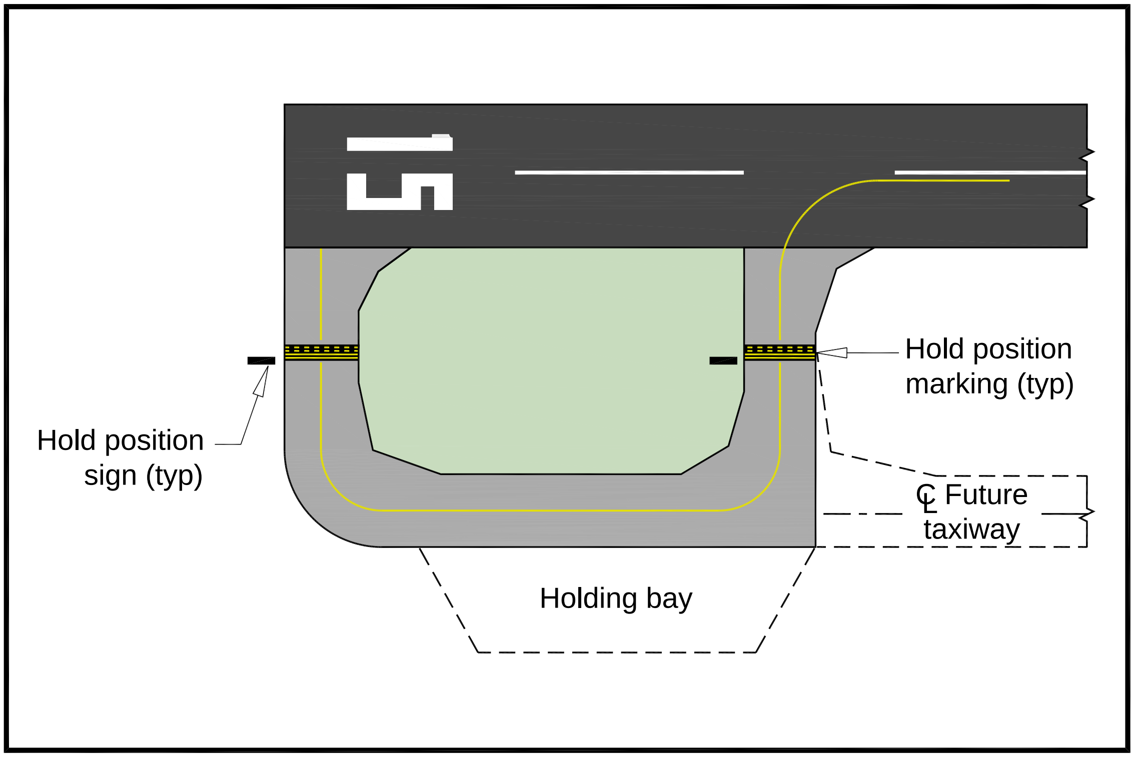
Note 1: See paragraph 4.9.2.

4.10 Taxiway Turnarounds.

4.10.1 Recommended Practices.

The provision of a full parallel taxiway may be impractical for some general aviation airports. For such airports, consider turnarounds as an interim alternative to a full or partial parallel taxiway. This may include a limited-sized holding bay to allow more than one aircraft to hold at a runway end. Design the geometry of the turnaround and any holding bay to the applicable ADG and TDG standards. See Figure 4-26.

Figure 4-26. Taxiway Turnaround



4.11 Apron Taxiways and Taxilanes.

There is often a need for through-taxi routes across an apron to provide access to gate positions or other terminal areas.

4.11.1 <u>Standards.</u>

1. Provide a clear line of sight (LOS) from the ATCT to movement area pavement.
2. Apron taxiways and taxilanes require the same separations as other taxiways and taxilanes.

4.11.2 <u>Recommended Practices.</u>

1. Provide a clear line of sight (LOS) from the ATCT for taxilanes not under ATCT control.
2. When an apron taxiway or taxilane is along the edge of the apron:
    a. Locate the centerline inward from the apron edge at a distance equal to one-half the width of the required taxiway/taxilane width.
    b. Provide shoulder, safety area, and obstacle free area standards along the outer edge.

4.12 End-Around Taxiways (EAT).

An EAT improves efficiency of runway operations and provide a safe means of aircraft movement from one side of a runway to the other side of the runway. The EAT allows aircraft to taxi around the runway end during approach and departure operations and to cross the extended runway centerline without specific clearance from ATC. The design of an EAT considers parameters unique to each airport and each runway. See Figure 4-27 and Figure 4-28 which illustrate EAT concepts per the design standards described below.

4.12.1 FAA Review.

Before initiating formal feasibility studies, submit the proposed EAT design layout to the local FAA Airports Regional or District Office for review. The FAA Office of Airport Safety and Standards, Airport Engineering Division (AAS-100) reviews the EAT proposal to assess risks associated with EAT installations. Upon receiving FAA pre-approval, the airport may proceed with feasibility studies and design efforts.

4.12.2 Standards.

1. Locate the EAT centerline a minimum of 1,500 feet (457 m) from the departure end of the runway.
2. The minimum length of that portion of the EAT crossing the extended runway centerline at the minimum distance of 1,500 feet (457 m) is equal to the width of the departure surface of the Departure End of Runway (DER), as shown in Figure 4-27 (i.e. central portion of departure surface).
3. Increase the minimum distances as necessary to prevent aircraft tails from penetrating the 40:1 departure surface and any surface identified in FAA Order 8260.3, as shown in Figure 4-28.
    a. Initiate an airspace study for each site to verify that the tail height of the critical design group aircraft operating on the EAT does not penetrate these surfaces.
    b. The airspace study will also confirm compliance with Part 121, §121.189, Airplanes: Turbine Engine Powered: Takeoff Limitations, which requires the net takeoff flight path to clear all obstacles either by a height of at least 35 feet (10.5 m) vertically, or by at least 200 feet (61 m) horizontally within the airport boundaries.
    c. In addition to the critical aircraft tail height, the elevation of the stop end of the runway relative to the elevation of points along the EAT is a factor in determining conformance with clearance criteria.
4. Locate the EAT outside of ILS critical areas.

4.12.3 Recommended Practices.

Construct the EAT below the stop end runway elevation to minimize the necessary distance between the end of the runway and points along that portion of the EAT crossing the extended runway centerline.

4.12.4 Visual Screens.

A visual screen masks, partially or completely, aircraft using the EAT from a viewpoint on the associated runway. This enables pilots operating on the runway to differentiate between an aircraft crossing the active runway or crossing on the EAT. Establish the height of the screen by masking the engine nacelles of the crossing aircraft from the pilot's view of a departing aircraft at the point on the runway the aircraft reaches V_1 speed during takeoff. Determine the need for a visual screen during the design process.

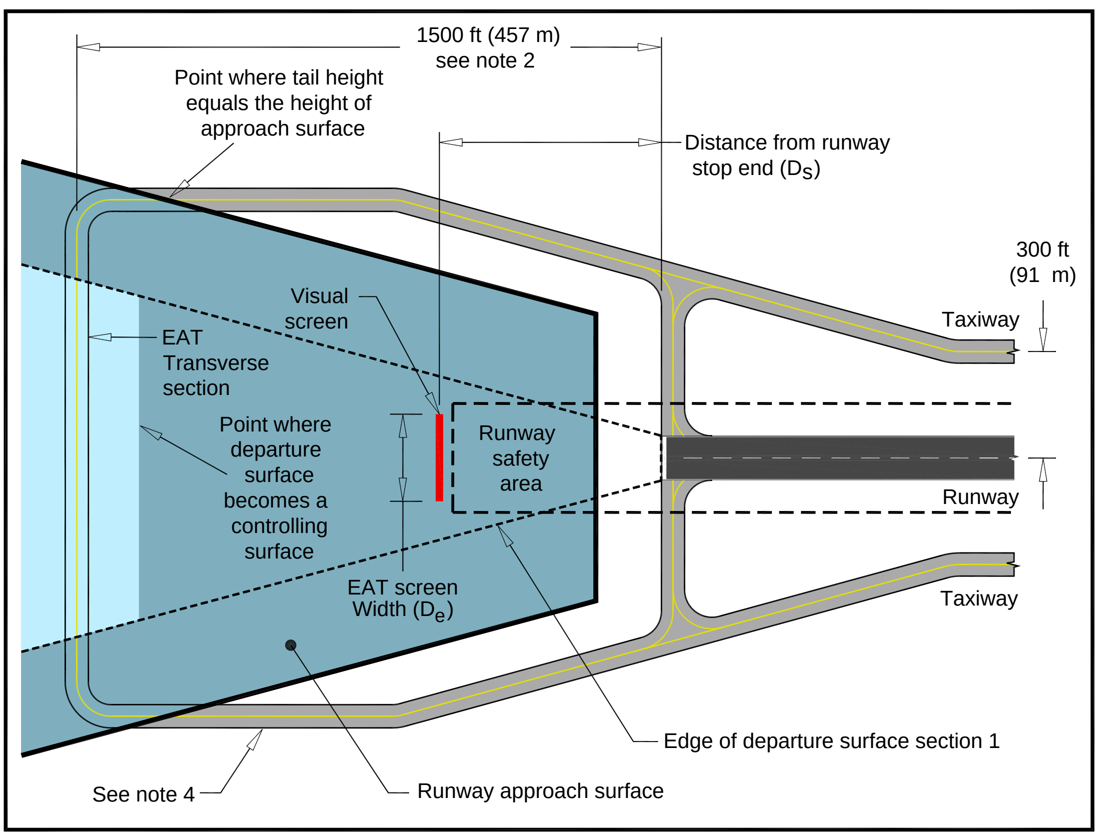
4.12.4.1 Standards.

1. Locate the visual screen structure outside all RSAs, runway OFAs, taxiway OFAs, and ILS critical areas.
2. Locate the visual screen so that it does not penetrate the inner approach OFZ, the approach light plane or other Terminal Instrument Procedures (TERPS) surfaces.

4.12.4.2 Design Considerations.

The design of the visual screen and siting of visual aids are co-dependent. Refer to Appendix D for detailed planning and design guidance on EAT screens.

Figure 4-27. End-Around Taxiway (EAT) – ADG-II



Note for Figure 4-27:

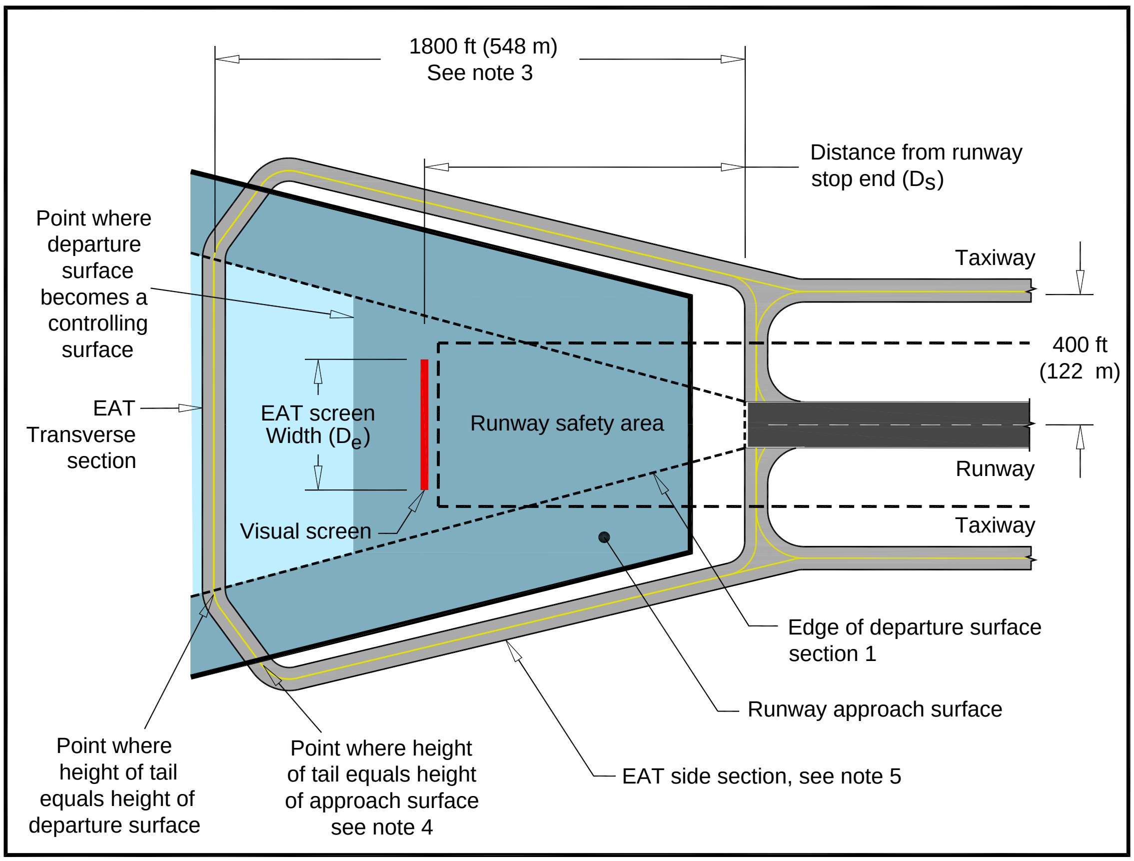
Note 1: This example assumes all centerline elevations to be equal to the elevation of the runway end centerline. Refer to Figure 3-10 for departure surface section 1.

Note 2: This distance varies dependent upon the ground elevation of the transverse EAT section relative to the applicable runway surface elevation (Departure end of runway or threshold elevation).

Note 3: The distance from the approach surface edge to that portion of the taxiway centerline parallel to the edge is a minimum of 40 ft (1/2 TSA width).

Note 4: To avoid an acute angle turn onto the transverse segment of the EAT, it is acceptable to align the taxiway relative to the outer edge of the surface such that the wings are under the controlling surface while the aircraft tail remains outside of the surface.

Figure 4-28. EAT – ADG-III



Note 1: This example illustrates the approach surface controls the location of the side taxiway segments of the EAT while the departure surface controls the location of the transverse taxiway section of the EAT.

Note 2: This example assumes all centerline elevations to be the same elevation as the runway end centerline. Refer to Figure 3-10 for departure surface section 1.

Note 3: This distance varies dependent upon the ground elevation of the transverse EAT transverse section relative to the applicable runway surface elevation (Departure end of runway or threshold elevation).

Note 4: The point where the tail height equals the approach surface height is 1730 ft from the runway threshold assuming no change in terrain elevation.

Note 5: The distance between the taxiway centerline and the outer edge of the approach surface edge is a minimum of one-half of the taxiway safety area (e.g. 59 ft).

4.13 Taxiway and Taxilane Shoulders.

Unprotected or unstabilized soils adjacent to taxiways are susceptible to erosion, which can result in engine ingestion problems for jet engines that hang near or over the edge of the taxiway pavement.

4.13.1 Standards.

1. Provide paved shoulders for taxiways, taxilanes and aprons accommodating ADG-IV and higher aircraft.
2. When installed, provide paved shoulders for the full length of the taxiway(s).
3. See Table 4-2 for taxiway shoulder width standards. Unusual local conditions may justify increases to these standard dimensions.
4. Design shoulder pavement to support the occasional passage of the most demanding airplane and the most demanding emergency or maintenance vehicle for the design life of the full-strength pavement. See AC 150/5320-6.
5. Design shoulders to provide proper surface drainage from the edge of the taxiway off the shoulder pavement.
6. Design the shoulder to be flush with the taxiway pavement.
7. Design a 1.5-inch (38 mm) drop-off with a ±½ inch (1.3 cm) tolerance at the edge of paved shoulders to enhance drainage off the shoulder and to prevent fine graded debris from accumulating on the pavement.

4.13.2 Recommended Practices.

1. Provide paved shoulders for taxiways, taxilanes and aprons accommodating ADG-III aircraft.
2. Provide turf, aggregate-turf, soil cement, lime or bituminous stabilized soil adjacent to paved surfaces accommodating ADG-I, ADG-II, and ADG-III aircraft.
3. Design shoulder base and subbase subsurface drainage to tie into adjacent taxiway subsurface drainage system.
4. Provide a sub-drainage system with manholes or handholes to permit observation, inspection and flushing of the system.
5. Provide base-mounted edge lights and conduit for power cables to facilitate maintenance.
6. When adding paved shoulders to existing taxiways, consider making improvements to the existing taxiway edge lighting to include base-mounted light fixtures and conduit-enclosed power cables.

4.13.3 Design Considerations.

A dense, well-rooted turf cover can prevent erosion and may be capable of supporting the occasional passage of aircraft, maintenance equipment, or emergency equipment under dry conditions. Refer to AC 150/5370-10, item P-217, Aggregate-turf

Runway/Taxiway. For locations where it is not feasible to establish turf suitable for this purpose, provide soil stabilization or a low-cost paved surface.

4.14 Surface Gradient for Taxiways, Taxilanes, and TSAs.

4.14.1 Longitudinal Gradient.

4.14.1.1 Standards.

1. Design the maximum longitudinal grade to not exceed 1.50 percent.
2. For taxiways/taxilanes exclusively serving aircraft weighing 30,000 lbs or less, it is acceptable to increase the maximum longitudinal grade to 2.0 percent.
3. When longitudinal grade changes are necessary, design parabolic vertical curves as follows:
    a. The maximum longitudinal grade change is 3.0 percent.
    b. The minimum length of the vertical curve is 100 feet (30 m) for each 1.0 percent of grade change.
    c. The minimum distance between points of intersection of vertical curves is equal to 100 feet (30 m) multiplied by the sum of the grade changes (in percent) associated with the two vertical curves.
    d. *Exception*: Where a taxiway crosses a runway or taxiway crown, adjust longitudinal grades as necessary to provide smooth transition over crossing the pavement section.
    e. *Exception*: A vertical curve is not necessary when the grade change is less than 0.40 percent.

4.14.1.2 Recommended Practices.

1. Use minimum longitudinal grades.
2. Design pavements to have no changes in longitudinal grades unless it is impractical to avoid a change in grade.
3. Design the taxiway crown elevation to be at or below the crown elevation of the corresponding point on the runway to avoid adversely affecting runway surfaces (e.g. ROFZ).
4. When developing the longitudinal gradient of a parallel taxiway (or any taxiways functioning as parallel taxiways) and connecting taxiways consider:
    a. Potential future connecting taxiways between the parallel taxiway and the runway, and between two taxiways.

b. Longitudinal gradient of connecting taxiways to future airfield facilities (future runways, taxiways, or aprons) that conform to gradient design standards.

4.14.2 Taxiway/Taxilane Transverse Gradient.

4.14.2.1 **Standards.**

Design transverse gradients and drainage improvements for taxiways/taxilanes, shoulders, and safety areas per the following standards. See Figure 4-29.

1. Taxiway/taxilane pavement transverse gradient:
   a. One percent to 1.5 percent from centerline to pavement edge.
   b. For Taxiways/taxilanes exclusively serving aircraft weighing less than 30,000 lbs, it is acceptable to apply a cross slope of 1 percent to 2 percent.
2. Design an edge drop-off of 1.5 inch ±½-inch (4 cm ±1.3 cm) between paved and unpaved surfaces to promote drainage off the pavement surface.
3. Design paved taxiway shoulders with a transverse gradient between 1.5% to 5%.
4. For an unpaved surface adjacent to a paved surface, design a 5% ±0.5% transverse gradient for a minimum distance of 10 feet (3 m) from the paved surface.
5. TSA transverse gradient: Design a 1.5% to 5% transverse gradient except as noted in subparagraph 4 above.
6. TOFA gradients:
   a. Side slope gradient: Design transverse gradient to promote positive drainage away from the TSA.
   b. Back slope gradient: When a back slope is necessary, design gradient not to exceed a maximum 4:1 slope provided the area immediately adjacent to the TSA edge permits positive drainage of surface water away from the TSA.

4.14.2.2 **Recommended Practices.**

1. Keep transverse gradients to a minimum as necessary to provide adequate surface drainage suitable for local conditions.
2. The ideal configuration is a center crown with equal, constant transverse grades on either side.
3. An off-center crown, with different gradients on either side, shed sections, and changes in transverse gradients (other than from one side of the crown to the other) of no more than 0.5 percent are acceptable.

4. A shed section may be more suitable:

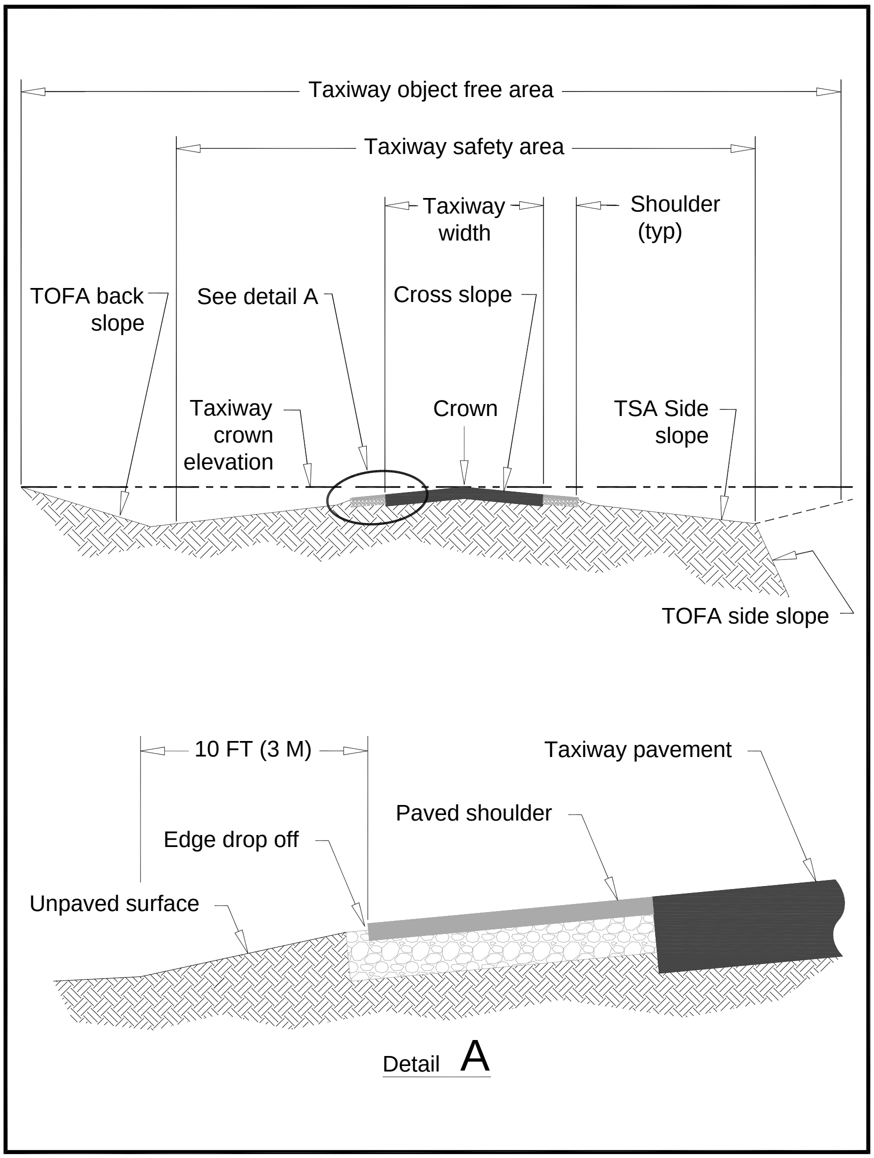
a. For high-speed exit taxiways.

b. When existing terrain makes it impractical to provide a crown and slope cross section.

4.15 Taxiway Line of Sight (LOS).

There are no specific LOS standards between intersecting taxiways. However, the sight distance along a runway from an intersecting taxiway needs to be sufficient to allow a taxiing aircraft to safely enter or cross the taxiway.

Figure 4-29. Taxiway Transverse Gradients



Note 1: See paragraph 4.14.2 for specific transverse grade and drainage requirements shown in this figure.

4.16 Taxiway/Taxilane Drainage.

1. Comply with transverse gradients of paragraph 4.14.2 to preclude standing water on the pavement and within the limits of the safety area.
2. Locate ditches and drainage structure headwalls outside of the safety area:
    a. Ensure depth of water in ditch for the design storm does not encroach upon safety area limits.
    b. Ensure five-foot vertical wingtip clearance to top of drainage structures located in the OFA when the outer edge or aircraft main gear is located at the edge of the shoulder.
3. Pavement inlets:
    a. For taxiways, locate inlets outside of taxiway pavement extents.
    b. For taxilanes, it is acceptable to locate trench drain or slotted drain inlets across taxilane pavements.
    c. Design drainage inlets flush with surrounding grade.
    d. Design inlet grates in accordance with AC 150/5320-6:
        i. Withstand loads of the most demanding aircraft.
        ii. Account for load transition from inlet to adjacent pavement.

4.17 Markings/Lighting/Signs.

Refer to AC 150/5340-1, AC 150/5340-30 and AC 150/5340-18 for standards on airfield marking, lighting, and signs.

4.18 Taxiway Bridges.

Refer to Chapter 6 for detailed design guidance on bridges.

4.19 Jet Blast.

Refer to Appendix C for information on the effects and treatment of jet blast.

CHAPTER 5. Aprons

5.1 Background.

This chapter presents design concepts, standards and guidelines related to airport aprons. An airport apron is a dedicated portion of the airfield that serves as an interface between the airside and landside environments. Aprons serve multiple functions including:

- Loading and unloading of passengers, mail and cargo
- Aircraft parking
- Aircraft fueling operations
- Aircraft Maintenance operations
- Ground service equipment (GSE) operations
- Aircraft deicing operations

5.1.1 Terminology.

While other terms exist in the public domain (i.e. ramp, etc.), this AC uses the term "apron" for the airside area addressed by this chapter.

5.1.2 Airport Needs.

Aprons are present at all commercial service and general aviation airports. The size and type of an airport are controlling factors in determining operational needs and capacity requirements that apply to apron design. The layout of an apron can have a significant effect on airport operators and tenants as it relates to efficiency, safety, capacity and operational costs.

5.1.3 Apron Elements.

Apron elements vary per size and type of airport. Common apron elements include:

- Stabilized surface
- Taxilanes
- Parking positions
- Tie-downs
- Passenger loading and off-loading areas
- GSE areas
- Vehicle service roads
- Utility areas (fueling, lighting, power, etc.)
- Pavement Marking
- Storm water drainage system

5.1.4 Related FAA Guidance.

1. Appendix E, *General Aviation Facilities*
2. AC 150/5340-1, *Standards for Airport Markings*
3. AC 150/5360-13, *Airport Terminal Planning*
4. AC 150/5390-2, *Heliport Design*

5.2 Apron Types.

The utility of an apron generally defines its type. Refer to Figure 5-1 for a depiction of the various types of aprons. The following describes common apron types:

5.2.1 Passenger Terminal Aprons.

A paved area between the face of the terminal building and the movement area boundary where aircraft taxi to a parking position for passenger boarding and deplaning and for aircraft servicing. Primarily associated with Part 139 certificated airports. Refer to paragraph 5.20 for additional information.

5.2.2 General Aviation (GA) Aprons.

A general aviation apron serves a broad range of civil aircraft activity exclusive of commercial service and military operations. The utility of a GA apron generally aligns with the aviation activities at the airport, which can vary widely between airports. Refer to Appendix E for additional information.

5.2.3 Remote Apron.

Remote aprons are located separately from other aprons and serve to stage or store aircraft on a temporary basis (e.g. Remain Overnight parking (RON)). Remote aprons may exist at all airport types. Refer to paragraph 5.20.2 for additional information.

5.2.4 Hangar Apron.

Hangar aprons are paved areas adjacent to an associated aircraft hangar. Hangar aprons are for the exclusive use of the hangar occupants and thus not generally available for open public use. Refer to Appendix E for additional information.

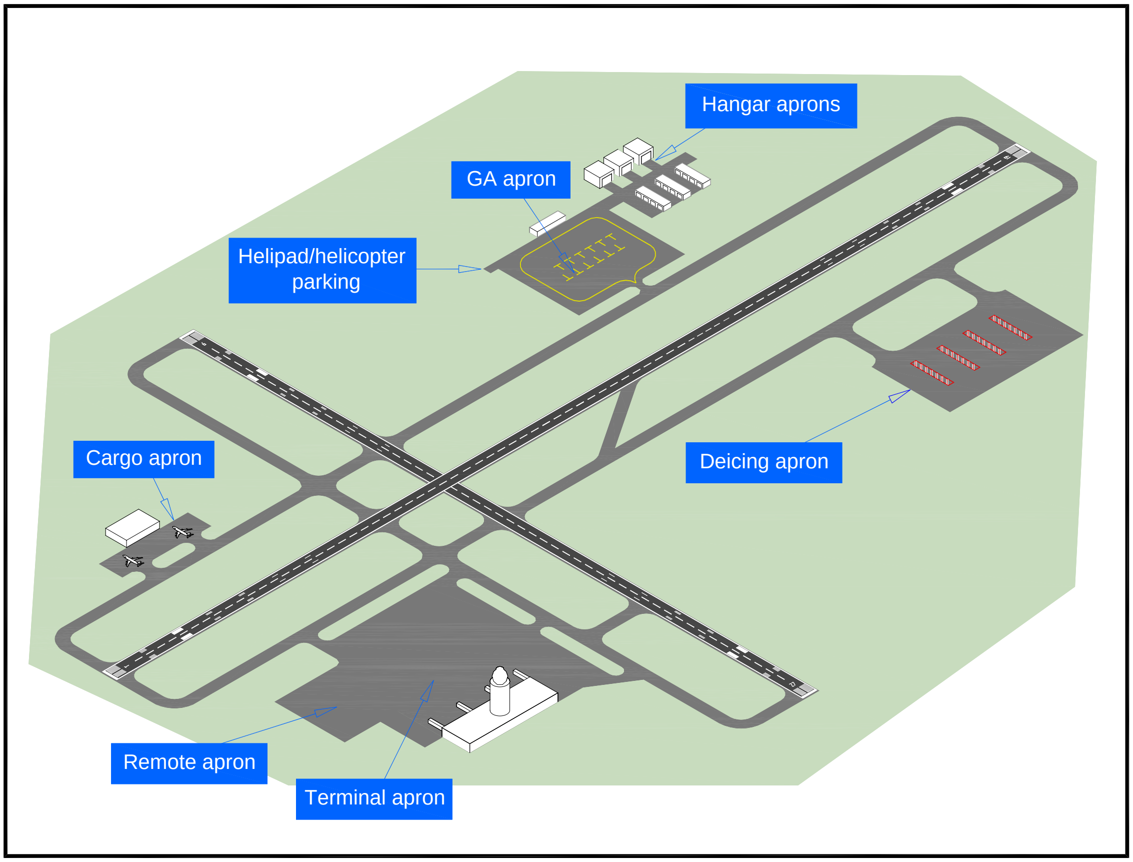
5.2.5 Deicing Aprons (Pads).

Deicing aprons are a unique form of remote apron dedicated for aircraft deicing operations, typically located apart from the terminal apron. However, in some instances, deicing aprons may be a designated portion of the terminal apron. Refer to paragraph 5.20.3 for additional information.

5.2.6 Helicopter (Rotary Wing) Parking Position.

Parking positions for rotary aircraft are typically located separate from parking positions for fixed-wing aircraft. Helipads, where rotary aircraft land and take off, may also serve as a parking position. Refer to AC 150/5390-2 for guidance on helicopter parking positions.

Figure 5-1. Types of Aprons



Note: Image is conceptual for illustrative purposes only. The actual location of the various aprons types is dependent upon factors specific to each airport.

5.3 Apron Design Objectives.

Effective apron design promotes acceptable levels of access, capacity, apron utilization, efficient flow management, safety of aircraft movements and future development potential. A deficient design can increase the risk of wingtip conflicts, loss of situational awareness, and constrained capacity.

5.3.1 Apron Access Factors.

1. Optimize taxi distances to and from runway ends.
2. Provide ease of aircraft maneuvering and GSE movements.
3. Design for aircraft access under self-power.

5.3.2 Utilization Factors.

1. Provide apron layout based on mix of aircraft types and sizes expected to use the facility.
2. Optimize apron layout by grouping aircraft parking areas and taxilanes based on wingspan classifications (i.e. larger vs small aircraft) and clearance requirements.

3. Separate jet aircraft from smaller aircraft to minimize risk of harmful jet blast effects.
4. Optimize GSE areas to promote efficient aircraft maneuvering.

5.3.3 Efficient Flow Management Factors.

1. Optimize location of taxiways and apron taxilanes to provide efficient taxi routes from parking areas to the airfield taxiways.
2. Provide secondary taxilane paths to maintain flow of taxiing aircraft.

5.3.4 Safety Factors.

1. Provide safe maneuvering of aircraft on the apron to avoid wingtip conflicts with fixed or moveable objects.
2. Provide apron layouts that limit risk for loss of situational awareness during taxi operations.
3. Design apron/taxiway configurations to provide taxi paths that reduce the risk of runway incursions.

5.3.5 Future Development.

As part of planning and design efforts, consider airport expansion, future aircraft use trends, and future separation clearance values when establishing apron locations and airside buildings (terminal, hangar, FBO, etc.) in relation to runway and taxiways. Key design considerations include:

1. Providing future expansion capability with minimal development constraints.
2. Avoiding configurations that may necessitate costly reconstruction or alteration of existing airfield infrastructure (e.g. aprons, taxiways, hangars and terminal buildings).
3. Minimizing configurations that may require future operational controls due to operation of larger aircraft at the airport.

5.4 Apron Location.

The location of apron elements can result in an adverse effect to operations on adjacent runways and taxiways. Application of standards and recommended guidelines when locating apron elements optimizes the utility of the apron as well as the operational efficiency of adjacent runways and taxiways.

5.4.1 Standards.

5.4.1.1 Apron Taxilanes.

Locate apron taxilanes in conformance with separation standards of the online Runway Design Standards Matrix Tool and Table 4-1.

5.4.1.2 **Parking Positions.**

Locate aircraft parking positions in a manner that ensures aircraft components (wings, tail and fuselage) do not:

1. Conflict with object free area for adjacent runways or taxiways:
   a. Runway Object Free Area (ROFA) (paragraph 3.11)
   b. Taxiway Object Free Area (TOFA) (paragraph 4.5)
   c. Taxilane Object Free Area (TLOFA) (paragraph 4.5)
2. Violate any of the following aeronautical surfaces and areas:
   a. Runway approach or departure surface (paragraph I.4)
   b. Runway Visibility Zone (Figure 3-13)
   c. Runway Obstacle Free Zone (paragraph 3.10)
   d. Navigational Aid Equipment critical areas (paragraph 6.11

5.4.2 Recommended Practices.

5.4.2.1 **Obstacle Evaluation.**

Locate parking aircraft parking positions in a manner that does not violate an imaginary surface as defined in 14 CFR Part 77.

1. Parking positions that result in aircraft penetrating a Part 77 imaginary surface require an aeronautical study to determine if the height of the parked aircraft represents a hazard to air navigation.
2. Consult with the FAA Airports Regional Office or Airports District Office (ADO) for guidance.

5.5 Runway Access from Aprons.

The design of aircraft taxi paths from apron areas to runways can affect airport capacity as well as safety of aircraft operations. Properly located taxi paths can enhance both airport efficiency and safety. Conversely, wide expanses of pavement at taxiway entrances and taxi paths that provide direct access to a runway can lead to loss of situational awareness for pilots and vehicle operators, which increases the risk of a runway incursion. Refer to Chapter 4 and Appendix J for information on problematic taxiway designs.

5.5.1 Standards.

5.5.1.1 Provide taxi paths that require a pilot or vehicle operator to make a right angle turn onto a taxiway when departing an apron area (Figure 5-3). This action optimizes the range of vision for pilots and vehicle operators.

5.5.1.2 Stagger the alignment of an apron exit taxilane with that of a connector taxiway that crosses a parallel taxiway for access to a runway. Refer to

Figure 4-2. Design the distance between connecting taxiways to make the length of the aircraft align with the centerline of the parallel taxiway before making another turning movement.

5.5.2 Recommended Practices.

5.5.2.1 Place high activity aprons in a central location to minimize aircraft taxiing distances and runway crossings.

5.5.2.2 Avoid wide throat taxiway entrance/exit pavements from aprons that:

1. Exceed standard widths for taxiways and associated fillets.
2. Violate the three-path concept.
3. Create non-standard locations for signage, lighting and marking.
4. Create surface drainage issues (e.g. ponding of storm water).

5.5.2.3 Mark and light wide apron pavement areas contiguous to a parallel taxiway to mitigate situational awareness risk. Paved islands, also known as NO-TAXI islands, channel aircraft departing the apron area using standard centerline markings and elevated signs.

5.5.3 Implementation.

5.5.3.1 **New Construction and Re-Construction Projects.**

Meet standards of paragraph 5.5.1.

5.5.3.2 **Rehabilitation Project.**

1. Assess opportunities to make full or incremental improvements that mitigate existing non-standard conditions.
2. If impractical or cost prohibitive under a rehabilitation project, develop a plan to correct non-standard conditions as future development project needs.

5.5.3.3 **Existing Aprons That Do Not Meet Standards.**

1. Implement operational measures that reduce runway incursion risks.
2. Close the portion of the apron that violation violates standards if operational controls are not adequate.

5.6 Lateral Object Clearance on Aprons.

Provide standard wingtip and fuselage clearances for the movement and parking of aircraft under self-power.

5.6.1 Standards.

5.6.1.1 **Apron Taxilanes.**

Refer to Table 4-1 for standard dimensions for TLOFA and wingtip clearance to fixed or moveable objects. Refer to paragraph 4.5 for explanation of wingtip clearance criteria.

5.6.1.2 **Parking Position.**

Provide sufficient clearance to establish:

1. Low risk of conflict between aircraft (wingtips and fuselage) and adjacent objects (other aircraft and structures) during entry and exit operations.
2. Space for personnel and vehicles (GSE, ARFF) to operate safely around perimeter of parked aircraft.

5.6.2 Recommended Practices.

5.6.2.1 **Vehicle Limit Line.**

Consider placement of a vehicle limit line marking to ensure adequate clearance of vehicles and equipment from the adjacent taxilane object free area. For locations where the aircraft is under ATC ground control at push back, a non-movement area boundary marking may serve as the vehicle limit line. For locations where the non-movement area boundary marking is remote from the gate area, consider placement of a vehicle limit line marking per the guidelines of Airports Council International (ACI) publication *Apron Markings and Signs* to define visually the near edge of an apron taxilane object free area.

5.6.2.2 **Parking Position.**

Refer to Table 5-1 for recommended minimum clearance dimensions between an aircraft and a fixed object or adjacent parked aircraft. These clearances allow for safe maneuvering of aircraft into and out of a parking position as well as sufficient space for personnel and equipment operation.

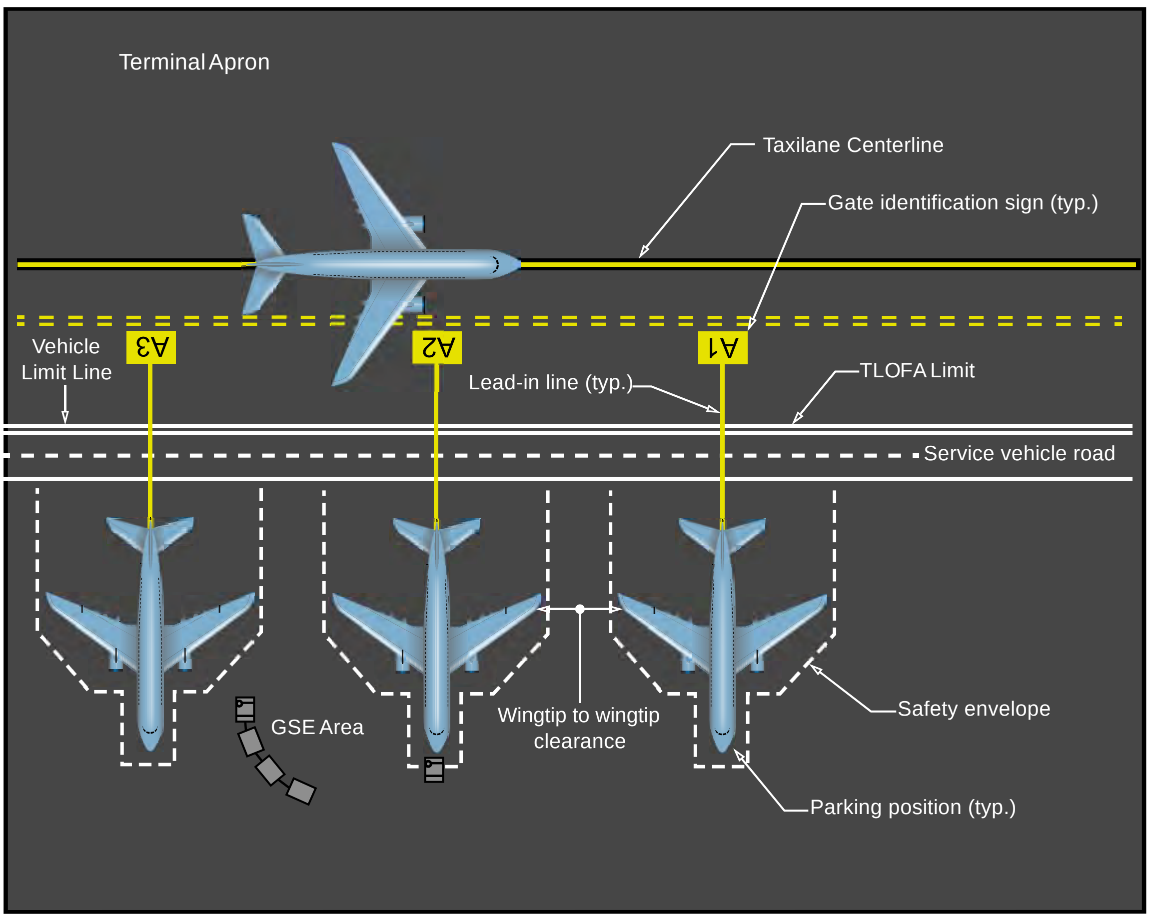
1. Additional factors may influence increasing the clearance values such as an operator's GSE work area envelop, equipment storage and the slope of the passenger boarding bridge ramp for Americans with Disabilities Act (ADA) conformance.
2. An acceptable level of safety may be achievable with reduced clearance values if controls are in place that minimize risk of conflict between aircraft and objects (e.g. gate operations rules, GSE management plan, training, etc.).
3. For parking positions parallel to terminal building structures, consider a minimum clearance of 45 feet to accommodate equipment operations between the wingtip and the building.

4. Refer to Figure 5-2 for illustration of parking position clearance for passenger terminals.
5. Refer to Figure E-9 for illustration of parking position for GA aircraft.

Table 5-1. Parking Position Clearance.

Airplane Design Group	Recommended Minimum Clearances
I and II	10 ft (3 m)
III, IV, V and VI	25 ft (7.5 m)

Figure 5-2. Parking Position Clearance



5.7 Apron Taxilanes.

The lower speed on apron taxilanes allows for precise taxiing operations.

5.7.1 Standards.

5.7.1.1 Width.

Refer to Table 4-2 for taxilane width standards based on TDG.

5.7.1.2 Object Free Area.

Refer to Table 4-1 for taxilane object free area values based on ADG.

5.7.1.3 Surface Gradient.

Refer to paragraph 5.9 for standards addressing gradients and grade change for apron taxilanes.

5.8 Fueling on Aprons.

The transport, storage and distribution of aviation fuel on an apron presents fire hazard risks to passengers, employees and property. Proper handling of aviation fuel in the apron area minimizes this risk. Generally, aircraft fueling operations occur on an apron by one of four methods:

1. Delivery by fuel truck to the aircraft.
2. Delivery by fuel cart and hydrant located at the gate.
3. Centralized fueling at a fuel island located away from terminal buildings.
4. Self-fueling by the aircraft operator.

5.8.1 Standards.

1. AC 150/5230-4, *Aircraft Fuel Storage, Handling, Training, and Dispensing on Airports*
2. National Fire Protection Association (NFPA) 407, *Standard for Aircraft Fuel Servicing*.

5.8.2 Design Considerations.

5.8.2.1 Minimize the potential for costly future relocation by considering future airside development in addition to current operational needs when locating fuel systems and components including:

- Fuel farms
- Underground fuel distribution loops
- Supporting facilities

5.8.2.2 Construct areas where fueling operations occur with materials that resist deterioration caused by fuel spillage.

5.9 Apron Surface Gradients.

The standards for surface gradient facilitate aircraft towing and taxiing while promoting positive drainage of surface water. Flat slopes facilitate aircraft maneuvering at parking positions and tiedown locations. Refer to paragraph 5.10 for drainage design considerations.

5.9.1 Standards.

5.9.1.1 Provide a minimum 0.5% apron gradient to facilitate aircraft maneuvering operations and apron drainage.

5.9.1.2 Comply with NFPA 415, Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways pavement slope standards where fueling operations occur.

5.9.1.3 Limit maximum grade change to 2 percent.

5.9.1.4 Design and construct apron grades for positive drainage of surface water to inlets or off the apron pavement edge. For pavement drop-off information, refer to Figure 3-30 and Figure 4-29.

5.9.1.5 Provide between a minimum 1.5-inch (38 mm) to maximum 3-inch (76 mm) drop-off at the pavement edge.

5.9.2 Recommended Practices.

5.9.2.1 Limit apron gradients as follows:

1. Maximum: 1% for parking positions.
2. Maximum: 1.5% for apron taxilanes servicing aircraft over 30,000 lbs. (13,608 kg).
3. Maximum: 2.0% for aprons taxilanes servicing aircraft 30,000 lbs. (13,608 kg) or less.

5.9.2.2 For apron locations where it is impractical to meet recommended maximum gradient values due to grade or space constraints, solicit comments from airport users and assess whether exceeding the recommended values may have an adverse effect on:

1. Aircraft maneuvering,
2. Aircraft braking, or
3. Control of aircraft during periods when surface contaminants are present (e.g. water, snow, ice, etc.).

5.9.2.3 Provide a 10-foot (3 m) wide shoulder at the edge of the apron with a 1% - 3% slope to promote flow of surface water away from the apron pavement. Consider paved shoulders if there is an erosion risk in this area. Beyond the shoulder edge, provide a 3-5% slope to facilitate flow of surface water away from the apron area.

5.9.3 Design Considerations.

1. Consider propeller clearance when transitioning between grade changes.
2. In lieu of a vertical curve for grade changes on apron taxilanes, consider an intermediate transitional grade section (e.g. 20 to 25 feet) to minimize abrupt longitudinal grade changes greater than 1 percent.

5.10 Apron Drainage.

Shallow grades and a wide expanse of impervious pavement in the apron area creates potential for significant volume of surface runoff. While hydroplaning is generally not a concern on aprons due to low taxi speeds, it is desirable to convey surface water to subsurface drainage system to prevent freestanding water on the apron.

5.10.1 Standards.

5.10.1.1 Design apron drainage systems for the design storm event in accordance with AC 150/5320-5, *Airport Drainage Design*.

5.10.1.2 Direct drainage away from buildings (e.g. terminal, hangar, FBO, etc.).

5.10.1.3 Where aircraft fueling operations occur, slope pavement away from buildings and structures a minimum of 1.0 percent for 50 feet and a minimum of 0.5 percent beyond 50 feet in conformance with the standards of NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways*.

5.10.1.4 Limit length of apron linear trench drains or slot drains to 125 feet with minimum of 6-foot interval between trench lines to act as a fire stop in accordance with NFPA 415.

5.10.1.5 Design apron grades to prevent accumulation of surface water (i.e. ponding) exceeding 1/4″ (6 mm) in depth as measured by 12-ft (3.7 m) straightedge.

5.10.1.6 Comply with federal and local statutory and regulatory requirements for water quality with appropriate design consideration for control and collection of sediment, fuel/oil, and deicing fluids.

5.10.2 Recommended Practices.

5.10.2.1 Construct linear drains (e.g. slotted drains) for collection of sheet flow; construct grated inlet catch basins for collection of channelized flow.

5.10.2.2 Locate surface inlets apart from aircraft wheel paths to:

1. Avoid direct aircraft loading on drainage structures.
2. Limit premature pavement deterioration surrounding inlets.

5.10.2.3 Separate the apron drainage system in deicing areas from other airfield drainage system to minimize the surface runoff volume collected for treatment.

5.10.2.4 Construct taxilanes with transverse grades that create positive flow of surface water off the taxilane pavement:

1. The continued presence of water on pavements can increase the risk of premature pavement deterioration.
2. Avoid use of taxilane as "V" bottom drainage conveyance.

5.11 Apron Snow Removal.

Snow removal from apron areas differs from that of snow removal from runways and taxiways. Snow removal equipment (SRE) for apron areas generally operate at slower speeds and require greater equipment maneuverability. Depending on the type and size of airport, removal responsibilities vary between airport operators, third party contractors, FBOs and tenants. Snow removal from apron areas presents challenges such as:

1. Working in constrained areas,
2. Limited equipment access and exit routes,
3. Limited options for disposal of snow,
4. Presence of GSE, and
5. Interaction with taxiing and parked aircraft.

5.11.1 Standards.

1. AC 150/5200-30, *Airport Field Condition Assessments and Winter Operations*, establishes standards for airfield priority areas and clearance times for a baseline snow event.
2. AC 150/5220-20, *Airport Snow and Ice Control Equipment*, establishes standards for airport snow and ice control equipment.

5.11.2 Design Considerations.

5.11.2.1 For airports that regularly experience accumulating snowfall events, give apron design consideration to how the airport will manage effectively, accumulated snowfall in the apron area.

5.11.2.2 Factors to consider:

1. Clearance priority of apron areas per the snow and ice control plan (see paragraph 5.11.1).

2. Efficient access and exit routes for haul trucks and SRE that limit interaction with aircraft.
3. Partial closure of apron areas to facilitate snow removal operations while maintaining minimum level of apron operations.
4. Use of designated areas (i.e. low priority areas) to serve as temporary snow pile storage in support of haul operations during low activity hours.

5.11.2.3 Airports that experience annual snowfall normals of 30-inches or greater will typically have a higher frequency of snow events exceeding 1-inch depths.[3] Frequent snow events at a commercial service airport can adversely affect the capacity of the airport as well as the efficiency of the National Airspace System (NAS). For airports certificated under Part 139 having annual snowfall normals greater than 30 inches:

1. Consider increasing the size of the terminal apron pavement to facilitate snow removal operations.
2. Design additional apron pavement to have utility for aircraft operations during non-winter months (e.g. RON apron, secondary taxilane, non-contact gate, etc.)
3. Design additional pavement to serve as temporary storage of snow piles during a snow event (e.g. priority 2 area) during winter months.
4. For purpose of this section, temporary means no greater than 48-hours from the end of a snow event.

5.12 Apron Markings.

Apron pavement markings provide a pilot visual guidance when maneuvering aircraft to and from a parking position or gate. Pavement markings also establish boundaries for vehicle operations, GSE areas and ground crew operations. In addition to FAA standards, industry groups and airlines publish best practices for apron markings not addressed by FAA standards.

5.12.1 Standards.

AC 150/5340-1 establishes FAA standards for the following apron pavement marking elements:

- Taxiway/taxilane centerline and edge marking
- Non-movement area boundary marking
- Intermediate holding position marking
- Vehicle roadway marking

[3] Annual snowfall normal based on current National Oceanic and Atmospheric Administration (NOAA) three-decade Climate Normals.

- Surface painted apron entrance points
- Ramp control marking
- Surface painted gate identification signs
- VOR receiver checkpoint marking

5.12.2 Industry Best Practices.

Industry practices and guidelines are available for select apron markings including aircraft safety envelopes, passenger walk paths, equipment parking, passenger-board-bridge area, and engine hazard zones. Individual airlines may establish company standards for gate area markings at gates the airline contractually controls. To ensure consistent and clear markings, coordinate installation of such markings with affected parties (i.e. airport, airline operators, service providers, tenants, etc.).

- Airports Council International – Apron Markings and Signs
- Airlines for America – Recommended Apron Markings and Identifications

5.13 Apron Signage and Edge Lighting.

Elevated signage and edge lighting provide a pilot visual guidance during taxi operations. Due to the operational nature of aprons, application of elevated signage and edge lighting is generally suitable only at the outer limits of apron pavement. Typical apron signage includes outbound and inbound destination signs and no-entry signs. Apron surface lighting is typically suitable for taxiway/taxilane edge lights located at the outer limits of the apron pavement or around no-taxi islands. Complex commercial and cargo aprons may necessitate in-pavement centerline lights or reflectors to provide a visible taxi route to a parking stand.

5.13.1 Standards.

1. AC 150/5340-18, *Standards for Airport Sign Systems*
2. AC 150/5340-30, *Design and Installation Details for Airport Visual Aids*

5.14 Area Lighting on Aprons.

Area lighting allows apron operations to take place in a safe and efficient manner during nighttime hours and low visibility conditions. Area lighting also enhances security of the AOA by illuminating vulnerable locations of the Security Identification Display Area (SIDA). Occupational Safety and Health Administration (OSHA) standard 29 CFR 1926.56 addresses illumination minimums (expressed in foot-candles) for select work-place activities.

5.14.1 Associated Risks.

While area lighting has beneficial use in the apron area, such lighting can introduce certain risk hazards to aircraft operations and control tower operations. This can involve obtrusive glare, misleading visual cues to pilots, impaired line-of-sight and obstructions to aeronautical activities.

5.14.2 Design Considerations.

When planning and designing apron area lighting, consider the following factors:

1. Avoid lighting configurations that create misleading visual cues that confuse a pilot's recognition of runway lighting systems.
2. Avoid light orientations that obscure or impair a pilot's or air traffic controller's view of movement area pavement (i.e. runways and taxiways).

5.14.3 Standards.

1. Submit required notification under 14 CFR Part 77 for proposed installation of apron lighting to allow FAA evaluation of potential adverse effect to air navigation and safe operation of the airfield.
2. Limit height of lighting structures to preclude violation of a runway approach surface, departure surface or obstacle free zone.
3. Locate apron light poles outside of taxiway/taxilane object free areas and clear of aircraft parking stands.

5.14.4 Recommended Practices.

1. Aim apron luminaires downward towards apron pavement to limit risk of spill light causing confusion for pilots and controllers.
2. Baffle or shield apron luminaires to prevent up light.
3. Establish uniform illumination across lighted areas with overlapping light sources to minimize ground shadowing.
4. Coordinate installation of area lighting with appropriate stakeholders (e.g. airport operations, airline operators, ground service providers, tenants, ATCT, etc.).
5. Refer to Illuminating Engineering Society of North America (IES), RP-37-15, Recommended Practice for Airport Service Area Lighting, for industry practices, recommended illuminance values and general guidance on designing apron area lighting.

5.15 Apron Security.

Airport security involves maintaining the integrity of the air operations area from entry by unauthorized individuals. Risk to security will vary per airport type and level of activity. Primary hub airports generally have a much higher security risk than a small commercial service airport. The measures, procedures and systems to counter risks to airfield security can also vary at different locations at the same airport. Refer to paragraph 6.8 for additional information on airport security. Refer to Appendix E for guidelines addressing fencing at GA airports, which primarily serve as a safety measure for inadvertent entry to the AOA.

5.16 Apron Pavement Design.

Design apron pavements to provide adequate support for the most demanding loads imposed by aircraft, GSE, SRE, ARFF vehicles, fuel trucks and other applicable aircraft servicing equipment. Isolated pavement areas of an apron may require load consideration that do not apply to the entire apron area (e.g. mobile passenger boarding bridges, people movers, etc.).

5.16.1 Standards.

1. Refer to AC 150/5320-6 for standards addressing pavement structural design.
2. Refer to AC 150/5370-10 for standards addressing construction of apron pavements.

5.16.2 Design Considerations.

It is not necessary or economical to construct all apron pavements at an airport to the same pavement strength. Design apron pavement for individual apron sections for the most demanding loads specific for the intended apron use (e.g. commercial airlines, cargo operations, GA operations). This approach necessitates clear delineation of the different apron areas through signage or physical separation of pavement areas. Other apron design considerations include:

1. Structural design life of pavement (typically 20 years)
2. Surface resistance to fuel spills
3. Effect and control of aircraft deicing materials
4. Resistance to rutting from wheel loads and static loads (e.g. aircraft, passenger boarding bridges, etc.)
5. Resistance to applicable environmental and climate factors

5.17 Jet Blast and Propeller Wash on Aprons.

5.17.1 Aircraft that maneuver on the apron under self-power introduce risk of property damage and personnel injury from wind velocities due to jet exhaust and propeller wash. Wind forces from jet blasts are capable of displacing equipment, vehicles and persons. Wind forces from propeller wash can create airborne projectiles endangering ground crew, passengers, structures and nearby aircraft.

5.17.1.1 Recommend Practices.

Refer to Appendix C for information on the effects and treatment of jet blast. When applicable, incorporate the following design considerations and guidelines.

1. Configure parking positions such that the direction of wind forces from jet exhaust and propeller wash point outward and away from personnel, equipment, aircraft and structures.
2. Construct blast barrier to protect GSE during aircraft power out maneuvers.

3. Construct pushback area (Figure 5-2) that provides sufficient space to push aircraft back to a point where aircraft maneuvering can be by self-power.
4. Implement operational controls that limit when pilots may use breakaway power.
5. Construct an engine run-up area with associated blast protection apart from parking positions and gate areas.
6. Avoid terminal gate and hardstand aircraft parking layouts that have "tail-to-tail" parking between turbo-jet aircraft and (1) small aircraft and/or (2) narrow-body and wide-body aircraft.
7. Provide tie-down anchors on apron areas serving small aircraft when adjacent taxiways/taxilanes serve turbojet aircraft.

5.17.2 Aircraft Parking Layout Methodology.

Identify aircraft jet blast contours (velocity and distance). Assess whether aircraft turning maneuvers create jet blast hazards.

5.17.2.1 **Wind Speed Design Factors.**

Consider the following wind exposure rates from the National Weather Service (NWS) Beaufort Wind Scale as part of planning and design of parking position layout. Apply these values to determine potential effect jet blast and propeller wash may have on adjacent areas of the apron.

5.17.2.2 **Terminal Tail-to-Tail Parking.**

1. Apply 35 mph (56 km/hr) maximum to assess harmful risk to adjacent aircraft, personnel and objects.
    a. Assumes trained ramp personnel are aware that occasion wind peaks may affect their ability to walk.
    b. Does not preclude locating service roads behind aircraft for tug/tractor service
    c. Avoid parking general aviation and commuter aircraft adjacent to turbojet aircraft.

5.17.2.3 **Terminal Parking at Parallel or Skewed Terminals Facing Each Other.**

1. Apply 50 mph (80km/hr) maximum breakaway condition to determine the "reach" of initial jet blast from aircraft entering or existing a gate position to the facing terminal concourse and service road.
2. Apply 35 mph (56 km/hr) maximum under breakaway conditions to locate facing terminal gate parking and service roads assuming:
    a. Trained ramp personnel are aware that occasion wind peaks may affect their ability to walk.

b. There is no general aviation parking in the vicinity

c. Parked commuter aircraft do not board or deplane passengers directly to or from the apron.

5.17.2.4 General Aviation/Commuter Aircraft Parked Next to Turbojet.

1. Apply 24 mph (38 km/hr) maximum under idle and breakaway conditions:

   a. The lower exposure rate takes into account conditions experienced by passengers during bad weather when having to deal with umbrellas and slippery ramp/stairs.

   b. Consider both idle and breakaway conditions to assess the variety of possible gate layouts, ramp taxiing and tug policies and procedures.

5.17.2.5 Hardstands.

Focus on mitigating the effects of "power plus turn" when assessing the hazard to taxiing operation

1. Apply 24 mph (38 km/hr) maximum under idle conditions to locate an adjacent hardstand when passengers are boarding/deplaning directly to and from the apron.

2. Apply 35 mph (56 km/hr) maximum under idle conditions when aircraft are arriving/departing from the hardstands only if the air carriers written ramp management plan prescribes boarding and escort of all passengers in the adjacent hardstand locations occurs away from the active hardstand by trained ramp personnel.

3. Apply 39 mph (62 km/hr) maximum under breakaway conditions for the location of service roads aft of parked turbojet aircraft.

   This value addresses drivers' control of vehicles/trucks when subjected to slightly higher winds and assumes no tug/tractor service operations at the hardstands.

4. Apply 35 mph (56 km/hr) maximum on service roads next to a hardstand location.

5.18 Airport Traffic Control Tower (ATCT) Visibility / Line Of Sight (LOS) on Aprons.

ATCT personnel require an unobstructed view from the ATCT cab to control aircraft movement. Parked aircraft, buildings and equipment may obstruct the controller's line-of-sight increasing the risk to safe movement of aircraft. For airports certificated under Part 139, this means a clear view of the movement area, including the non-movement area boundary marking. For non-139 airports, this generally means a clear view of the runway, taxiways and apron area. FAA Order 6480.4 provides addition information on the ATCT visibility requirements.

5.18.1 Standard.

Configure apron layout to preclude parked aircraft, equipment and structures from obstructing the controller's line of sight from the ATCT cab to all points of the airport movement area.

5.18.2 Recommended Practice.

When designing new airfield development, evaluate the controller's line of sight from the ATCT cab to points on the airport non-movement area.

5.19 Apron Vehicle Service Road.

Apron vehicle service roads are designated roadways in the AOA that concentrate vehicle operations for safe maneuvering and interaction with taxiing and parked aircraft. Apron vehicle service roads are primarily for the exclusive use of vehicles and equipment that service aircraft and by airport operations personnel. Apron service roads often tie into airfield service roads, which control vehicle movements to other portions of the AOA.

5.19.1 Design Characteristics.

5.19.1.1 Lane Characteristics.

The level and type of ground vehicle traffic on an apron service road are key factors in determining the number and width of lanes. Typically, apron service roads on commercial service airports are two-way marked roadways between 20 to 25 feet (6.1 to 7.5 meters) in width.

5.19.1.2 Location.

Generally located in non-movement area in the following areas:

1. In front of an aircraft nose (i.e. head of stand)
2. Immediately behind the aircraft tail (back of stand)
3. Apart from aircraft parking positions

5.19.2 Pavement Strength.

1. For commercial and cargo aprons, aircraft loads control the pavement design strength.
2. For GA aprons serving small aircraft, consider airport vehicle loading (e.g. fuel trucks) in addition to aircraft loads.

5.19.3 Standards.

1. Clearance from vehicles to:
    a. Taxiway/Taxilane – Except were necessary to intersect a taxiway or apron taxilane, provide applicable clearances from Table 4-1.

b. Parking positions – Provide a minimum of 10-foot (3 m) lateral clearance or 5-foot (1.5 m) vertical clearance from parked aircraft to the service road using the tallest vehicle expected to operate on the apron service road.

2. Surface Marking – Refer to vehicle roadway marking standards in AC 150/5340-1.

5.19.4 Recommended Practices.

1. Minimize points where service vehicle roads intersect with taxiways and taxilanes.
2. Do not install vertical vehicle road signs in the apron extents.

5.20 Design Considerations for Specific Apron Types.

5.20.1 Passenger Terminal Apron Factors.

5.20.1.1 Characteristics.

1. Parking gates may be contact type (e.g. by passenger boarding bridge) or non-contact (e.g. by ground loading).
2. Provide efficient and safe maneuvering of aircraft from the taxiway system to and from parking position.
3. Provide safe and efficient passenger boarding and deplaning.
4. Provide sufficient space for GSE (e.g. baggage tugs, cargo tugs, catering trucks, etc.) and support vehicles such as fuel trucks and aircraft maintenance equipment.

5.20.1.2 Design Considerations.

1. Size passenger aprons to accommodate peak hour operations considering factors and design elements appropriate for the airport type and service level.
2. Provide sufficient clearance at gate area for maneuvering of aircraft under self-power and for ground service vehicles. (See Figure 5-2)
3. For airport that have frequent congestion on apron taxilanes due to aircraft departing a gate, consider providing a push back area that allows unimpeded flow on the apron taxilane. (See Figure 5-3)
4. Design parking stands and gate configurations to accommodate the range of aircraft sizes anticipated to operate at the airport.
5. Provide a clear delineation of passenger walkways to boarding area for non-contact gates.
6. Provide a clear demarcation of the SIDA at Part 139 airports with an airport security plan.

7. Segregate commercial aprons from GA aprons (preferably by physical separation of pavement areas) to limit interaction of aircraft and to maintain integrity of the SIDA.

5.20.2 Cargo Apron.

5.20.2.1 **Characteristics.**

1. Cargo aprons are typically located apart from passenger terminals due to different space requirements and different GSE needs.
2. Cargo aprons are typically located adjacent to a cargo facility building, which acts as an interface with other transportation modes (e.g. freight trucks, rail cars, ships).
3. A cargo apron may be exclusive-use, where cargo operators maintain control of designated areas; or the apron may be a common-use area, where all cargo operators may operate.

5.20.2.2 **Design Considerations.**

1. Size a cargo apron for design peak volume of aircraft, aircraft servicing equipment and cargo handling equipment.
2. Provide sufficient clearance at parking position for maneuvering of aircraft under self-power and operation of GSE and related equipment.
3. Locate service roads at head-of-stand to allow movement of vehicles independent of aircraft maneuvering.
4. Consider providing space for a remote cargo aircraft-parking stand as a reserve location for empty aircraft during peak hours.
5. Consult ACRP Report 143, *Guidebook for Air Cargo Facility Planning and Development for industry practices*.

5.20.3 Remote Apron.

5.20.3.1 **Characteristics.**

1. Provides an area to hold incoming aircraft at peak hours until a terminal gate becomes open.
2. Provides an area to park non-active aircraft overnight without occupying gate space; commonly known as remain-overnight (RON) positions.
3. Provides an area for air traffic control to stage aircraft for effective flow management of arrivals and departures (see paragraph 4.9).
4. Serves as a remote passenger gate during situations where operations exceed gate capacity and apron buses or other ground vehicles transport passengers from the terminal building to the aircraft (uncommon practice).

5.20.3.2 **Design Considerations.**

1. Locate remote aprons in a non-movement area where parked aircraft will not impede efficient flow of taxiing aircraft from terminal to runway/taxiway system.
2. Size remote apron to provide a reasonable number of reserve parking stands based on recurring space deficiencies observed during peak hours or operations.

5.20.4 Deicing Apron.

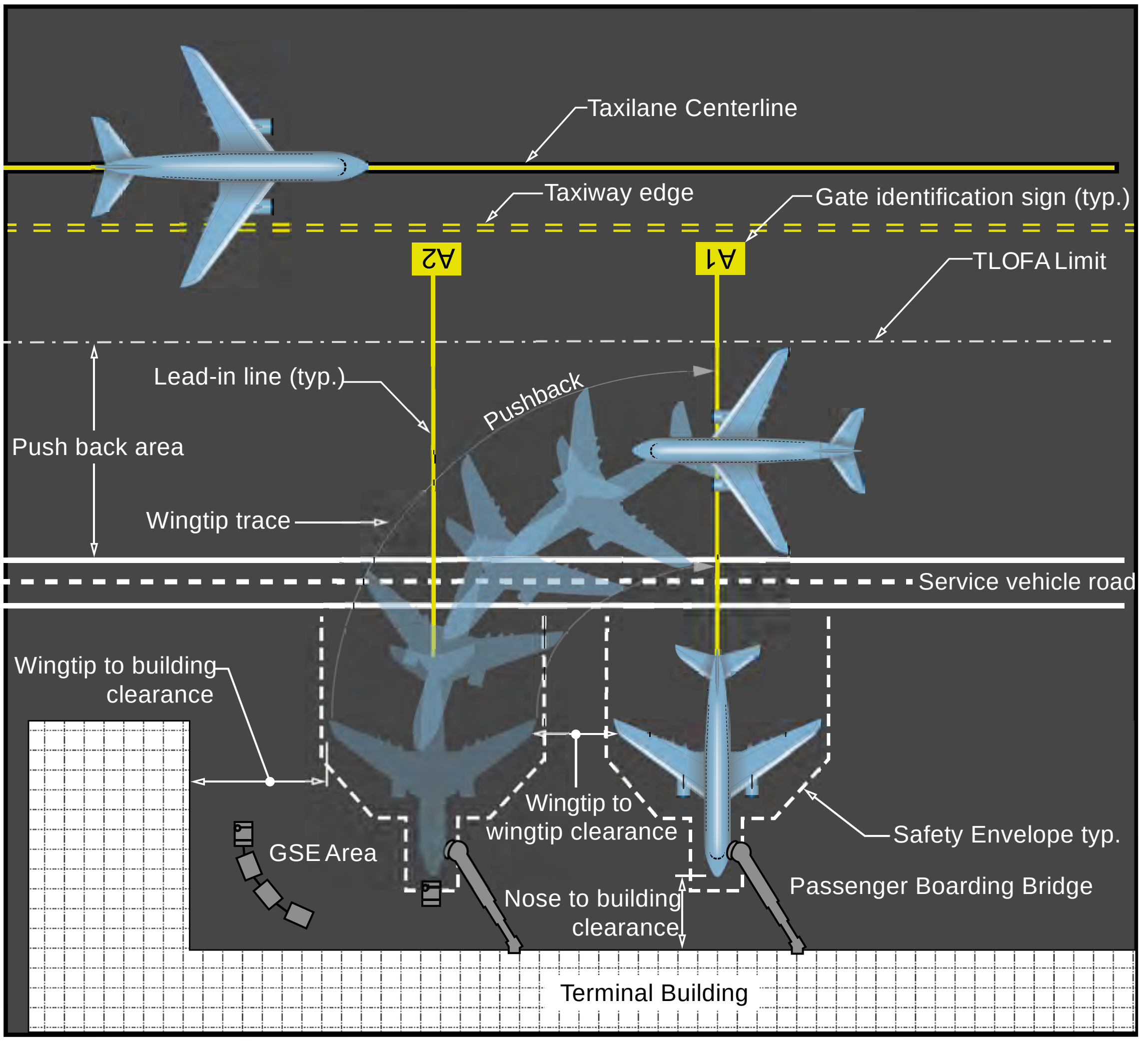
5.20.4.1 **Characteristics.**

1. Centralized facility typically located apart from gate area to minimize conflicts with GSE.
2. Size of deicing pad accommodates the aircraft receiving treatment as well as space for maneuvering of deicing equipment around the aircraft.

5.20.4.2 **Design Considerations.**

1. Refer to AC 150/5300-14 for standards and guidelines addressing layout, clearance, marking and lighting.
2. Locate deicing facilities away from the terminal gate along taxiways leading to runway departure ends to minimize taxi time from start of treatment to departure clearance.
3. Design containment system to collect deicing fluid runoff for subsequent treatment for compliance with environmental regulations.

Figure 5-3. Passenger Terminal Gate Area



Note 1: Image is conceptual for illustrative purposes only. Actual configuration is dependent upon factors unique to the airport.

Note 2: Refer to Table 5-1 for ADG III-VI wingtip clearance values

Note 3: Refer to paragraph 5.17.1.1 for jet blast and push back design considerations

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CHAPTER 6. Airfield Systems and Facilities

6.1 Introduction.

This chapter presents information for various systems and facilities located on airports including:

- Airfield Bridges and Tunnels
- Airfield Drainage
- Airfield Pavements
- Airfield Roadways
- Blast Fences
- Buildings within AOA
- Security of Airports
- Compass Calibration Pads
- Underground Cables
- NAS Facilities and Equipment

6.2 Airfield Bridges and Tunnels.

6.2.1 General.

This section presents guidance for general design standards and considerations for airfield bridges and tunnels. This section does not provide guidance or standards for structural design.

6.2.2 Need for Airfield Bridge.

An airfield bridge or tunnel may be necessary due to airport physical constraints such as space, the presence of roadways, railways, terrain, bodies of water, or the need to construct systems to move passengers and luggage. For safety as well as economic reasons, assess whether relocation of the constraining feature (e.g. public roadway) prevents the need to construct a bridge or tunnel. Examples of airfield applications include:

1. Bridge for a runway or parallel taxiway over a public highway
2. Taxiway bridge crossing an airport entrance road
3. Tunnel under an apron for people mover trains or baggage tugs.

6.2.3 General Siting Guidelines.

Apply the following guidelines to minimize the need for bridge structures:

1. Route or reroute the constraining feature(s) to affect the fewest runways and/or taxiways.
2. Co-align the constraining feature(s), including utilities, so that a single structure can resolve all conflicts.

3. Locate bridges and tunnels along runways and tangent portions of taxiways; away from intersections, exits or curves.
4. Design bridge locations that do not have an adverse effect upon the airport's drainage systems, utility service lines, airfield lighting circuits, Instrument Landing System (ILS), or Approach Lighting System (ALS).
5. Design bridge elevations to facilitate a near flat vertical grade for the runway and/or taxiway.
6. Make provision for a separate bridge structure for service vehicle and Aircraft Rescue and Fire Fighting (ARFF) per paragraphs 6.5.2 and 6.5.3.

6.2.4 Dimensional Criteria.

The standards of the authority having jurisdiction (e.g. state code) will govern the structural design of a bridge. However, there are dimensional standards and design considerations unique to airports as described below:

6.2.4.1 **Standards.**

1. Design the width of the bridge to be equal to or greater than the associated safety area, as measured perpendicular to the runway or taxiway centerline.
2. With the exception of parapets, design the bridge so no structural members project more than 3 inches (76 mm) above the bridge surface:
    a. Parapets represent a safety feature by containing aircraft and vehicles that wander to the pavement edge.
    b. Construct parapets to a height of no more than 12 inches (30 cm) above bridge deck and outside of the RSA and/or TSA limits.
    c. Construct parapets to the strength requirements as prescribed in federal highway standards.

6.2.4.2 **Design Considerations.**

1. Minimize bridge length by aligning the structure with the runway or taxiway centerline.
2. Consider a combined structure (e.g. tunnel) spanning the full (combined) width of the runway and taxiway safety areas when both the runway and taxiway pass over a surface feature such as a highway. This approach facilitates access by emergency vehicles by eliminating the presence of a gap between the two safety areas.

6.2.5 Load Considerations.

6.2.5.1 Standards.

Design runway and taxiway bridges to support both static and dynamic loads imposed by the heaviest aircraft expected to use the structures.

6.2.5.2 Design Considerations.

Consider any concentrated loads due to the main gear configurations. Design load considerations unique to airfield bridges include:

1. Runway load factors due to dynamic loading.
2. Longitudinal loads due to braking forces.
3. Transverse loads caused by wind on large aircraft.
4. Braking loads as high as 0.7G (for no-slip brakes) on bridge decks subject to direct wheel loads.
5. Horizontal loads from vehicle wheels if bridge is within limits of a curve.
6. Evaluate the future need to accommodate heavier aircraft:
    a. It is economical to apply a reasonable load increase factor during design than it is to reconstruct or strengthen an existing bridge in the future.
    b. FAA considers it reasonable to consider a load increase factor in the range of 20% - 25% to account for fleet growth over anticipated service life of the bridge.

6.2.6 Marking and Lighting for Bridges and Tunnels.

6.2.6.1 Standards.

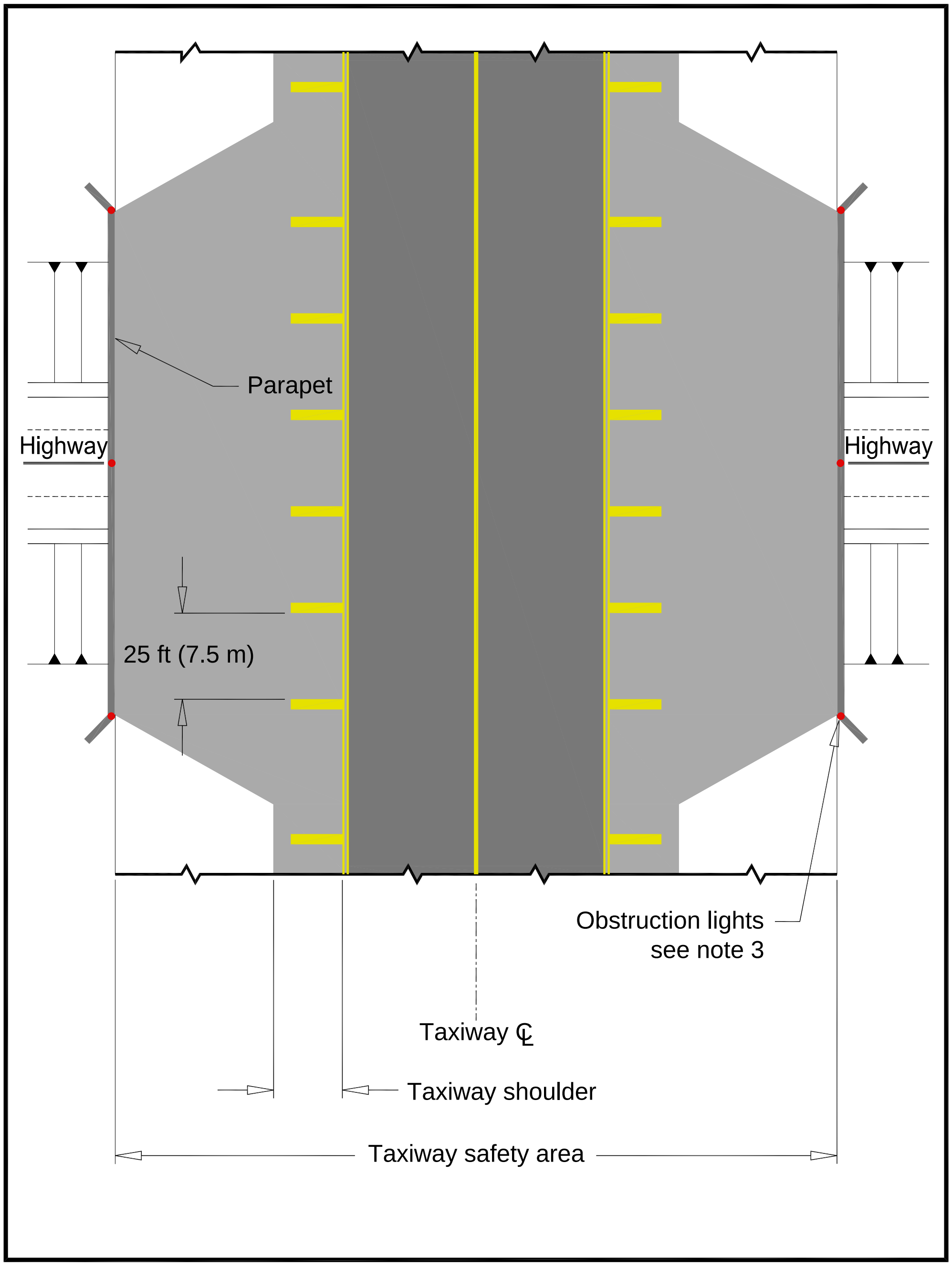
1. Mark, light and sign all taxiway routes and runways supported by bridges or tunnels according to the standards in AC 150/5340-1, AC 150/5340-18, and AC 150/5340-30.
2. Identify bridge edge portals with a minimum of three equally spaced L-810 obstruction lights on each side of the bridge structure as shown in Figure 6-1.
3. Paint 3-foot (1 m) yellow stripes spaced 25 feet (7.5 m) apart on taxiway shoulders on bridge decks, as shown in Figure 6-1. See AC 150/5340-1 for additional information.

6.2.6.2 Design Considerations.

1. Consider installation of centerline lighting if aircraft will use the taxiway bridge during nighttime operations and/or during low visibility conditions.

2. Airports may reduce the spacing between successive taxiway light fixtures (whether on the edge or centerline) from the standard values of AC 150/5340-30 on the segment of the taxiway pavement crossing the bridge or tunnel, but not below 50 feet (15 m).

Figure 6-1. Shoulder Markings for Taxiway Bridges



Note 1: The shoulder area assumes a fully closed cover instead of a partial cover open to traffic below.

Note 2: See AC 150/5340-1 for taxiway marking details.

Note 3: Spacing maximum 150 ft (46 m).

6.3 Airfield Drainage.

Airfield drainage systems collect, convey and discharge storm water from airfield pavements to allow safe vehicle and aircraft operations during a storm event. An effective drainage system maintains the integrity of safety areas by diminishing the risk of erosion and providing suitable surface for operation of safety and emergency vehicles. Consider the following drainage design factors when undertaking airfield design projects.

6.3.1 Standards.

6.3.1.1 System Design.

Refer to AC 150/5320-5 for guidance on the design of airport drainage systems.

6.3.1.2 Regulatory Requirements.

Comply with federal, state and local requirements for storm water management. Federal requirements include compliance with the Clean Water Act.

6.3.1.3 Airfield Pavement and Safety Areas.

Comply with transverse gradient standards to prevent accumulation of surface water on airfield pavements and safety areas following a storm event. See paragraph 4.14.

6.3.1.4 Wildlife Management.

Minimize the potential for the storm water system to attract wildlife to the airport. Refer to AC 150/5200-33 for guidance and requirements on land use management and storm water management facilities that minimize wildlife hazard attractants.

6.3.2 Design Considerations.

6.3.2.1 Drainage System.

Design the drainage system to collect, convey and discharge storm water from the airfield in a manner that prevents damage to airport pavements and safety areas.

1. Locate ditches, channels and collection structures (e.g. inlets and detention basins) outside of safety area limits.
2. Design the grate and structure to resist loading of the critical aircraft where it is impractical to install an inlet outside of a safety area.
3. Install a pavement sub-drain system to control and remove subsurface water to preserve and prolongs pavement performance.
4. Locate open channels and watercourses away from runway approach and departure paths.

6.3.2.2 **System Adaptability.**

Consider future airport expansion and grading requirements when establishing storm water management needs during planning and design efforts.

6.3.2.3 **Water Quality.**

Employ best management practices (BMPs) to mitigate the adverse impacts of development activity on water quality. Refer to the National Pollution Discharge Elimination System (NPDES) for permitting requirements. Refer to AC 150/5320-15 for guidance on the management and regulations of industrial waste generated at airports.

6.4 **Airfield Pavements.**

6.4.1 General.

Airfield pavements provide a suitable support surface for the safe and efficient operation of aircraft. In addition to resisting aircraft loads, airport pavements provide a firm skid resistant surface suitable for year-round aircraft operations under various environmental conditions. Proper pavement design considers the cumulative effective of repetitive aircraft loadings over the design life of the pavement section.

6.4.2 Standards.

6.4.2.1 **Pavement Design.**

Refer to AC 150/5320-6 for standards and guidance for airfield pavement design.

6.4.2.2 **Surface Friction Treatment.**

Provide grooving or other surface friction treatment for primary and secondary runways at commercial service airports and runways serving turbojet operations. Refer to AC 150/5320-12 for information on skid resistant surfaces.

6.5 **Airfield Roadways.**

The operation of ground vehicles within the AOA introduces conflict risks with taxiing and parked aircraft. Airfield roads are dedicated routes that separate vehicle operations from aircraft operations. AOA roadways are primarily for use by vehicles that service aircraft, navigational equipment, airport operations and airport security.

6.5.1 All Roadways.

6.5.1.1 **Design Considerations.**

1. Use of local, county or state construction specifications are suitable for construction of airfield roadways.

2. Construct roads that traverse a safety area flush with the adjacent grade to allow a pilot to maintain control of the aircraft during an excursion event.
3. Where a road surface consists of granular material, pave the first 300 feet (91 m) adjacent to a paved surface to limit tracking of debris on operational pavements.
4. Provide pavement markings to delineate roadway edges in apron areas.
5. Provide surface pavement hold line marking and road signs when intersecting with taxiways and taxilanes.

6.5.2 AOA Vehicle Service Road.

AOA vehicle service roads (VSR) are dedicated routes in the non-movement area that allow passage of ground service equipment and airport operations vehicles without impeding aircraft movements. VSRs enhance safety by channelizing ground vehicle traffic to areas that minimize interaction with aircraft operations.

6.5.2.1 **Standards.**

1. Locate the roadway outside the limits of ROFAs, TOFAs and TLOFAs except where it is necessary to cross a taxiway or taxilane.
2. Refer to AC 150/5340-1 for standard marking details for airfield roadways.
3. Do not route a VSR across a runway or through a runway safety area.

6.5.2.2 **Design Considerations.**

1. Factors to consider when assessing the justification for a VSR include:
    a. Frequency of ground vehicle traffic in the non-movement
    b. Potential for conflict with parked or taxiing aircraft
2. Design width of VSR to accommodate two-way traffic for equipment and vehicles that operate at the airport. Typical VSR widths range from 20 to 25 feet (6 to 7.6 m).
3. Route VSRs in a manner that limits crossing of taxiways and taxilanes.
4. For locations that justify a need for ground service vehicles to traverse a similar path as a taxiway bridge, construct a separate bridge for vehicle use.
5. Locate airfield vehicular bridges outside of object free areas.
6. See Chapter 5 for guidance related to service roads located on the apron.

6.5.3 ARFF Access Roads.

ARFF access roads provide ARFF vehicles unimpeded access to potential accident areas on a certificated airport. These roads also facilitate access for mutual aid vehicles, ambulances, and other emergency operations and equipment. ARFF access routes may consist of a combination of dedicated ARFF roads, taxiways, and runways.

6.5.3.1 Standards.

1. Provide a road surface suitable to permit emergency vehicle passage for all weather conditions that occur at the airport.
2. Design a route to provide unimpeded access to select points on the runway to achieve Part 139 response times from the ARFF building.
3. Provide ARFF access to the RSA and RPZ so that no area is more than 330 feet (100 m) from a prepared surface (i.e. roadway, taxiway or runway).

6.5.3.2 Recommended Practices.

1. Establish width of ARFF access road to provide safe passage of two-way traffic based on dimensions of equipment at the airport, with typical roadway widths ranging from 20 feet to 30 feet (6 m to 9 m).
2. Provide sufficient radius curve to permit high center-of-gravity vehicles to navigate a turn at a high speed; use a typical maximum design speed of a fully loaded ARFF vehicle of 70 mph (113 kph).

6.5.3.3 Design Considerations.

1. Evaluate how mutual-aid vehicles and other emergency vehicles will access the AOA and movement area in the event of an incident.
2. VSRs may provide effective access for mutual-aid and other emergency vehicles; however, vehicle traffic precludes the use of VSRs as a primary ARFF access route in meeting Part 139 response times.
3. Consider installing boat launch ramps at airports where the AOA is located immediately adjacent to a large body of water.

6.5.4 Perimeter Security Road.

A Transportation Security Administration security vulnerability assessment may justify installation of a perimeter security road to facilitate monitoring of the AOA fence line at a certificated airport. See paragraph 6.8 for guidance on airport security programs.

6.5.4.1 Standards.

The following design criteria apply when the Transportation Security Administration determines a perimeter security road is necessary based on risk at the airport.

1. Construct width of roadway to be 12 to 15 feet (3 to 5 m).

2. Construct roadway to be a well-graded, compacted gravel surfacing:
    a. suitable for low volume traffic during all weather conditions at the airport.
    b. conforming to local, county or state standards for aggregate surfaced roadways.
3. Locate the roadway near the fence line to provide the vehicle operator a clear view of the AOA fence.

6.5.4.2 **Design Considerations.**

1. Consider paving those segments of the roadway that have a higher volume of traffic due to multiple purposes (e.g. vehicle service).
2. Consider the effects that erosion may have on maintaining the integrity of the AOA fence installation due to storm water runoff from the roadway.

6.5.5 NAVAIDs Access Roads.

Some NAVAIDs facilities (e.g. PAPI, glide slope, runway visual range, wind cones, etc.) are fixed-by-function. This requires equipment to reside within or near safety areas and object free areas of runways and taxiways. Access to these facilities is necessary to ensure proper operation of the equipment. Responsibility for the road (i.e. construction, maintenance, etc.) is generally a function of who owns and operates the equipment or facility.

6.5.5.1 **Standards.**

1. Locate entrances to NAVAID access roads from a vehicle service road or a taxiway to avoid entering the runway environment.
2. Where impractical to locate a NAVAID access road from other than the runway, provide paved access road per paragraph 6.5.3.

6.5.5.2 **Recommended Practices.**

1. Design NAVAID access road width as follows:
    a. Single Lane: 10 to 12 feet (3 to 3.7 m)
    b. Dual lane: 20 to 24 feet (6 to 7.3 m)
2. Provide well-graded, compacted gravel or crushed rock surfacing:
    a. suitable for low volume traffic during all weather conditions at the airport.
    b. conforming to local, county or state standards for aggregate surfaced roadways.
    c. Refer to paragraph 6.5.3 for intersections of granular surfaces with runways, taxiway and aprons.

6.5.5.3 Design Considerations.

1. Locate access roads to minimize interference with protected surfaces such as safety areas, object free areas, and obstacle free zones.
2. Consider parking areas and turnaround areas that are clear of safety areas, object free areas and obstacle free zones.

6.6 Blast Fences.

Blast fences substantially reduce or eliminate the damaging effects of jet blast by deflecting or dissipating wind forces. They may mitigate issues related to fumes and noise associated with jet engine operation. Blast fences near apron areas protect personnel, equipment, and facilities from the jet blast of aircraft using nearby taxilanes and maneuvering into or out of parking positions. Blast fences may be necessary near runway ends, run-up pads, and the airport boundary to shield public roadways, structures, and individuals located near the AOA boundary.

6.6.1 Design Factors.

Conduct an engineering analysis that considers all applicable factors to ensure the fence properly withstands the force of the exhaust velocities. Different blast fence types are commercially available from various manufacturers. Factors influencing blast fence design include:

- Location
- Aircraft fleet
- Engine exhaust velocities
- Distance to engine
- Grading
- Height of structures
- Desired protection area

6.6.2 Location.

Consider wingtip clearance standards during aircraft maneuvering near the blast fence. Locate blast fences outside of the following surfaces:

- RSA
- ROFA
- TSA
- TOFA
- ILS critical areas

6.6.3 Distance from Aircraft.

Design placement of a blast fence relative to aircraft so that the centerline of the jet exhaust stream falls below the top of the fence. This will generally be between 60 to 120 feet from the jet engine. Maintain a minimum 50-foot clearance from the tail of the aircraft to the front of the blast fence.

6.6.4 Structural Design.

Design fence support elements to resist the exhaust forces of the critical aircraft. Refer to the aircraft manufacturer's manual for information on exhaust velocity contours. For locations where it is impractical to locate portions of the blast fence outside of an object free area, design the structure to fail mechanically by fracture or buckling when impacted by an aircraft. Refer to AC 150/5220-23 for additional information.

6.7 Buildings within AOA.

6.7.1 Building Restriction Line (BRL).

The BRL is a line the airport establishes to indicate suitable locations for locating buildings and structures within the AOA, with appropriate consideration for the protection of aircraft operational surfaces. Structures located in close proximity to aircraft movement areas may result in operational restrictions and limitations on future expansion opportunities within the airside area of the airport (e.g. apron parking, proper taxiway to runway separations).

6.7.1.1 **Criteria.**

1. Identify a suitable BRL on the ALP.
2. Establish the BRL to protect applicable operational surfaces to include:
    a. Runway Protection Zones (RPZs)
    b. Obstacle Free Zones (OFZs)
    c. Object Free Areas (OFAs)
    d. Runway Visibility Zone (RVZ)
    e. NAVAID critical areas
    f. TERPS surfaces
    g. ATCT clear line of sight (LOS).

6.7.1.2 **Recommended Practice.**

In addition to the surfaces in paragraph 6.7.1.1, establish the location of the BRL by ensuring an airport-established allowable structure height does not penetrate the transitional Part 77 imaginary surface. Typical structure heights for BRL establishment range from 25 feet (7.6 m) to 35 feet (10.5 m).

6.7.2 Standards for Buildings and Structures.

The standards listed below apply to new development as it relates to paragraph 3, *Applicability*.

1. Americans with Disabilities Act (ADA) – Comply with applicable ADA standards for accessible design per 28 CFR Part 36 and 49 USC § 47102(3)(F).

2. ARFF Building – Comply with standards of AC 150/5210-15.
3. Building Code – Comply with building code requirements as adopted by the local governing body; or in the absence of a formally adopted code, the current International Building Code.
4. Equipment Vault – Comply with standards of AC 150/5340-30 which include standards from the National Electric Code.
5. Snow Removal Equipment Building – Comply with standards of AC 150/5220-18.
6. Terminal Building – Comply with the standards of AC 150/5360-13.

6.8 Security of Airports.

The overall objective of airport security is to safeguard the AOA against acts, intentional or unintentional, that harm or interrupt airport operations. This includes protecting the safety of passengers, crew, ground personnel and general users of the airport. The risks to airport security vary between airports. Airport size, type, location, topography, and activity are important factors that can affect the risk. Establishing the appropriate level of security at a given airport involves applying a risk-based analysis including:

- Assessing vulnerabilities
- Identifying threats
- Implementing measures and controls that mitigate risk
- Monitoring implemented security measures

6.8.1 Transportation Security Administration.

The Transportation Security Administration is responsible for security in all modes of transportation, including responsibilities for civil aviation security per 49 USC Chapter 449.[4] The Transportation Security Administration regulations for airport security are codified at 49 CFR § 1542, *Airport Security* (§1542).

6.8.1.1 Transportation Security Administration Regulations for Airport Security.

6.8.1.1.1 Commercial Service Airports.

Transportation Security Administration regulations for airport security apply to airports with commercial service operations. Airports subject to §1542 must adopt and implement a security program acceptable to the Transportation Security Administration. Key program elements maintaining security of the movement area, secured areas and security identification area.

[4] 49 CFR § 1502.1, *Responsibilities of the Administrator*.

6.8.1.1.2 General Aviation Airports.

Currently, there are no regulations that establish security requirements for general aviation (GA) airports. For GA airports, the Transportation Security Administration has published *Security Guidelines for General Aviation Airport Operators and Uses*, which establishes voluntary guidelines and suggestions a GA operator may implement to address security at its airport.

6.8.2 FAA Regulations for Airport Security.

FAA regulations for airport security apply to airports operating under 14 CFR Part 139. Part 139 airports must provide safeguards that prevent unauthorized person entry to the movement area. This includes installation of fencing, provision of access controls and conformance to the Transportation Security Administration approved airport security program.

6.8.3 AOA Security Measures and Controls.

The following guidelines represent basic measures and controls acceptable to the FAA for maintaining the security of the AOA at a certificated airport. Conducting a security risk assessment may support additional measures and controls, as approved by the Transportation Security Administration Federal Security Director (FSD) that address risk specific to an airport.

6.8.3.1 **Fencing Standards.**

Basic chain link fence conforming to the standards of section F-162, Chain-Link Fence, of AC 150/5370-10 and having the following characteristics:

1. Minimum height of 8 feet (2.4 m) measured from grade consisting of:
   a. 7-feet (2.1 m) high chain link fabric.
   b. 1-foot (0.3 m) high outrigger with 3-strand barbwire mounted at a 45-degree angle.
2. Fabric mesh consisting of 9-gauge galvanized wire in 2-inch (5 cm) mesh.
3. No more than a 2-inch (5 cm) gap between bottom of fabric and grade.
4. Prevent intrusion under the fence by:
   a. Securing bottom rail to concrete footing at mid-point of line posts, or
   b. Burying fabric a minimum of 12 inches (30.5 cm) below grade.

6.8.3.2 **Vehicle Barrier Standards.**

When required by a security risk assessment, construct vehicle barriers at locations on the AOA boundary found to have a threat of vehicle intrusion. Basic barrier characteristics include:

1. Barrier height ranging between 30 to 36 inches (70.2 to 91.4 cm) above grade.
2. Barrier types:
   a. Reinforced concrete barrier
   b. Steel bollards with minimum 6-inch (15.2 cm) diameter and schedule 40 pipe.
   c. Steel guardrail between 30 to 36 inches (70.2 to 91.4 cm) in height.
   d. Steel guardrail consisting of 12-gauge W-beam and W6×9 steel posts at 6-foot 3-inch (1.9 m) spacing.

6.8.3.3 **Access Gate and Gate Operator Standards.**

Comply with ASTM standard F-2200 for Class IV gate installation. Comply with UL 325 for Class IV gate operators. Position gate operators in a location that prevents tampering by individuals exterior to the fence line.

6.8.4 Existing AOA Physical Barrier.

The criteria of paragraph 6.8.3 apply to new and replacement development projects. There is no obligation for an airport owner/operator with existing AOA physical barriers not meeting the basic features of paragraph 6.8.3 to take corrective action. However, the FAA expects any replacement security fence at a certificated airport to conform to the minimum criteria of paragraph 6.8.3 whenever a FSD approved security risk assessment determines:

1. the existing AOA barrier, or portions thereof, present an unacceptable security risk; or,
2. the existing fence, or portions thereof, have met its useful life and can no longer function properly.

6.9 **Compass Calibration Pad.**

A compass calibration pad is a paved area where aircraft position to calibrate the aircraft magnetic compass (see Figure 6-2). This allows the pilot to determine the deviation error in the magnetic compass. Pilots periodically check their magnetic compass to determine accuracy of readings. The compass calibration pad is not the only means to perform aircraft compass calibration. See Appendix F for guidance on compass calibration pad surveys.

6.9.1 Compass Calibration Pad Location.

Site conditions and airport design criteria are key factors in determining a suitable location for a compass calibration pad. Conducting a magnetic survey establishes the suitability of a final location. Determine a tentative site by visual application of the criteria listed below and a thorough magnetic survey of the site(s).

6.9.1.1 Check for locally generated or natural magnetic anomalies.

1. Note a site may be unsatisfactory even if it appears to meet all visually applied criteria regarding distances from structures, etc.
2. Check location(s) for presence of industrial areas.
3. Conduct magnetic surveys at various times as needed to determine if the area experiences intermittent magnetic variations.

6.9.1.2 The optimum site has a uniform magnetic variation or declination. Magnetic declination is the difference between magnetic north and true north.

6.9.1.3 Perform preliminary magnetic surveys to determine the angular difference between true and magnetic north measured at any point does not differ from the angular difference measured at any other point:

1. by more than one-half degree (30 minutes of arc) within a space between 2 feet and 6 feet (0.5 m and 2 m) above the grade elevation of the pad, and
2. over an area within a 250-foot (76 meters) radius from the center of the pad.

6.9.1.4 Small anomalies may be acceptable if the magnetic surveys indicate no effect on any magnetic measurements on the paved portion of the compass calibration pad. Have the geophysicist, surveyor or engineer conducting the magnetic survey provide a compass rose report certifying the results and noting all anomalies.

6.9.1.5 **Compass Calibration Pad Location Standards.**

Locate the pad to meet the following criteria:

1. Center of pad is a minimum of 600 feet (183 meters) from magnetic objects such as large parking lots, busy roads, railroad tracks, high voltage electrical transmission lines or cables carrying direct current (either above or below ground).
2. Center of pad is a minimum of 300 feet (91 meters) from buildings, aircraft arresting gear, fuel lines, electrical or communication cable conduits when they contain magnetic (iron, steel, or ferrous) materials and from other aircraft.
3. Center of pad is minimum of 150 feet (46 m) from runway and taxiway light bases, airfield signs, ducts, and grates for drainage if they contain iron, steel, or ferrous materials.
4. Location of pad is clear of any critical area for electronic NAVAID facilities.

5. Location of pad is clear of all airport design surfaces so aircraft using the pad do not penetrate the OFZ, safety areas, object free areas, etc.

6.9.2 Compass Calibration Pad Design and Construction Standards.

See Figure 6-2 for a typical compass calibration pad configuration. Apply the following design and construction criteria to ensure the effectiveness of the calibration pad.

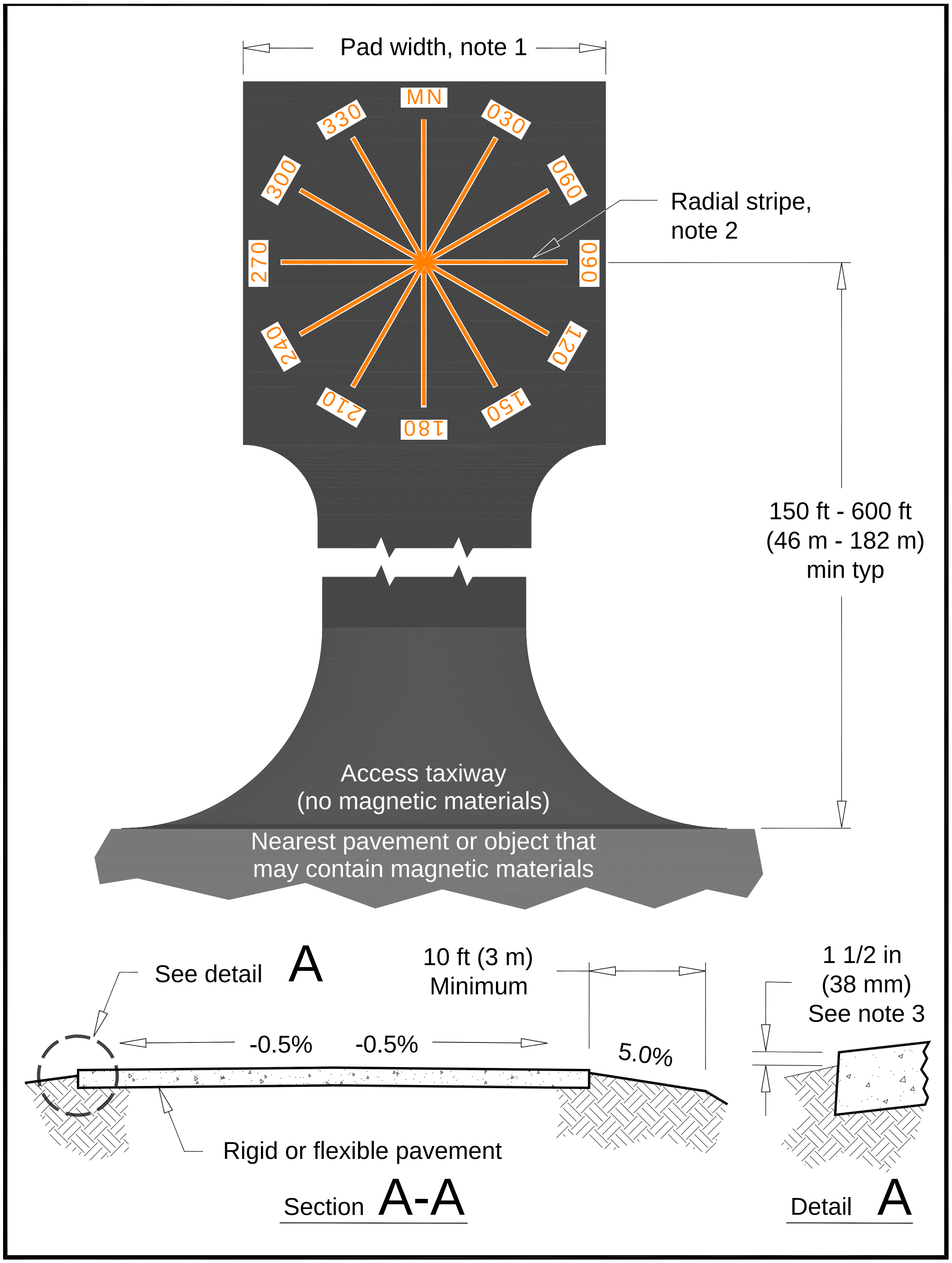
6.9.2.1 **Material.**

1. Construct pad(s) using either non-reinforced concrete or asphalt pavement.
2. Do not use magnetic materials, such as reinforcing steel or ferrous aggregate, in the construction of the calibration pad.
3. Use dowels that are non-ferrous (e.g. aluminum, brass, bronze) or non-metallic (e.g. fiberglass).
4. Use non-metallic or aluminum material for any drainage pipe within a 150-foot (46 m) radius of the center of the pad site.
5. Do not use magnetic materials in the construction of any pavement within a 300-foot (91 m) radius of the center of the pad site.

6.9.2.2 **Design and Construction.**

1. Size pad for the most demanding aircraft that will use the pad.
2. Design the pavement to support the most demanding aircraft and/or maintenance equipment loading.
3. Construct joint type and spacing in concrete pavement in accordance with FAA standards and paragraph 6.9.2.1.
4. Slope pavement to drain storm water from the center of pad to the edge of pavement.
5. Refer to the applicable portions of AC 150/5320-6 and AC 150/5370-10 for pavement design and construction standards respectively.

Figure 6-2. Compass Calibration Pad



Note 1: Diameter of calibration pad varies depending on requirements of user aircraft.

Note 2: The color of the radials is at the discretion of the airport operator provided there is adequate contrast with the pavement surface and the marking does not create pilot confusion with taxiway marking.

Note 3: Provide 1 ½ in (38 mm) drop off, plus or minus ½ inch (13 mm) to promote drainage off the pavement surface.

6.10 Underground Power, Control and Communications Cables.

Airports typically have a network of underground cables providing power, control, communication and video functions that serve airfield facilities and equipment. The complexity of the underground cable network varies by size and type of airport. Ownership of underground cables may involve the airport, Federal government, local tenants and utility companies. Typical airside facilities served by underground cables include:

- Runway/taxiway edge lighting
- Airfield sign systems
- NAVAIDs (e.g. approach lights, ILS, PAPIs, etc.)
- NAS surveillance (e.g. radar, ASDE-X, ASSC, multilateration, ADS-B)
- Communication systems (e.g. RTR)
- Weather systems (e.g. AWOS, LLWAS, RVR, etc.)
- AOA security controls (e.g. gate access controls, perimeter cameras, etc.)
- Apron area lighting

6.10.1 Airfield Cable Management Plan.

Failure to maintain accurate and current information on subsurface utilities can create a situation that increases the risk of disruptions that may affect safe and efficient airport operations. Discovery of project conflicts with existing underground cables can lead to costly project delays. Establishing an underground cable management plan is a best practice reducing the risk of unscheduled interruptions and disruptive project conflicts. By maintaining accurate and current information on underground cables, an airport owner can identify potential conflicts during the design phase rather than the construction phase.

6.10.1.1 Recommended Practices.

1. Maintain an information repository of all underground cables located on the airfield (e.g. design drawings, as-built drawings, GIS, asset management software) as projects occur.
2. Collect and maintain the following minimum information for each underground cable:
   a. Owner
   b. Servicing facility or equipment
   c. Type of cable (e.g. power, control, communication, fiber optic, etc.)
   d. Location (e.g. mapped points, geo-referenced, etc.)
   e. Structures (e.g. ductbanks, handholes, manholes, etc.)
   f. Depth from surface (e.g. estimated or surveyed)
   g. Dates (e.g. installation, verification, alterations, etc.)

3. Implement no-cost permitting process for all airside projects to collect information on underground cables and utilities prior to installation.
4. Collect and verify as-built information as construction projects are completed.
5. Refer to ACRP Synthesis 34, *Subsurface Utility Engineering Information Management for Airports*.

6.10.2 Airport-Owned Underground Cables.

Consider the following when undertaking an airside project that installs or modifies underground cables:

1. Collect and maintain information on underground cables per paragraph 6.10.1.1.
2. When practical and reasonable, install spare raceways in duct banks under airside pavements to preclude saw cutting of pavement for future airport development or utility expansion work.
3. Consider future airport development shown on the approved ALP in assessing future ductbank requirements.
4. When installing new underground cables and utilities, consider pavement or foundation section depth of future airport facilities as shown on the approved ALP in order to avoid future conflicts.
5. The depth of underground cables can migrate in areas subject to repetitive freeze-thaw conditions.
6. Integrate subsurface utility engineering into project design.

6.10.3 FAA-Owned Underground Cable Systems.

FAA installs and maintains a network of underground power, control and communication cables that service communication, surveillance, NAVAIDs and weather facilities. See FAA specification FAA-C-1391, *Installation, Termination, Splicing, and Transient Protection of Underground Electrical Distribution System Power Cables*. Take actions during the design phase of airside development project to identify and avoid adversely affecting FAA-owned cables.

6.10.3.1 **ATO Coordination.**

As part of the preliminary design phase, contact the local FAA ATO Technical Operations Organization for underground cable information specific to an airport.

6.10.3.2 **Cable Depths.**

FAA installs underground cable up to 600V a minimum of 24 inches below grade. For cable ducts under taxiway and runways, the depth increases to 48 inches or greater. Due to as-built drawings accuracy risks, the preferred method for positive identification of cable depths is by cable locators or by exposing existing cables using non-destructive methods (e.g. vacuum excavation).

6.10.3.3 **Cable Loop Systems.**

Order 6950.23 establishes FAA policy for installation of cable loop systems at select airports. Cable loops provide the benefits of redundancy to facilitate uninterrupted facility service. Because the location of cable loop segments occurs apart from the facility it serves, there is increased risk of cable cuts due to unawareness. As part of the design process for airfield development projects, contact the local FAA ATO Service Center to determine the presence of cable loop systems at an airport.

6.10.3.4 **Continuous Power Airports.**

Order 6030.20, *Electrical Power Policy*, establishes FAA policy for continuous power of select airport critical to NAS operations. This ensures continued operation of critical NAS facilities in the event of a power failure from a public utility company. Refer to Appendix A of FAA Order 6030.20 for continuous power airport (CPA) runways. For development projects at a CPA, consider the risk of power disruption to the CPA runway as part of the design process.

6.11 **CNSW and ATC Facilities and Equipment.**

This section presents information for Communications, Navigation, Surveillance and Weather (CNSW) facilities and Air Traffic Control (ATC) facilities that contribute to safe airport operations in the NAS. Figure 6-3 depicts the typical types and location of these facilities.

6.11.1 Purpose.

FAA owns, operates and maintains the majority of CNSW and ATC facilities at an airport. Federal requirements pertaining to non-Federal facilities are located at 14 CFR Part 171 and FAA Order 6700.20, *Non-Federal Navigational Aids, Air Traffic Control Facilities, and Automated Weather Systems*. Use of the information in this section during airport planning and design will assist the airport with minimizing conflicts between future development and existing or future CNSW and ATC facilities.

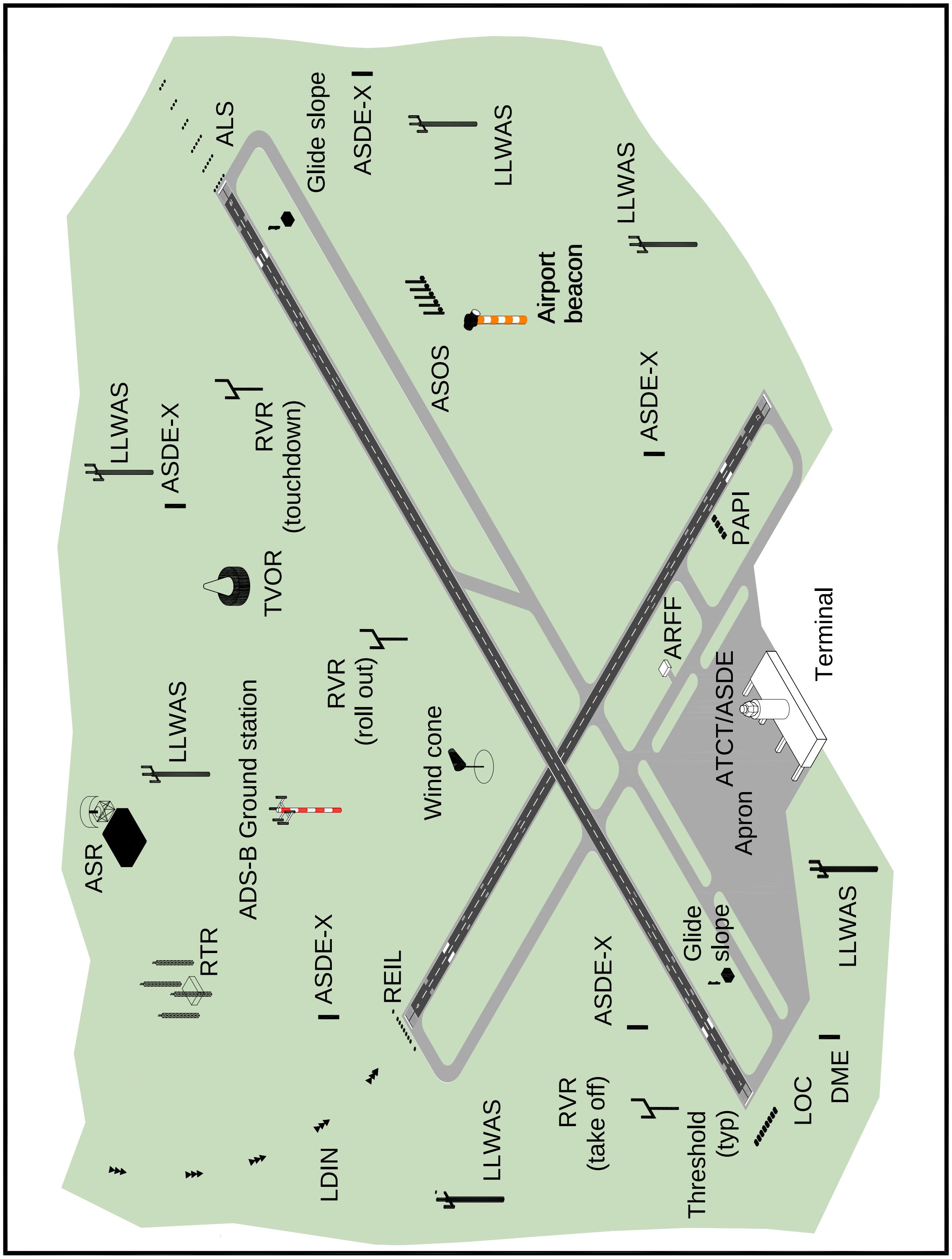
6.11.2 Limitations of Information.

This information does not represent complete guidelines and standards for the siting and establishment of CNSW or ATC facilities. Standards and requirements for facility siting and establishment are contained in the various FAA Orders referenced within this section.

6.11.3 FAA Owned Facilities Impacted by Airport Development.

Airport development can have an adverse effect on existing CNSW and ATC facilities. This includes unscheduled outages and the need to relocate an existing facility. Airports may not alter, remove or relocate FAA owned equipment without approval from the FAA.

Figure 6-3. Typical Communications, Navigation, Surveillance and Weather (CNSW)



6.11.3.1 **Reimbursable Agreement.**

Airport development affecting FAA operations or FAA-owned facilities and equipment may require establishment of a reimbursable agreement for materials, supplies, equipment and services provided by the FAA for a Sponsor's proposed development. To limit the loss of operational service, provide at least three years advance notice to the FAA NAS Planning and Integration (NPI) Team responsible for the airport where the project is taking place.

6.11.4 General Facility Criteria.

Each CNSW facility has specific criteria to allow the device to function properly. The optimum location of a facility relative to the runway/taxiway or airport varies by the function of the facility. Consider the following factors during planning and design of airport development to minimize impacts to existing FAA facilities.

6.11.4.1 **Notification.**

Proponents of development on an airport must submit a Notice of Proposed Construction or Alteration (FAA Form 7460-1) per 14 CFR Part 77. The FAA uses this information to evaluate the potential impact of any proposed construction near a FAA-owned facility.

6.11.4.2 **Separation and Clearance.**

In addition to the physical area and land necessary for a CNSW or ATC facility, each facility may require meeting specific separation and clearance criteria to function properly. The basis for the criteria may be visual (e.g. line of sight) or electronic (radio frequency (RF)). Visual aid facilities typically require an obstacle clearance surface to provide a clear line of site.

6.11.4.3 **Critical Areas.**

Some facilities have a defined critical area that require protection to ensure proper performance. Such areas may preclude the presence of objects that may induce electromagnetic interference (EMI). The size and shape of a facility's critical areas vary by facility type. Some facilities require conformance to specific grading criteria.

6.11.5 Jet Blast/Exhaust.

Locate CNSW facilities, monitoring devices, and equipment shelters at least 600 feet (183 m) from the source of any jet blast to minimize the accumulation of exhaust deposits on antennas.

6.11.6 Facilities and Equipment near Runways.

Objects located near an active runway can present an increased risk to aircraft operations. The FAA standards for RSAs and ROFAs recognize that certain equipment is fixed-by-function and are located within the limits of the RSA or ROFA to function properly.

6.11.6.1 Fixed-by-Function.

FAA classifies certain CNSW equipment as being fixed-by-function. This means the safety benefit of the equipment residing in a RSA or OFA outweighs the potential risk of an aircraft striking the equipment. A fixed-by-function determination allows the equipment, or portions of the equipment, to reside within the RSA or ROFA. Table 6-1 identifies the CNSW equipment the FAA designates as fixed-by-function for location within a RSA or ROFA.

Table 6-1. Fixed-by-function Designation for CNSW Equipment

CNSW Equipment	Fixed-By-Function		
	In RSA	**In ROFA**	**Associated Equipment**
ADS-B	No	No	No
Airport Beacon	No	No	N/A
ALS	Yes	Yes	No [1]
ASDE-X or ASSC	No	No	N/A
ASOS, AWOS	No	No	N/A
ASR	No	No	N/A
ATCT	No	No	N/A
DME	No	No	No
GS	No [2]	No [2, 3]	No
IM	Yes	Yes	Yes
LDIN	Yes	Yes	No [1]
LOC	No	No	No
LLWAS	No	No	No
MM	No	No	No
NDB	No	No	N/A
OM	No	No	No
PRM	No	No	No
REIL	Yes	Yes	No [1]

CNSW Equipment	Fixed-By-Function		
	In RSA	In ROFA	Associated Equipment
Runway Lights and Signs	Yes	Yes	No
RTR	No	No	No
RVR	No	Yes	Yes
RWSL	Yes	Yes	No
Taxiway Lights and Signs	Yes	Yes	No
VOR/TACAN/VORTAC	No	No	N/A
PAPI & VASI	Yes	Yes	No
WCAM	No	No	No
WEF	No	No	No
Wind Cone	No	No	No

Note 1: Flasher light power units (Individual Control Cabinets) are fixed-by-function.
Note 2: End Fire glideslopes are fixed-by-function in the RSA/ROFA.
Note 3: Space constraints may necessitate locating a Glide slope antenna within a ROFA. Evaluate on a case-by-case basis through an aeronautical study.

6.11.6.2 **Associated Equipment.**

Although a piece of equipment may have a fixed-by-function designation, it does not necessarily mean all components of the equipment can reside in the RSA or ROFA. The associated equipment shelters and power and control racks are not fixed-by-function. Locate such components outside RSAs and ROFAs in accordance with Table 6-1.

6.11.6.3 **Frangibility.**

Mount equipment located within an RSA on frangible couplings. These couplings have a point of frangibility on the mounting legs no higher than 3 inches (76 mm) above the ground designed to break away upon impact. This reduces the potential damage to aircraft inadvertently leaving the paved surface. The frangibility requirement is a standard for RSAs, whether or not the CNSW equipment is fixed-by-function. AC 150/5220-23 provides guidance on frangible connections.

Figure 6-4. Two Frangible Connections

6.11.6.4 Non-Standard Installations.

The FAA considers existing facilities and associated equipment residing within an RSA but not fixed-by-function or meeting frangibility requirements to be non-standard installations. The FAA expects the airport to develop plans to correct the non-standard installation by relocating the equipment as soon as practicable.

6.11.7 Airport Traffic Control Tower (ATCT).

The ATCT is a staffed facility that uses air/ground communications and other ATC systems to provide air traffic services both on the airport and for the surrounding airspace. The location of an ATCT gives controllers a clear line of sight to all surface movement areas, takeoff areas, and landing areas. Refer to FAA Order 6480.4 for FAA ATCT siting criteria.

6.11.7.1 Key Factors for Airport Development.

New airport development has potential to affect the operations of an existing ATCT. Key factors to consider when planning and designing any new airport development projects include:

1. Maintain an unobstructed line of sight from ATCT cab to all points on movement area pavement.
2. Maintain the minimum angle of incidence from the ATCT cab to all points on the movement area at 0.80 degrees.
3. Ensure new light sources (e.g. area lighting) do not obscure the controller’s view of the movement area.

6.11.8

6.11.8 Remote Transmitter/Receiver (RTR) and Remote Communications Outlet (RCO).

RTR and RCO are air-to-ground communications systems having transmitters and/or receivers allowing radio communications between the pilot and air traffic control. See Figure 6-5. See FAA Order JO 6580.3 for additional information.

6.11.8.1 **Design Considerations for Airport Development.**

Key factors to consider during planning and design of airport development projects include:

1. Maintaining unobstructed line-of-sight between communications towers, aircraft and ATCT.
2. Ensure development does not present a risk of electronic interference that distorts the RF signal or reduces receiver performance.

Figure 6-5. Remote Transmitter/Receiver (RTR) Communication Facility

6.11.9 Airport Surveillance Radar (ASR).

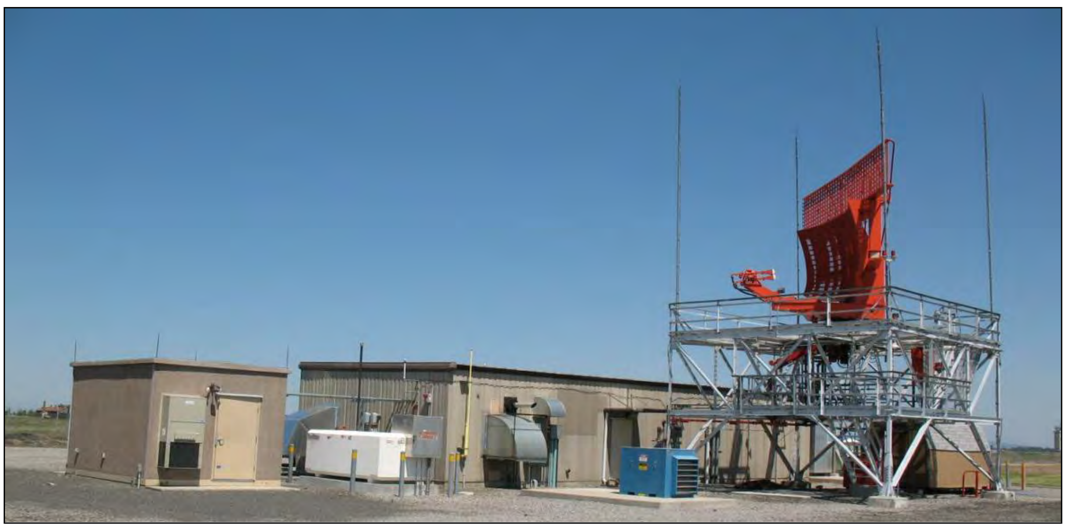
ASR is a radar facility used to detect and display azimuth, range, and elevation of aircraft operating within terminal airspace. Figure 6-6 shows a typical ASR. Typical ASRs range from 17 to 77 feet (5 to 23.5 m) above ground level (AGL) with a standard antenna tower 24 feet × 24 feet (7 m × 7 m). See FAA Order 6310.6 for information on ASR siting criteria.

6.11.9.1 **Key Factors for Airport Development.**

Key factors to consider during planning and design of airport development projects include:

1. Locate buildings and other facilities at least 1,500 feet (457 m) from ASR antennas to avoid potential signal reflections.
2. Locate electronic equipment at least one-half mile (0.8 km) from ASR antennas.
3. Ensure trees and structures remain below the elevation of the ASR mezzanine level.
4. Watch for proposed development (e.g. wind turbines) in the airport vicinity that may cause potential reflectivity issues (resulting in false targets) or that otherwise affect the ASR's operation.

Figure 6-6. Airport Surveillance Radar (ASR) Steel Tower (17 feet [5 m] high)



6.11.10 Airport Surface Surveillance Capability (ASSC)/Airport Surface Detection Equipment Model X (ASDE-X).

ASSC/ASDE-X systems improve surface surveillance and situational awareness in all kinds of weather. ASSC is similar to the Airport Surface Detection Equipment, Model X (ASDE-X) system deployed in the U.S. With ASCC/ASDE-X, controllers see aircraft and ground vehicles on the airport surface, and on approach and departure paths within a few miles of the airport, during periods of reduced visibility. The systems consists of several transmitters and receivers located near runways and taxiways.

6.11.10.1 **Key Factors for Airport Development.**

Key factors to consider during planning and design of airport development projects include:

1. Ensure proposed development does not affect the continuous line-of-sight between aircraft, surface vehicles and ASCC/ASDE-X equipment.
2. Ensure proposed development does not cause relocation of remote units (multilateration) or create other signal or multipath constraints.

6.11.11 Approach Lighting System (ALS).

Approach lighting systems are light configurations positioned symmetrically along the extended runway centerline. They begin at the runway threshold and extend outwards towards the runway's approach area. The ALS control may be by the ATCT, the airport operator, or by pilot-controlled lighting systems. An ALS often supplements electronic NAVAIDs, resulting in lower visibility minimums. Guidance on ALSs is available in FAA Order JO 6850.2.

6.11.11.1 **ALS Configurations.**

The FAA uses many ALS configurations to meet visual requirements for precision and non-precision approaches (NPAs).

1. ALS with Sequenced Flashing Lights (ALSF, ALSF-1, or ALSF-2). See Figure 6-7.
2. High intensity ALS required for CAT-II and CAT-III precision approaches. See Figure 6-8.
3. Medium Intensity ALS with Runway Alignment (MALSR) used for CAT-I precision approaches and special authorization CAT-II approaches. See Figure 6-9.

Figure 6-7. Approach Lighting System (ALS) with Sequenced Flashers II (ALSF-2)

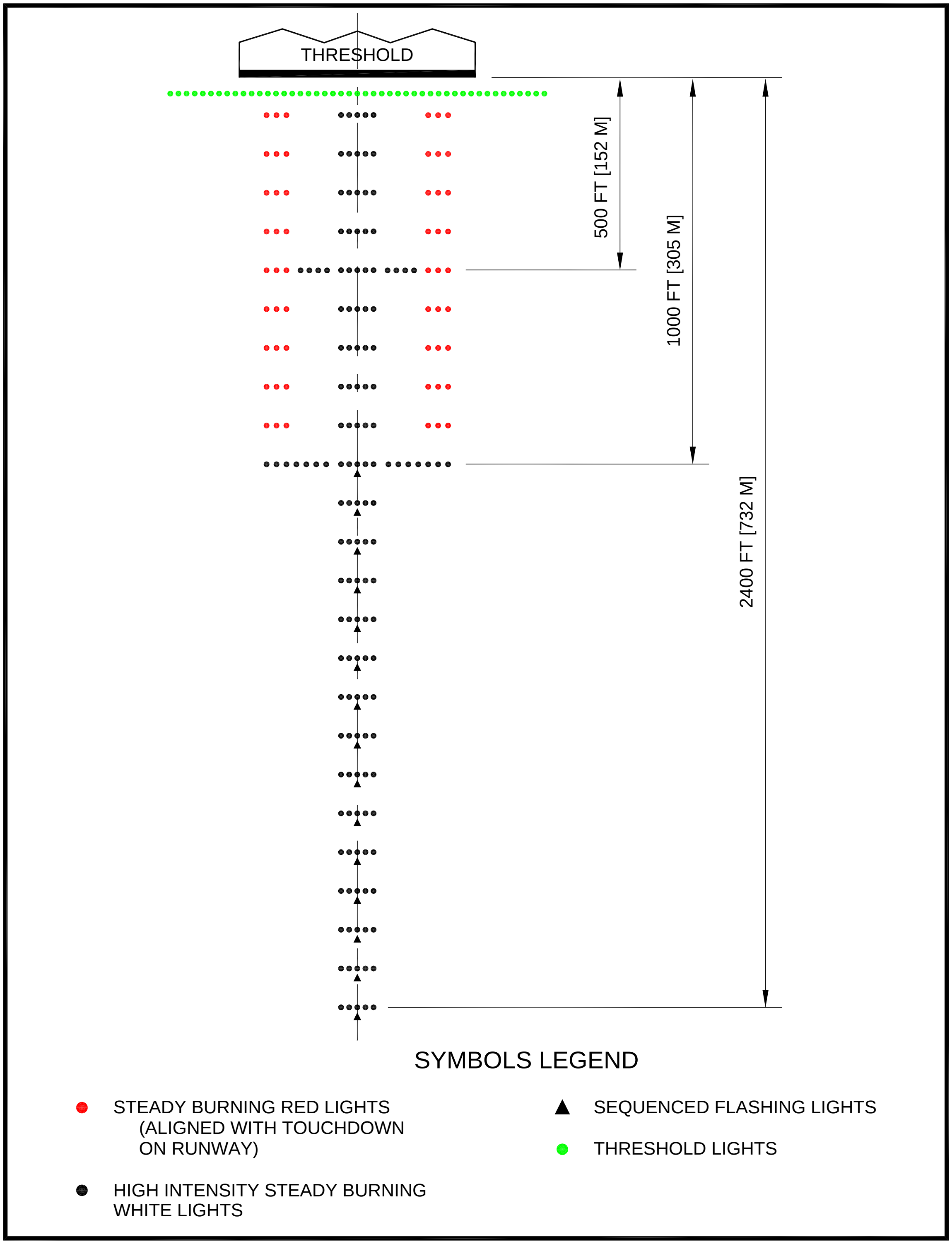


Figure 6-8. Simplified Short Approach Light System with Runway Alignment (SSALR)

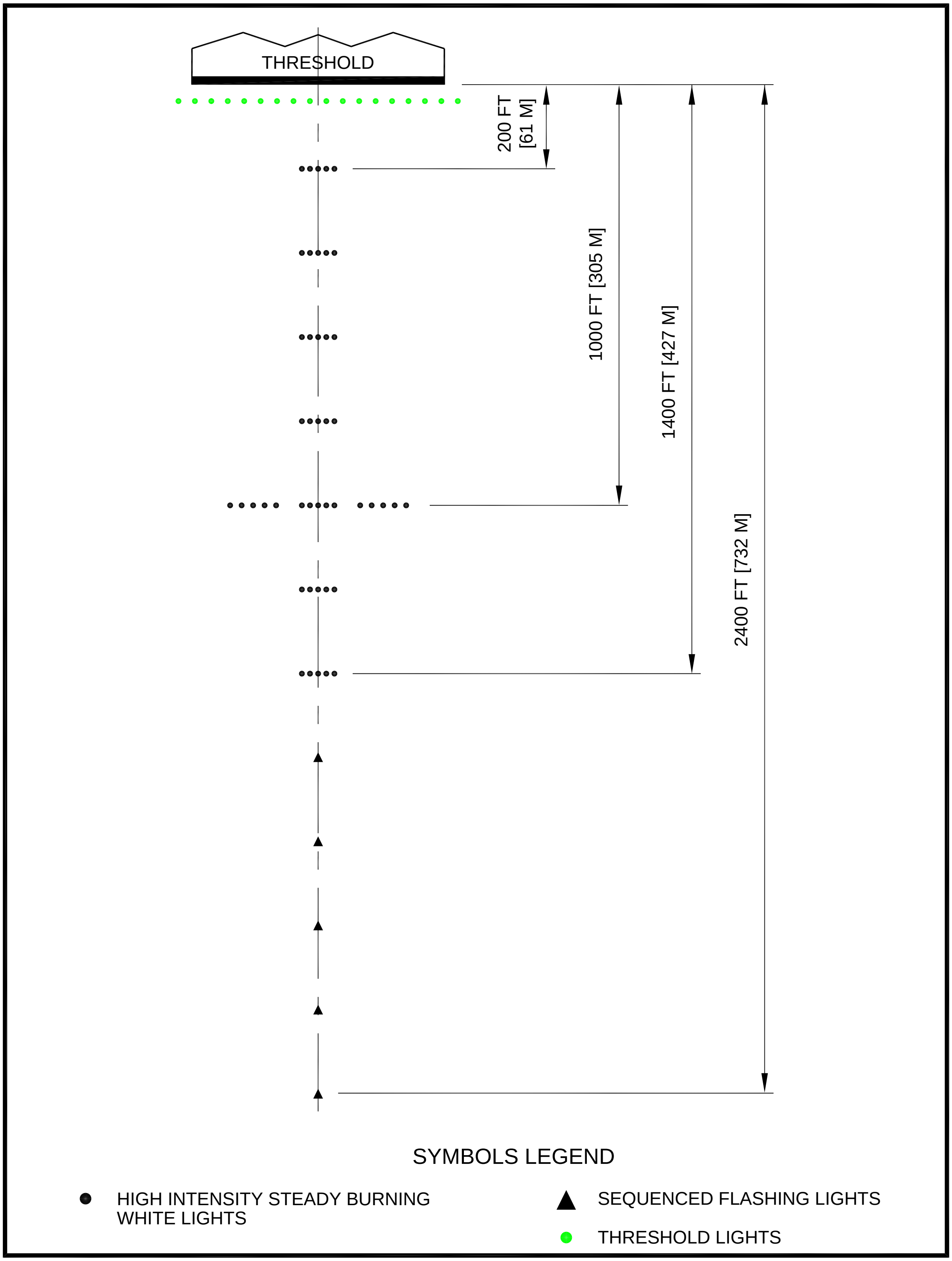
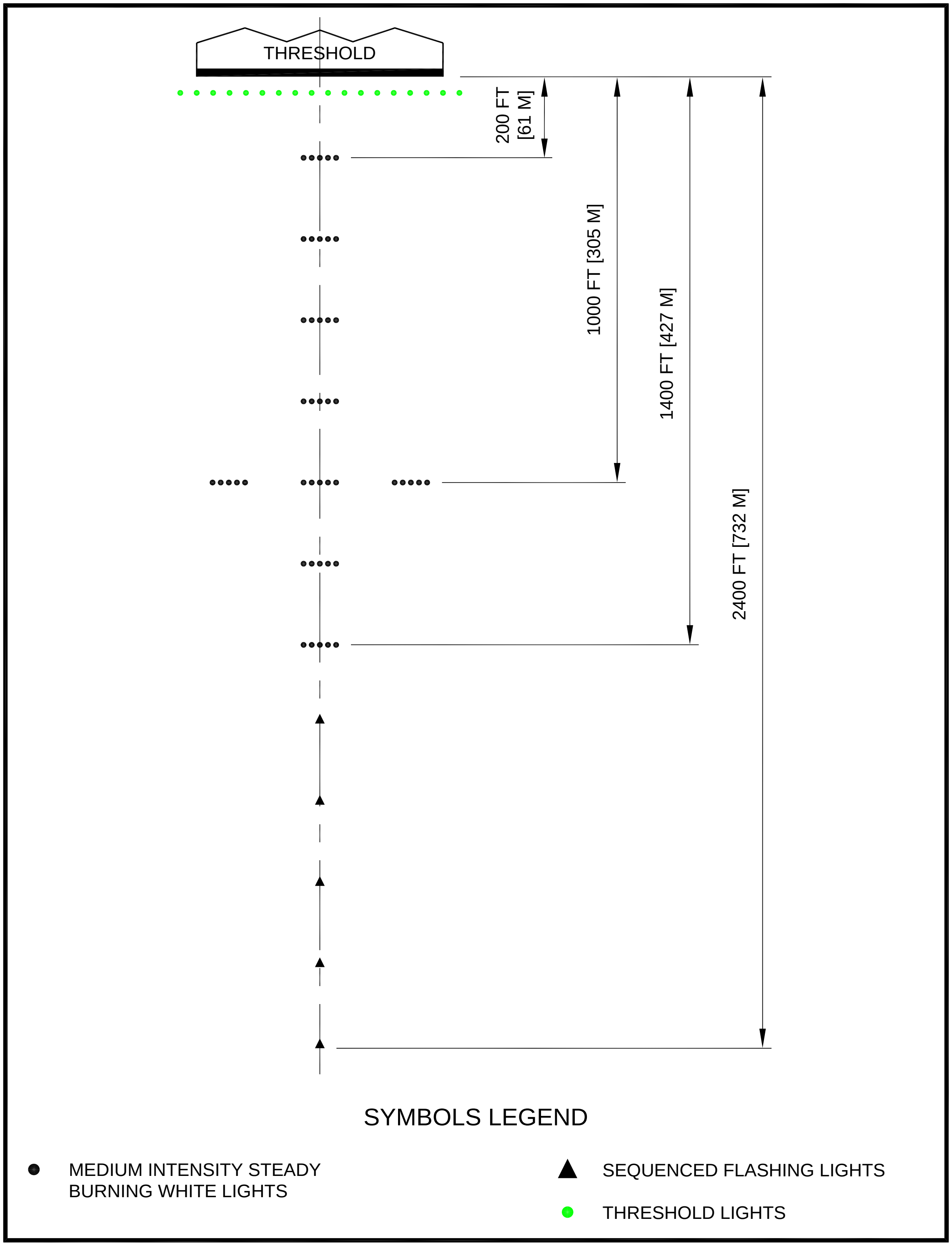


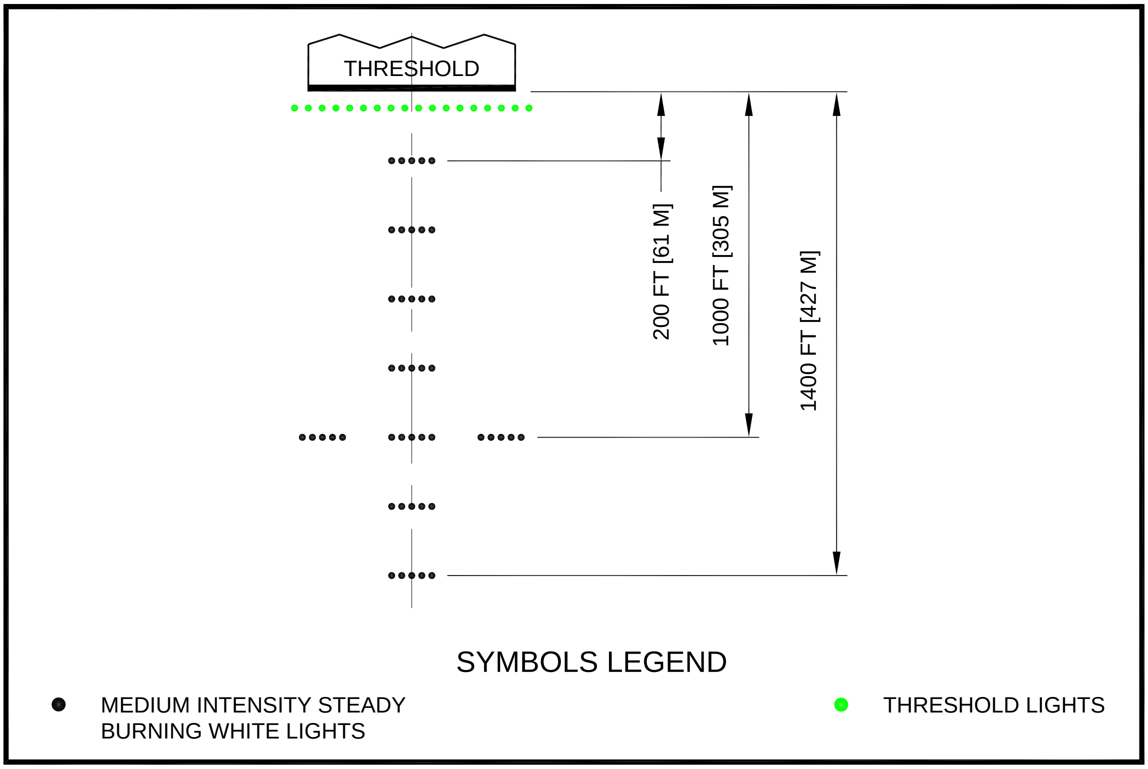
Figure 6-9. Medium Intensity Approach Lighting System (MALS) with Runway Alignment Indicator Lights (MALSR)



6.11.11.2 Medium Intensity Approach Lighting System (MALS).

1. Economy approach lighting aid that enhances visual recognition of runway end for non-precision instrument and visual approaches.
2. Simplified Short Approach Light System (SSALS) have the same configuration as a MALS but use high intensity lights.
3. See Figure 6-10.

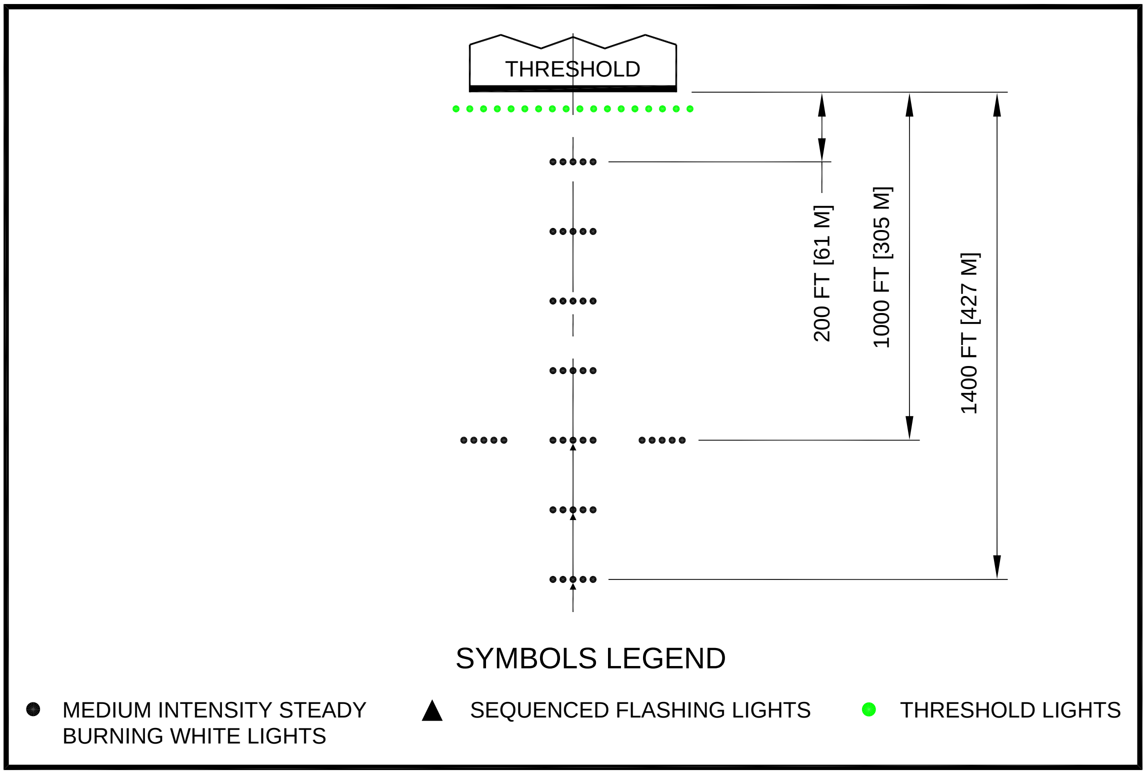
Figure 6-10. MALS



6.11.11.3 Medium Intensity ALS with Sequenced Flashing Lights (MALSF).

1. Economy approach lighting aid that enhances visual recognition of runway end for non-precision instrument and visual approaches.
2. Simplified Short Approach Light System with Sequenced Flashing Lights (SSALF) have the same configuration as a MALSF but use high intensity lights.
3. See Figure 6-11.

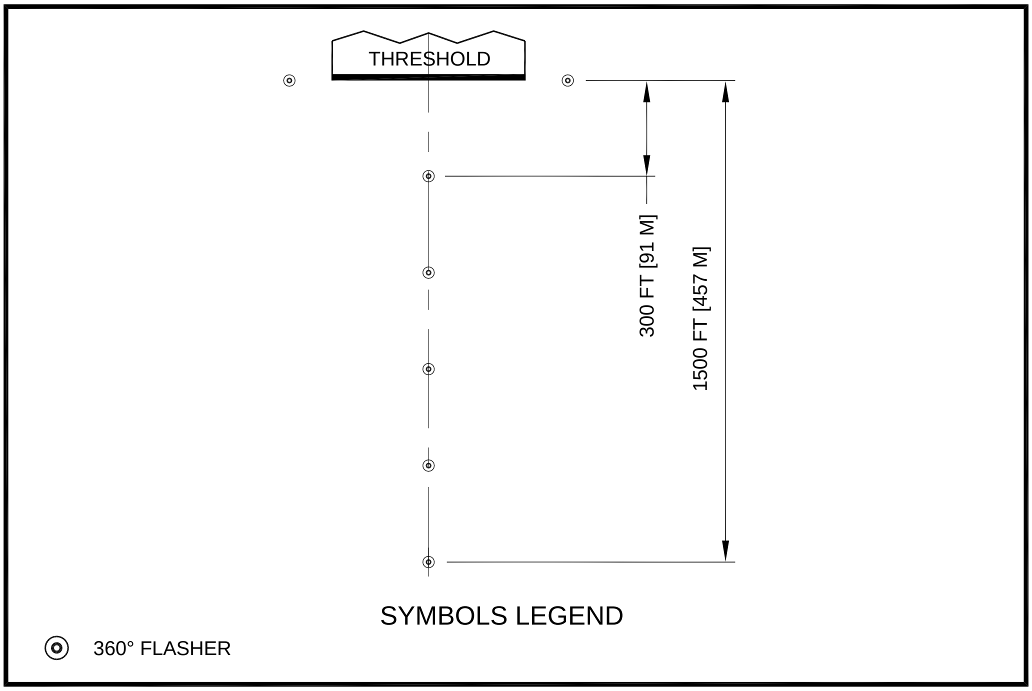
Figure 6-11. MALS with Sequenced Flashers (MALSF)



6.11.11.4 **An Omnidirectional Approach Lighting System (ODALS).**

1. Provides for circling, offset and straight-in visual guidance to non-precision runways.
2. Consists of seven (7) 360-degree flashing light stations that extend up to 1,500 feet (457 m) from the runway threshold.
3. Two of the lights positioned on either side of the runway threshold effectively function as Runway End Identifier Lighting (REIL).
4. See Figure 6-12.

Figure 6-12. Omnidirectional Airport Lighting System (ODALS)



6.11.11.5 Land Requirements.

An ALS requires a site centered on the extended runway centerline that is 400 feet (122 m) wide, starts at the runway threshold, and extends 200 feet (61 m) beyond the outermost light of the ALS.

6.11.11.6 Obstacle Clearance Requirements.

A clear line of sight (LOS) is necessary between approaching aircraft and all lights in an ALS.

6.11.11.7 Key Factors for Airport Development.

Key factors to consider related to an ALS system during planning and design of airport development projects include:

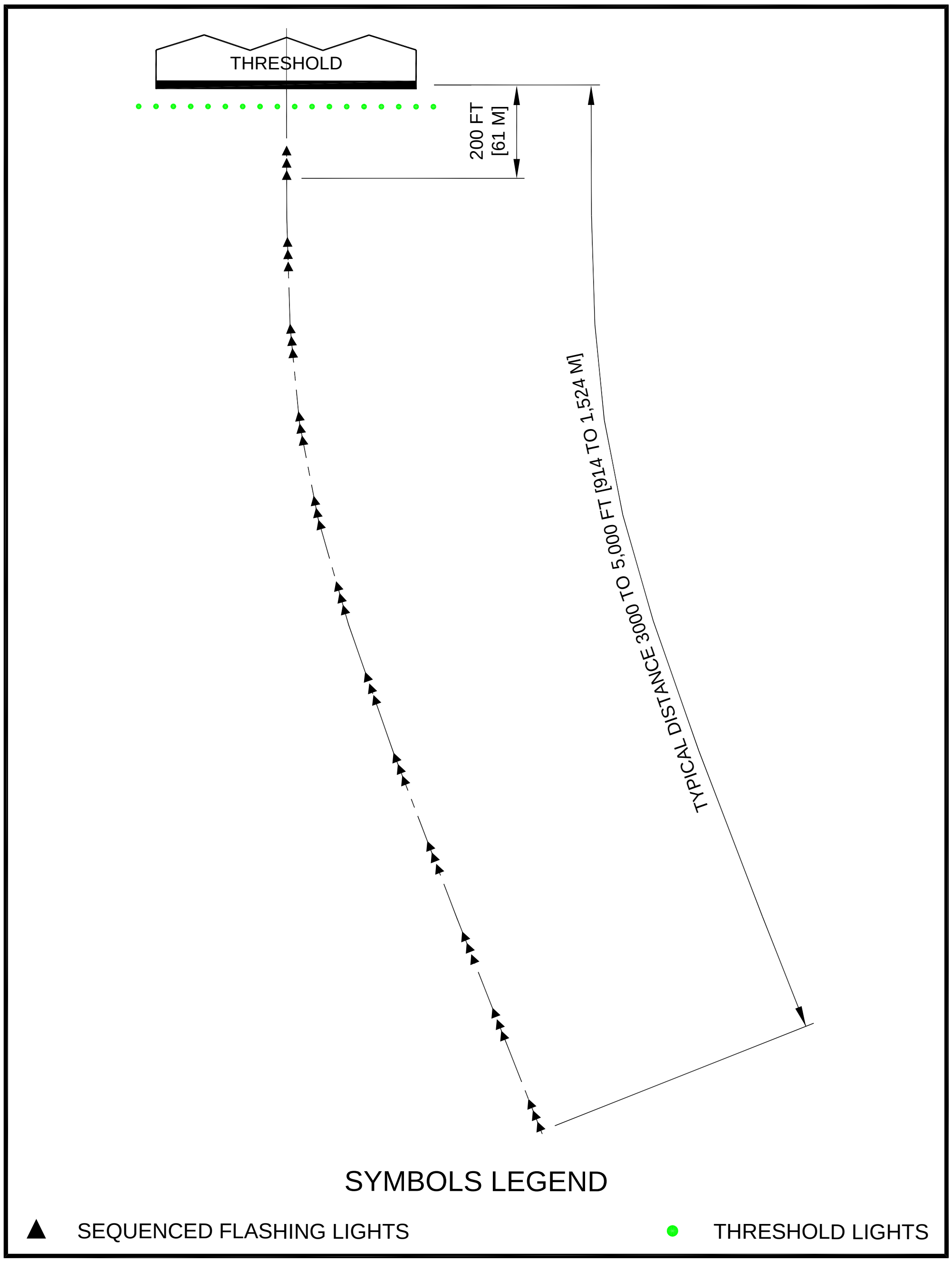
1. Maintain the obstacle clearance surface, as applicable for each type of ALS facility, with no objects protruding through the approach light plane or the secondary plane.
2. Maintain approach light-lane clearance over highways, rail lines and public roadways as follows:
    a. Highways – 17 feet (5.1 m)
    b. Rail lines – 23 feet (7 m)
    c. Public roadways and parking – 15 feet (4.6 m)
3. Ensure that components of airport installed ALS systems meet obstacle clearance criteria per Chapter 3 and Chapter 4.

4. See FAA Order JO 6850.2 and AC 150/5340-30 for specific requirements for each ALS system as described in this paragraph.

6.11.11.8 Approach Lead-In Lighting System (LDIN).

LDINs consist of at least three flashing lights installed at or near ground level to define the desired course to an ALS or to a runway threshold. See Figure 6-13.

Figure 6-13. Lead-in Lighting System (LDIN)



6.11.11.9 **LDIN Configuration and Clearance for Line of Sight.**

Each LDIN installation is unique. LDIN serve to address problems related to the approach area associated with hazardous terrain, obstructions, noise sensitive areas, etc. LDIN systems may be curved, straight, or a combination thereof, consisting of a grouping of flashing lights located on the desired approach path. The spacing between light groups is typically at 3,000-foot (914 m) intervals.

6.11.11.10 **Key Factors for Airport Development.**

1. Ensure development does not interfere with clear line of sight between approaching aircraft and the next light ahead of the aircraft.
2. Maintain the minimum obstacle clearance.

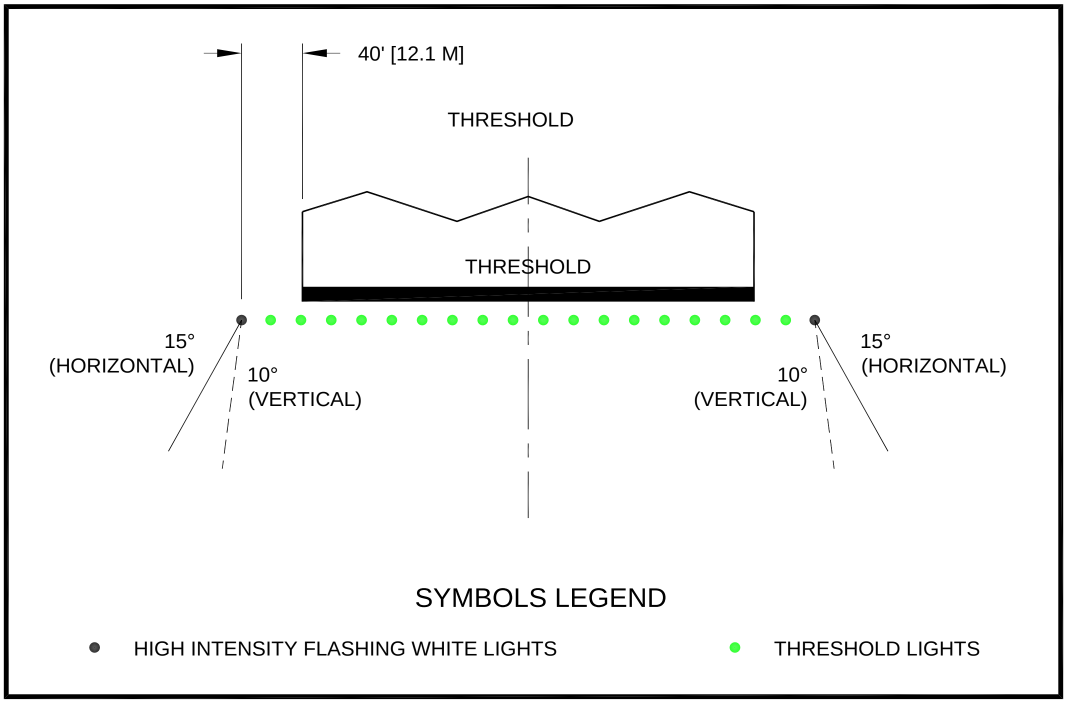
6.11.12 Runway End Identifier Lighting (REIL).

A REIL consists of two synchronized flashing unidirectional or omnidirectional lights, one on each side of the runway threshold (see Figure 6-14). The function of the REIL is to provide rapid and positive identification of the runway end, in particular for a runway surrounded by other ground lighting sources or lacking contrast with the surrounding terrain. Additional guidance on REILs is available in FAA Order JO 6850.2 and AC 150/5340-30.

6.11.12.1 **Key Factors for Airport Development.**

1. Maintain a clear line of sight to the REILS for approaching aircraft.
2. Verify separation distance compliance when constructing new taxiway pavement in proximity to runway end.

Figure 6-14. Runway End Identifier Lighting (REIL)



6.11.13 Airport Rotating Beacons.

Airport rotating beacons indicate the location of an airport by projecting beams of light spaced 180 degrees apart. Airport rotating beacons are a requirement for all Part 139 airports (reference 14 CFR § 139.311). For all other airports, a rotating beacon is standard for any airport with runway edge lights. See AC 150/5340-30 for design and installation guidance.

6.11.13.1 Key Factors for Airport Development.

Key factors to consider during planning and design of airport development projects include:

1. New runway construction may necessitate relocation of an existing beacon in order to maintain a location within 5,000 feet (1524 m) of the runways.
2. Ensure that new installations do not interfere with pilot or ATCT controller visions.
3. Maintain the beam sweep, aimed 2 degrees or more above the horizon, from obstruction by any natural or manmade objects.

6.11.14 Precision Approach Path Indicator (PAPI).

A PAPI is a light array of equally spaced light units color-coded to provide a visual indication of an aircraft's vertical position relative to the glide path to a touchdown point on the runway. PAPIs are a type of VGSI that assists pilots with maintaining a safe altitude over objects. See FAA Order JO 6850.2 and AC 150/5340-30 for design and installation guidance.

6.11.14.1 **Application.**

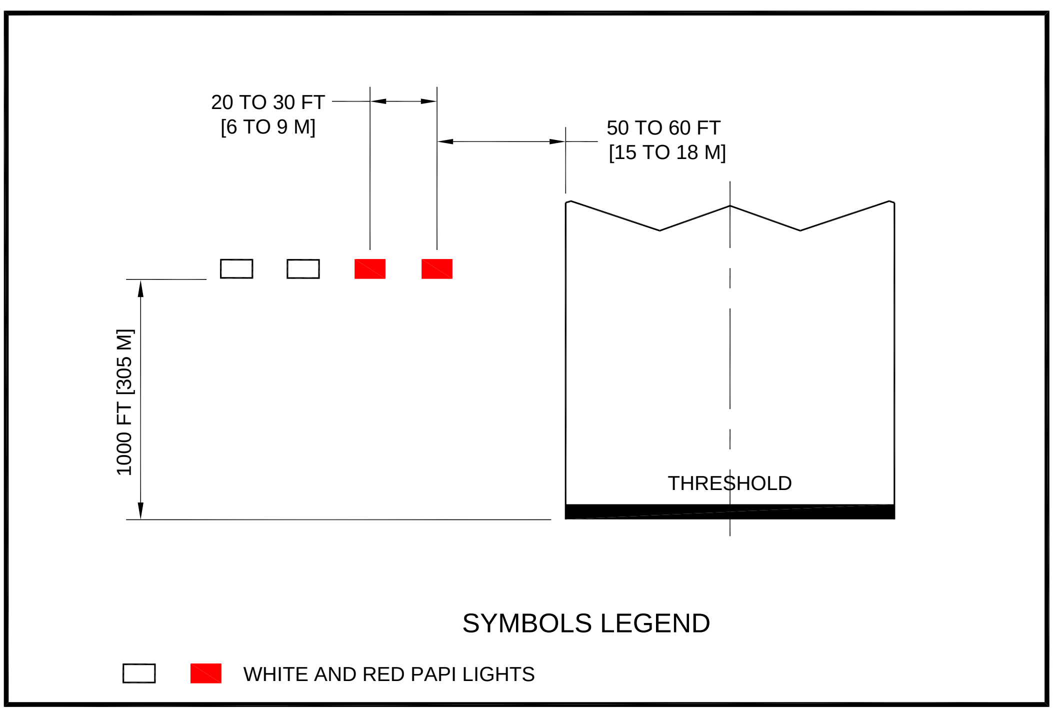
1. A 2-box PAPI system is suitable for visual and non-precision runways with runway edge lights; or when obstacle mitigation is necessary in the runway approach.
2. A 4-box PAPI is suitable for Part 139 runways and runways serving jet aircraft operations.

6.11.14.2 **Key Factors for Airport Development.**

Key factors to consider during planning and design of airport development projects include:

1. Maintain the obstacle clearance surface (OCS) clear of penetrating objects.
2. Assess the effect of any change to the runway threshold location on:
    a. the minimum threshold Crossing Height (TCH).
    b. The PAPI runway reference point relative to an existing Glide Slope runway reference point.

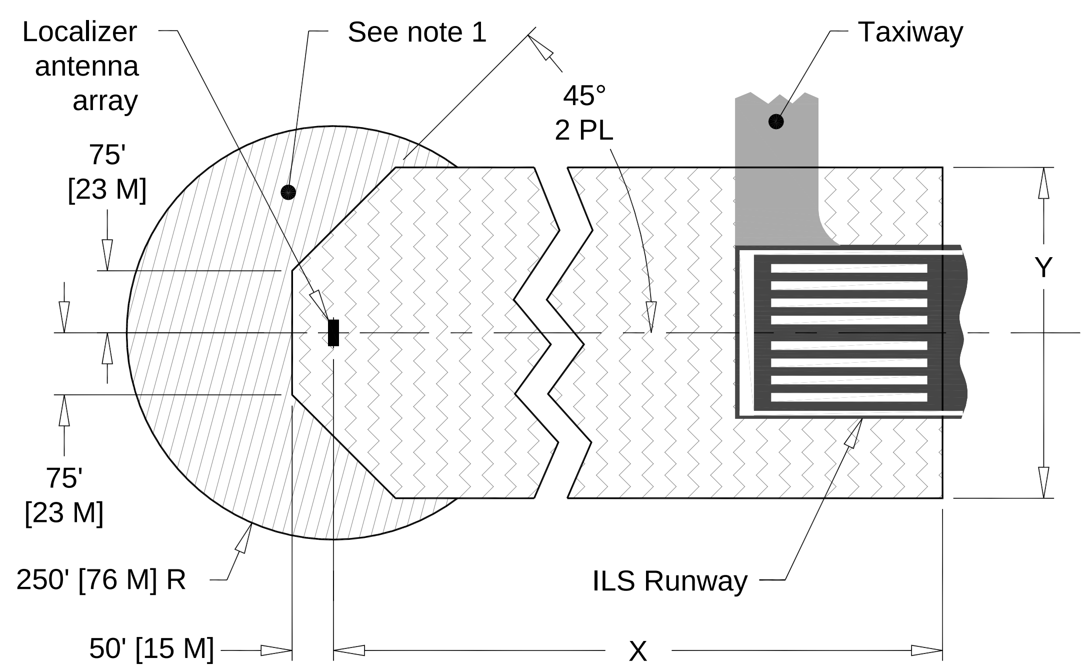
Figure 6-15. 4-Unit Precision Approach Path Indicator (PAPI)



6.11.15 Instrument Landing System (ILS).

The ILS provides pilots with electronic guidance for aircraft alignment, descent gradient, and position for landing safely under conditions of reduced ceilings and visibility. An ILS uses a line-of-sight RF signal path from the LOC antenna, marker beacons and GS antenna to provide horizontal and vertical guidance to pilots. The FAA owns and operates the majority of ILS systems in the NAS. FAA Order 6750.16 provides guidance on siting ILS components.

Figure 6-16. Instrument Landing System (ILS) Localizer (LOC) Siting and Critical Area



Legend:

Critical area "A":

Critical area "B":

Critical area dimensions		
Category	X	Y
I	2000' [609 M]	400' [122 M]
II /III (Note 2)	2000' [609 M]	400' [122 M]
II	4000' [1219 M]	500' [152 M]
III	7000' [2133 M]	500' [152 M]

Note 1: Additional critical area when back course localizer is available.
Note 2: Dimension apply when aircraft length is equal to or less than 135'.

6.11.15.1 **Key Factors for Airport Development.**

Key factors to consider during planning and design of airport development projects include:

1. Ensuring critical areas remain clear of signal interference sources such as power lines, fences, buildings, dense or tall vegetation, aircraft surface operations, ground vehicles, etc., that could adversely affect ILS system performance.
2. Consider the potential impacts to ILS components in the event of a change in runway length or runway threshold location.

6.11.16 Localizer (LOC) Antenna.

The LOC signal provides lateral course guidance allowing a pilot to maintain the aircraft's position relative to the runway's extended centerline. The LOC antenna array is located beyond the RSA typically on the extended runway centerline. Depending on the length of the RSA, the distance of the antenna array from the stop end of the runway varies between 600 to 2,000 feet (183 to 610 m). See Figure 6-17.

6.11.16.1 **Key Factors for Airport Development.**

Key factors to consider during planning and design of airport development projects include:

1. Maintain the critical area clear of objects.
2. Maintain the longitudinal grade between the antenna array and runway end clear of surface irregularities similar to RSA grading standards.
3. Maintain -0.5 percent to -3.0 percent symmetrical transverse grades from centerline to outed edges of the critical area.
4. Assess the effect relocation of a runway end (near or far end) has on localizer performance.
5. Assess the effect proposed development may have on existing localizer ground-check points.

Figure 6-17. LOC 8-Antenna Array

6.11.17 Glideslope (GS) Antenna.

The GS signal provides vertical decent guidance allowing a pilot to land at a designated point on the runway. The GS is located along the side of the runway, optimally outside of the ROFA limits. The desired threshold crossing height and runway slope control the location of the GS antenna from the runway threshold. See Figure 6-18 for the GS critical area. The GS equipment shelter is located behind the antenna and a minimum of 400 feet (122 m) from the runway centerline.

6.11.17.1 Key Factors for Airport Development.

Key factors to consider during planning and design of airport development projects include:

1. Ensure development does not alter the terrain within the GS critical area beyond standard grading tolerances.
2. Ensure development does not create any signal interference sources (e.g. buildings, power lines, surface vehicles, aircraft, etc.) adversely affecting GS performance.
3. In the event of a change to the runway threshold location, verify the effect the new location will have on GS performance with respect to touchdown point, TCH and PAPI runway point of intersection.

Figure 6-18. Glideslope (GS) Siting and Critical Area

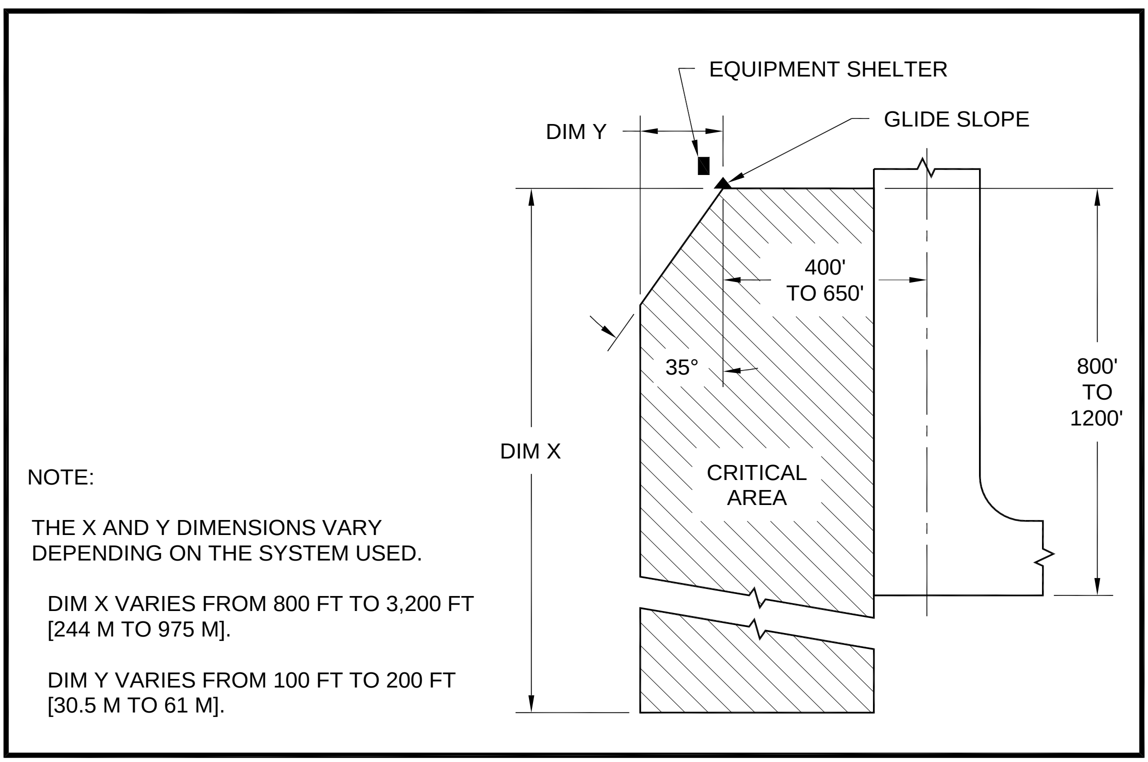


Figure 6-19. GS Antenna and Equipment Shelter

6.11.18 Distance Measuring Equipment (DME).

A DME provides pilots with a slant range measurement of distance to the runway in nautical miles. The DME is usually co-located with the LOC when used as an ancillary aid of the ILS. DME can also serve as an alternate position, navigation, timing service for aircraft in the event of a GPS outage. The FAA typically owns and operates DME equipment (see Figure 6-20). Refer to FAA Order 6780.5 for design and installation guidance on DME installations. ATO requirements for DME clearance are expected in late 2019.

6.11.18.1 **Key Factor for Airport Development.**

Ensure new airport development does not introduce electromagnetic interference sources that may degrade performance of the DME signal.

Figure 6-20. Distance Measuring Equipment (DME) Antenna

6.11.19 Runway Visual Range (RVR).

RVR measures the atmospheric transmissivity along runways and translates this visibility value to the air traffic user. RVRs support increased precision takeoff and landing capacity per the authorized ILS minimums. RVR visibility readings assist ATCT controllers when issuing control instructions and to avoid ground operations that may interfere with ILS critical areas. See Figure 6-21 and FAA Order 6560.10.

Figure 6-21. Touchdown Runway Visual Range (RVR)

6.11.19.1 Key Factors for Airport Development.

Key factors to consider during planning and design of airport development projects include:

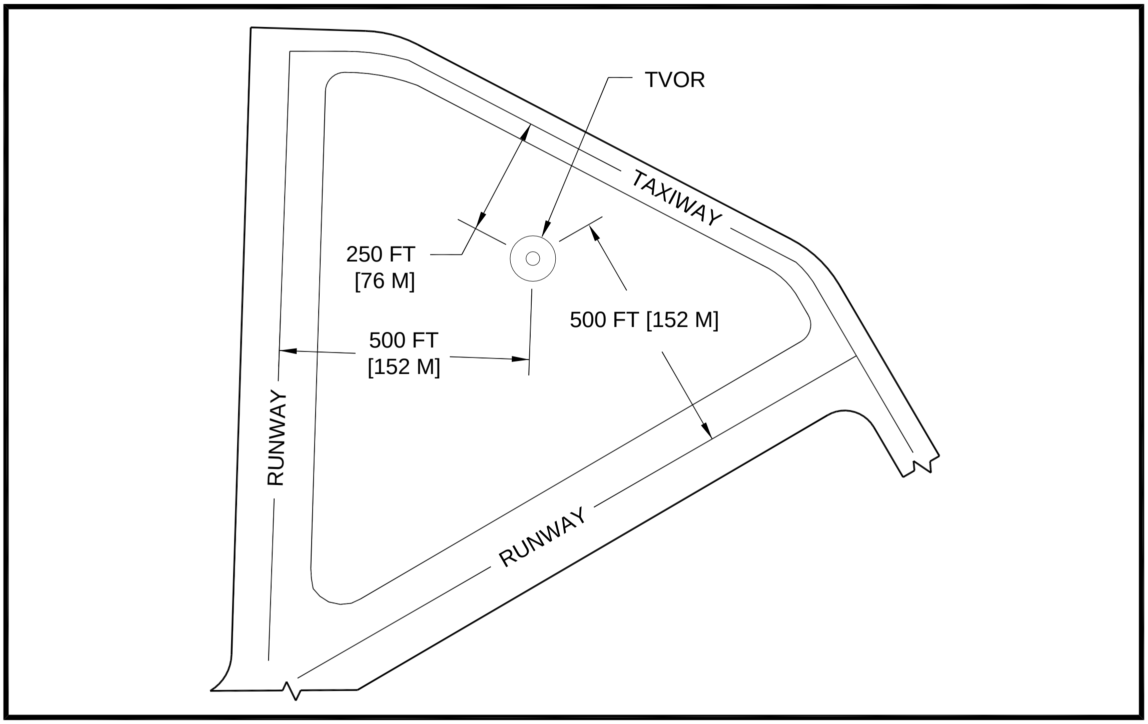
1. In the event of a change in runway length, runway operations, or runway threshold location, verify the effect of the change on the proper location(s) and functioning of all RVR units.
2. Consider potential for RVR sharing in the event of construction of a new adjacent runway.

6.11.20 Very High Frequency Omnidirectional Range (VOR).

VORs are a ground based navigation system that transmit RF signals that allow a pilot to establish course heading. See Figure 6-22 and Figure 6-23. The VOR Minimum Operational Network provides a conventional navigation backup service in the event of a loss of Global Positioning System (GPS) signal. The Minimum Operational Network enables pilots to revert from PBN to conventional navigation for approach, terminal and en route operations. The Minimum Operational Network also allows aircraft to use ILS or VOR approach procedures without the necessity of GPS, DME, automatic direction finding, or surveillance. See FAA Order 6820.10.

Figure 6-22. Enroute VHF Omnidirectional Range (VOR) Facility

Figure 6-23. TVOR Installation



Note: See FAA Order 6820.10 for VOR siting details.

6.11.20.1 Key Factors for Airport Development.

Key factors to consider during planning and design of airport development projects include:

1. Ensure development does not create signal interference sources (e.g. buildings, power lines, surface vehicles, aircraft, etc.) that can adversely affect VOR performance.
2. In the event of construction of new runways or taxiways, comply with Lateral offsets from runways and taxiways to ensure proper VOR performance.

6.11.21 Non-Directional Beacon (NDB).

A non-directional beacon is a radio beacon that aids the pilot of an aircraft equipped with direction finding equipment. NDBs also serve as a compass locator for the outer marker of an ILS. See Figure 6-24.

6.11.21.1 Key Factors for Airport Development.

Key factors to consider during planning and design of airport development projects include:

1. Ensure development does not establish sources of electromagnetic interference that degrades the NDB performance.

2. Use caution when grading near an NDB facility as subsurface ground radials can extend outward from the antenna a distance of 40 feet.

Figure 6-24. Non-Directional Beacon (NDB) Facility

6.11.22 Segmented Circles and Wind Cones.

A wind cone visually indicates prevailing wind direction at a particular location on an airfield or heliport. The segmented circle provides visual indication of current airport operations such as active landing direction and traffic patterns. See AC 150/5340-5 for guidance on segmented circles. See AC 150/5340-30 for guidance on wind cones.

6.11.22.1 **Key Factors for Airport Development.**

Key factors to consider during planning and design of airport development projects include:

1. In the event of a change in runway length or runway threshold relocations, verify the proper location(s) of segmented circles and wind cones per the standard.
2. Evaluate the need for a supplemental wind cone for both landing and takeoff operations in the event of a runway extension.
3. Ensure adequate wingtip clearance to existing wind cone assemblies when constructing new parallel taxiway.

6.11.23 Automated Surface Observing System (ASOS) and Automated Weather Observing System (AWOS).

An ASOS and AWOS are multi-sensor climate recording instruments that measure cloud cover and ceiling; visibility; wind speed and direction; temperature; dew point; precipitation accumulation; icing (freezing rain); and sea level pressure for altimeter setting. See Figure 6-25. Some configurations may also detect cloud-to-ground lightning. ASOS/AWOS facilities are often co-located with glide slopes. Refer to FAA Order 6560.20 and AC 150/5220-16 for additional information.

6.11.23.1 **Key Factors for Airport Development.**

Key factors to consider during planning and design of airport development projects include:

1. Airport development or changes in runway category changes (e.g. visual/non-precision or precision) may adversely affect the proper location of the ASOS/AWOS relative to the runway.
2. New runway and taxiway development may result in the existing ASOS/AWOS facilities violating object free areas.
3. Proposed development may create conditions that cause false or incorrect sensor readings (e.g. wind speed sensor).

Figure 6-25. Automated Surface Observing System (ASOS) Weather Sensors Suite

6.11.24 Weather Camera (WCAM).

A WCAM provides aircraft with near real-time photographical weather images via the Hypertext Transfer Protocol (HTTP). These cameras are common in the western region of the United States and specifically in Alaska where rapid changes in weather conditions require remote weather monitoring equipment. See Figure 6-26.

6.11.24.1 Key Factors for Airport Development.

Proposed airport development may adversely affect the camera's visual line of sight.

Figure 6-26. Weather Camera (WCAM) Pole

6.11.25 Wind Equipment F-400 (WEF)/Wind Measuring Equipment (WME).

WEFs and WME measure wind speed and direction for areas near runways. See Figure 6-27. These systems feed wind data to air traffic control facilities and automated broadcast systems. A typical WEF pole is 30 feet (9 m) tall and is located away from structures that may cause artificial wind profiles. See FAA Order 6560.20 for additional information.

6.11.25.1 Key Factors for Airport Development.

Airport development near the facility may create conditions that cause inaccurate wind readings.

Figure 6-27. Weather Equipment Sensor Pole

6.11.26 Low Level Windshear Alert System (LLWAS).

LLWAS measures wind speed and direction at remote sensor station sites situated around an airport. See Figure 6-28. Equipped airports may have as few as 6 or as many as 12 remote anemometer stations. The system transmits remote sensor data to a master station and generates warnings upon detecting windshear or microburst conditions. Refer to FAA Order 6560.21 for LLWAS siting guidelines.

6.11.26.1 Key Factors for Airport Development.

Airport development (e.g. buildings, structures, and other man-made features) may cause conditions that alter wind speed or direction in the vicinity of the anemometer stations.

Figure 6-28. Low Level Windshear Alert System (LLWAS) Sensor Pole

6.11.27 Runway Status Lights (RWSL).

RWSL are a fully automated system providing runway status information to pilots and surface vehicle operators to indicate when it is unsafe to enter, cross, or begin takeoff on a runway. RWSL are suitable only at airports with ASDE-X or ASSC, which are necessary to trigger the safety logic that activates RWSL. The RWSL system processes information from surveillance systems and activates Runway Entrance Lights (REL) and Takeoff Hold Lights (THL) along with the motion and velocity of the detected traffic. The RWSL system provides lights on runways and taxiways, increasing a pilot's situational awareness and reducing the risk of runway incursions.

6.11.27.1 Key Factors for Airport Development.

Airport development may adversely affect circuitry and functioning of the RWSL components.

6.11.28 Automated Dependent Surveillance Broadcast (ADS-B) Ground Station.

Automatic dependent surveillance—broadcast (ADS–B) is a NextGen surveillance technology that relies on satellites and a network of ground station transceivers rather than radar to accurately observe and track aircraft. Aircraft equipped with an ADS-B

Out transmitter send their position, altitude, heading, ground speed, vertical speed and call sign through the data communications network to air traffic control facilities. Pilots may also have the capability to receive air traffic information and other advisories.

6.11.28.1 Key Factors for Airport Development.

Key factors to consider during planning and design of airport development projects include:

1. Development may introduce RF interfering sources that can affect performance of the ground station.
2. Development may adversely affect line of sight to airborne aircraft.
3. Be aware of underground communications cables when trenching in the vicinity of an ADS-B ground station.

Figure 6-29. Automated Dependent Surveillance Broadcast (ADS-B) Ground Station

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APPENDIX A. AIRCRAFT CHARACTERISTICS

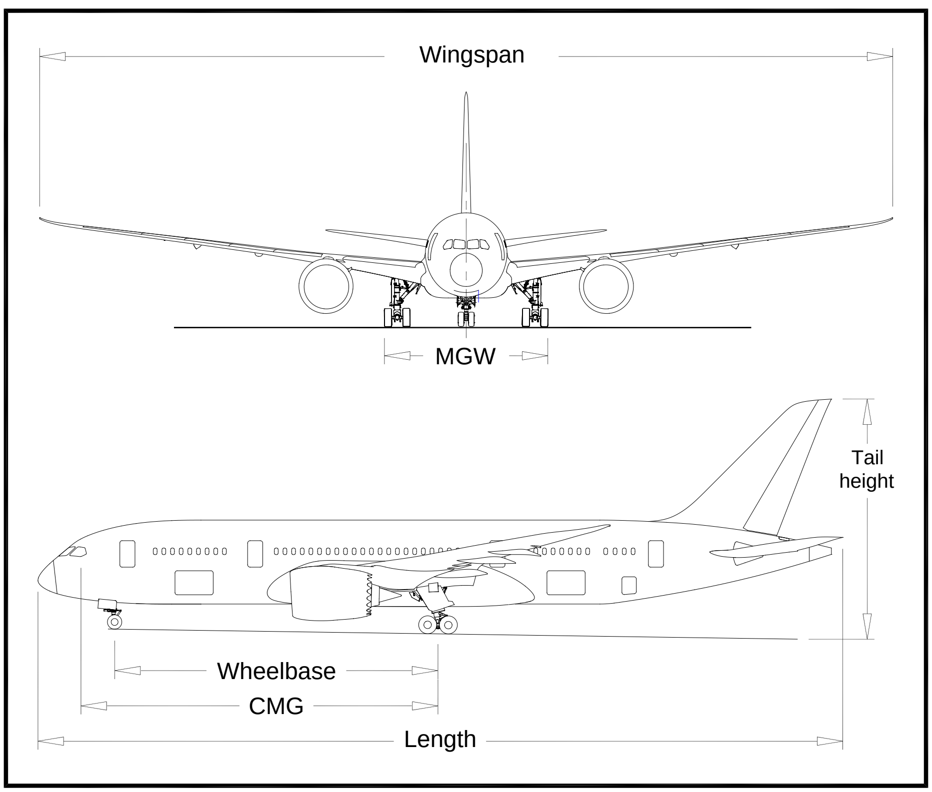
A.1 Basic Aircraft Characteristics.

A.1.1 This appendix provides basic aircraft characteristics for common aircraft as needed to perform such design functions as taxiway fillet layout and taxiway to taxilane separation requirements. The best manufacturers' information available at the time of issuance of this AC is available online in the Aircraft Characteristic Database (see paragraph A.3.1).

Note: This data does not include all aircraft or aircraft versions. The FAA does not guarantee the accuracy of the data values. Consult the manufacturer's technical specifications if there is a question on a specific aircraft.

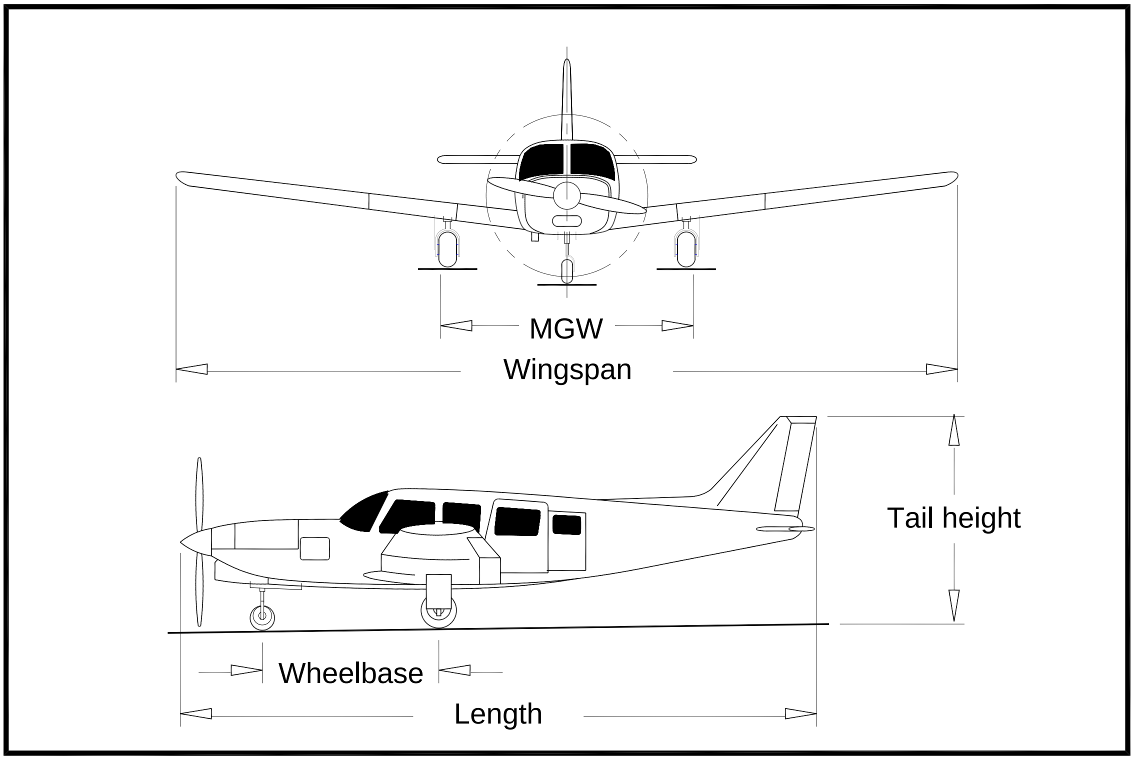
A.1.2 In accordance with the cockpit over centerline design method, the Cockpit to Main Gear (CMG) dimension will be used in lieu of wheelbase for aircraft (typically larger) where the cockpit is located forward of the nose gear. For aircraft with the cockpit located aft of the nose gear, use the wheelbase in lieu of CMG to determine the Taxiway Design Group (TDG). Refer to Figure A-1 and Figure A-2. The aircraft characteristics database will continue to be updated periodically as new aircraft are certified and as more complete information becomes available for existing aircraft.

Figure A-1. Key Dimensions – Large Aircraft



Note: Wingspan includes extent of winglets.

Figure A-2. Key Dimensions – Small Aircraft



Note: Wingspan includes extent of winglets.

Sources of the information provide in this appendix include aircraft manufacturers' websites and various databases:

- FAA Aircraft Characteristics Database: http://www.faa.gov/airports/engineering/aircraft_char_database/
- Eurocontrol Aircraft Performance Database
- Airbus Airplane Characteristics for Airport Planning
- Boeing Airplane Characteristics for Airport Planning
- Embraer Aircraft Characteristics for Airport Planning

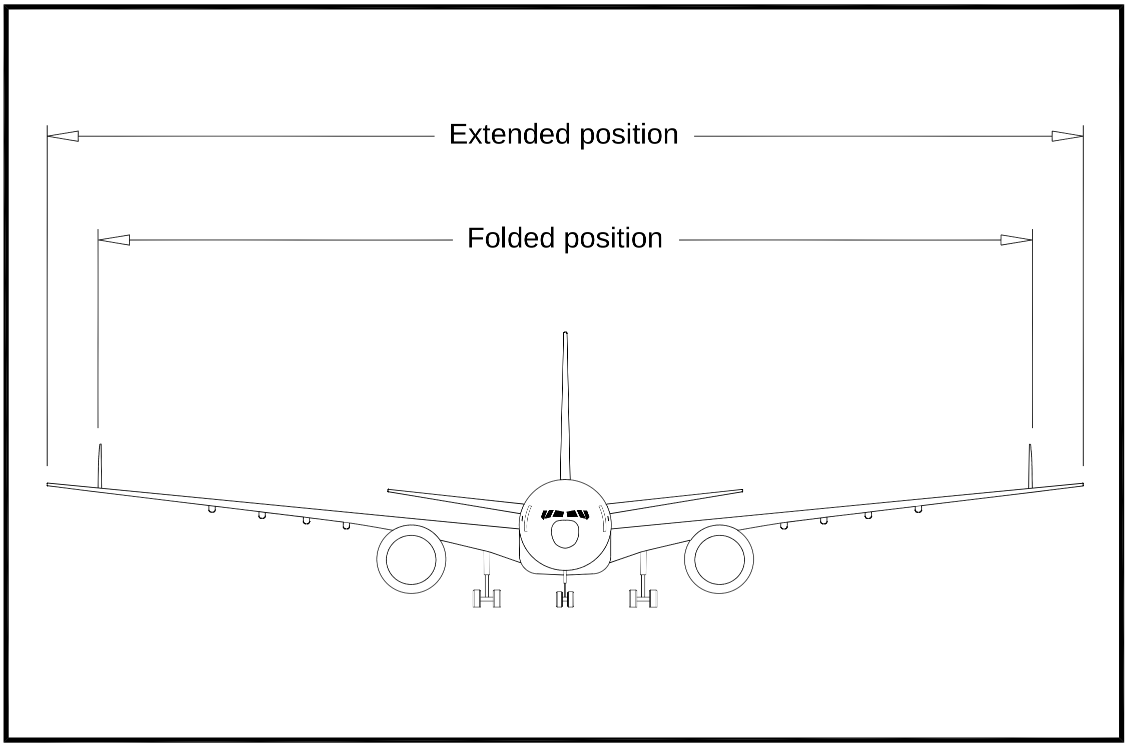
A.2 Background.

A.2.1 Aircraft physical characteristics have operational and economic significance affecting an airport's design, development, and operation. They influence the design aspects of runways, taxiways, ramps, aprons, servicing facilities, gates, and life safety facilities. Their consideration when planning a new airport or improving existing airport facilities maximizes facility utilization and safety. Anticipate growth in air traffic and the effects of near future model aircraft operating weights and physical dimensions.

A.2.2 Military aircraft frequently operate at civil airports. Meet the physical characteristics for military aircraft at joint-use airports. Therefore, consider routine military operations such as medical evacuation, strategic deployment and dispersal, and Reserve and National Guard training missions during airport facility design.

A.2.3 Aircraft with folding wingtip technology occupy two different ADGs depending on the status of the wingtips. Folded wingtips allow aircraft with this technology to access parts of the airport with a smaller critical ADG than with the wingtips extended, without a need for operational mitigations. See Figure A-3.

Figure A-3. Folding Wingtips



A.3 Aircraft Arranged by Aircraft Manufacturer, and Runway Design Code (RDC).

A.3.1 Aircraft Characteristics Database.

Aircraft characteristics guides (sometimes known as Airport Planning Manuals, or APMs) provide relevant information and are available from aircraft manufacturers. The FAA's Aircraft Characteristics Database is located at http://www.faa.gov/airports/engineering/aircraft_char_database/.

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APPENDIX B. WIND ANALYSIS

B.1 Objective.

This appendix provides guidance on the basics of wind coverage, allowable crosswind components to aid in runway orientation, wind data sources, and methods of analyzing wind data. Accurate analysis of the wind coverage adds substantially to the safety and utility of an airport. Airport planners and designers conduct an accurate analysis of wind to determine primary runway orientation and coverage, and if a crosswind runway is necessary at an airport.

B.1.1 Wind conditions affect all aircraft to some degree. Generally, wind affects small aircraft to a greater degree than large aircraft having larger rudders. Adverse crosswind conditions are often a contributing factor in small aircraft accidents. During wind conditions exceeding the allowable crosswind component for an aircraft type (or the pilot's skill level), during approach the pilot may divert to another airport in the interest of maintaining flight safety. If departing, the pilot may elect to wait until more favorable conditions occur.

B.2 Coverage and Orientation of Runways.

Wind coverage is the percent of time crosswind components are below an acceptable velocity. Normally the best runway orientation, based on wind, is the one providing the greatest wind coverage with the minimum crosswind components.

B.2.1 The desirable wind coverage for an airport is 95 percent of time based on the total numbers of weather observations during the record period of at least 10 consecutive years. Normally, use the all-weather winds to assess overall wind coverage at an airport. If wind coverage on the primary runway alone is less than 95 percent for an RDC with regular use, a crosswind runway may be justified to achieve the desired 95 percent wind coverage, provided both runways would independently have regular use of the applicable critical aircraft. A crosswind runway is not justified if the aircraft effected by the crosswind component does not meet the criteria for regular use.

B.2.2 If the primary runway orientation provides less than 95 percent wind coverage, evaluate the need for a crosswind runway.

B.2.3 When analyzing wind data, consider:

B.2.3.1 Operationally weight the wind data to reflect the shift in use periods at airports where operations are predominantly seasonal or if operations decline substantively after dark. Only use operational weighting if there are significant variations in operational levels during the applicable conditions. Note that except for the above, FAA does not consider shorter-term, seasonal variations in wind coverage as a rationale for a crosswind runway.

B.2.3.2 For locations that justify a crosswind runway for an RDC with regular use but provision of a crosswind is impractical or cost prohibitive, it is acceptable to increase the width of the primary runway to the next standard width in lieu of providing a crosswind runway. The greater width allows for better operational tolerance to crosswinds. However, if the existing primary runway is already wider than what is necessary for the RDC with crosswind constraints, a further increase in width to the primary runway is unwarranted.

Example: Consider an airport with a primary B-II runway with a width of 75 feet and less than 95 percent wind coverage for the B-II RDC. If it is impractical to provide a crosswind runway, it is acceptable to increase the width of the primary from 75 feet to 100 feet as an alternate means of meeting crosswind needs. However, if the RDC (with regular use) needing a crosswind is an A-I aircraft, which has a standard runway width of 60 feet, the existing 75-foot primary runway is already sufficiently wide for crosswind purposes. No further increase in width is justified.

B.2.3.3 Analyses will normally consider all weather and IMC wind conditions, but supplemented with VMC, Category II/III, and other specific conditions as needed. For example, the IMC wind analysis may help with identifying the best runway end for an IFP. The FAA does not consider other conditions (such as gusts) in reviewing wind coverage.

B.2.3.4 FAA recommends a wind coverage of 95 percent. Rarely do a primary and crosswind runway (if provided) yield a wind coverage of 100 percent. Having wind coverage of less than 100 percent is not a deficiency on the part of an airport.

B.3 Allowable Crosswind Components.

See Table B-1 for the allowable crosswind component(s) of each Runway Design Code (RDC) percentage of wind coverage determination. Note that individual aircraft types may have crosswind components differing from the values indicated in Table B-1. However, use the indicated crosswind component by RDC where the maximum crosswind component of the critical aircraft is less than the allowable crosswind component by RDC.

Table B-1. Allowable Crosswind Component per Runway Design Code (RDC)

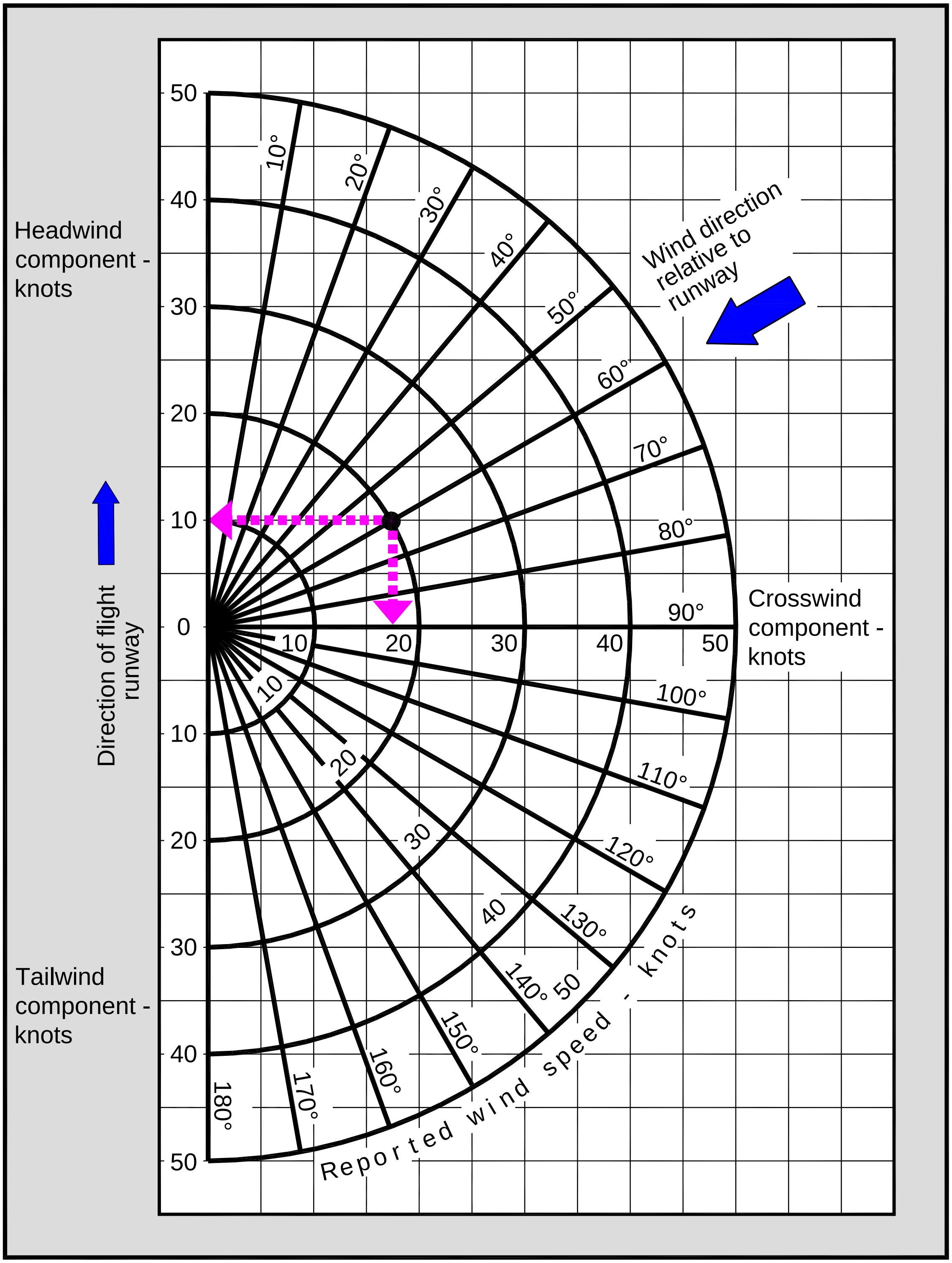
RDC	Allowable Crosswind Component
A-I and B-I *	10.5 knots
A-II and B-II	13 knots
A-III, B-III, C-I through D-III D-I through D-III	16 knots
A-IV and B-IV, C-IV through C-VI, D-IV through D-VI	20 knots
E-I through E-VI	20 knots

Note: * Includes A-I and B-I small aircraft.

B.3.1 Crosswind Components.

The crosswind component of wind direction and velocity is the resultant vector acting at a right angle to the runway. It is equal to the wind velocity multiplied by the trigonometric sine of the angle between the wind direction and the runway direction. Solve the wind vector triangles graphically as shown in Figure B-1 to determine the headwind and tailwind component for different combinations of wind velocities and directions.

Figure B-1. Wind Vector Diagram



Note: Example: Wind speed 20 knots angle between runway and direction of wind – 60° crosswind component – 17 knots. Headwind component – 10 knots.

B.4 Wind Data Sources.

1. Use the latest, most reliable wind information to carry out a wind analysis. Wind observations recorded on the airfield are more suitable than offsite observations.
   a. The FAA recommends a data period covering at least the last 10 consecutive years of wind observations. Calm wind conditions are always included in the wind data.
   b. Use up to 30 years of consecutive data if needed to assess long-term trends in weather; a 10-year sample of data is insufficient for use in trend analysis (i.e. to asses if winds are shifting with time).
2. Records of lesser duration may be acceptable on a case-by-case basis, but this requires approval by the FAA Airports Region/District Office prior to proceeding.
3. Wind data of recent vintage (newest observations are less than five years) are acceptable for analysis purposes.

B.4.1 National Climatic Data Center.

Wind information is available from the National Oceanic and Atmospheric Administration, National Climatic Data Center (NCDC). NCDC has long-term repositories of the weather data collected at most US airports. The hourly data is available at the following website: https://www1.ncdc.noaa.gov/pub/data/noaa/. NCDC data is also available via the FAA ADIP website, as described in paragraph B.5.1.

Note: NCDC wind directions based on true north. The magnetic declination for the airport determines the magnetic-based runway headings.

B.4.2 Data Not Available.

B.4.2.1 When NCDC or local AWOS data is not available for the site, develop composite wind data using wind information obtained from two or more nearby recording stations. However, exercise caution because the composite data may have limited value if there are significant changes in the topography (such as hills/mountains, bodies of water, ground cover, etc.) between the sites. Augment limited records with personal observations (wind-bent trees, interviews with the local populace, etc.) to determine if a discernible wind pattern can be established.

B.4.2.2 Obtain onsite wind observations when there is a question on the reliability of or lack of wind data. The FAA recommends at least a one-year monitoring period to produce reliable data and account for daily wind fluctuations and seasonal changes at the site. Acquire adequate wind data before proceeding with airport development.

B.5 Analyzing Wind Data.

The most common wind analysis procedure uses a computer program to assess wind coverage, as discussed in paragraphs B.5.1 and B.5.3. In addition, provide a scaled graphical presentation of the wind information for the Airport Layout Plan (ALP) per paragraph B.5.2. Analyses normally consider all weather and IMC wind conditions, and supplemented with VMC, Category II/III, and other specific conditions as needed.

B.5.1 Standard Wind Analysis Tool.

The Standard Wind Analysis Tool is on the FAA's ADIP website https://adip.faa.gov/agis/public/#/public. The Standard Wind Analysis tool performs the wind analysis specified in this AC and stores the uploaded data and calculated results to a text file (*.TBW), an AutoCAD Drawing Interchange file (*.DXF), or a scalable vector graphics file (*.SVG). Additionally, the data and results display in a browser window as a report or the traditional Windrose graphic. This tool requires the wind data files in FAA data format. Generate wind data files by selecting the Windrose File Generator as a tool option on the ADIP website.

B.5.1.1 The Windrose File Generator:

1. Connects to the Integrated Surface Hourly/Integrated Surface Data (ISH/ISD) inventory from the National Climate Data Center (NCDC).
2. Compiles and summarizes the latest 10 years of wind observations by hours from the recording station associated with the airport location ID (ICAO Identifier).
3. Produces three different types of wind data files (ALL_WEATHER, IFR, and VFR) in the standard tool format with the recording station number as a part of the filename and PRN as its file type.

B.5.1.2 Generate and download these wind summary files and later upload them into the wind table for each particular type of windrose analysis.

B.5.1.3 For background information on the NCDC's ISH/ISD wind data inventory, visit the NCDC web site. If the PRN files are in the standard tool format, use the Upload Wind Data File link to load wind data into the standard tool for analysis.

B.5.2 Windrose Graphic.

The standard graphical windrose (Figure B-2) is a series of concentric circles cut by radial lines. The perimeter of each concentric circle represents the division between successive wind speed groupings (Figure B-2). Radial lines divide the windrose into 36 wind sectors, the area of each sector centered on the reported wind direction. Figure B-3 is an example of a typical wind summary.

B.5.2.1 **Plotting Wind Data.**

Each segment of the windrose represents a wind direction and speed grouping, based on the number of hourly observations. Within each segment, the recorded directions and speeds of the wind summary convert to a percentage of the total recorded observations. Figure B-4 illustrates a completed windrose analysis based on data from Figure B-3. Plus (+) symbols indicate direction and speed combinations occurring less than one-tenth of one percent of the time.

B.5.2.2 **Runway Wind Box.**

A runway wind box is a useful aid to visualize the windrose analysis (Figure B-4). The wind box is a series of three parallel lines drawn to the same scale as the windrose. The allowable crosswind component for the runway as determined by the RDC establishes the physical distance between the outer parallel lines and the centerline. Draw the allowable crosswind component lines directly on the windrose when analyzing the wind coverage for a runway orientation.

B.5.3 Spreadsheets.

For analyses purposes, wind coverage calculations use spreadsheets that calculate the crosswind component of each hourly wind observation. Such calculations are accurate and facilitate analysis of specific conditions, such as IMC or Cat II/III weather, or seasonal or daytime/nighttime wind coverage as discussed in paragraph B.2. When requested, furnish calculations to the FAA for validation.

B.5.4 Example: Analysis Procedure for New Runway Location.

B.5.4.1 For a new airport location, the analysis determines the runway orientation providing the greatest wind coverage within the allowable crosswind component limits. This process involves rotating the runway wind box about the windrose center point to maximize the sum of the individual segment percentages appearing between the outer “crosswind limit” lines.

B.5.4.2 Figure B-4 illustrates the analysis procedure used in determining the wind coverage for a 90-270 degree runway orientation intended to serve RDC B-II. The wind information is from Figure B-3. For a new runway, iterate on several orientations to determine the orientation that maximizes wind coverage.

B.5.4.3 The example Figure B-4 wind analysis shows the optimum wind coverage possible with a single runway and a 13-knot crosswind component is 97.8 percent. If the analysis had shown it was not possible to obtain at least 95.0 percent wind coverage with a single runway, then evaluate a crosswind runway oriented to bring the combined wind coverage of the two runways to at least 95.0 percent.

Table B-2. Standard Wind Analysis Results for ALL_WEATHER

TITLE: Anytown, USA

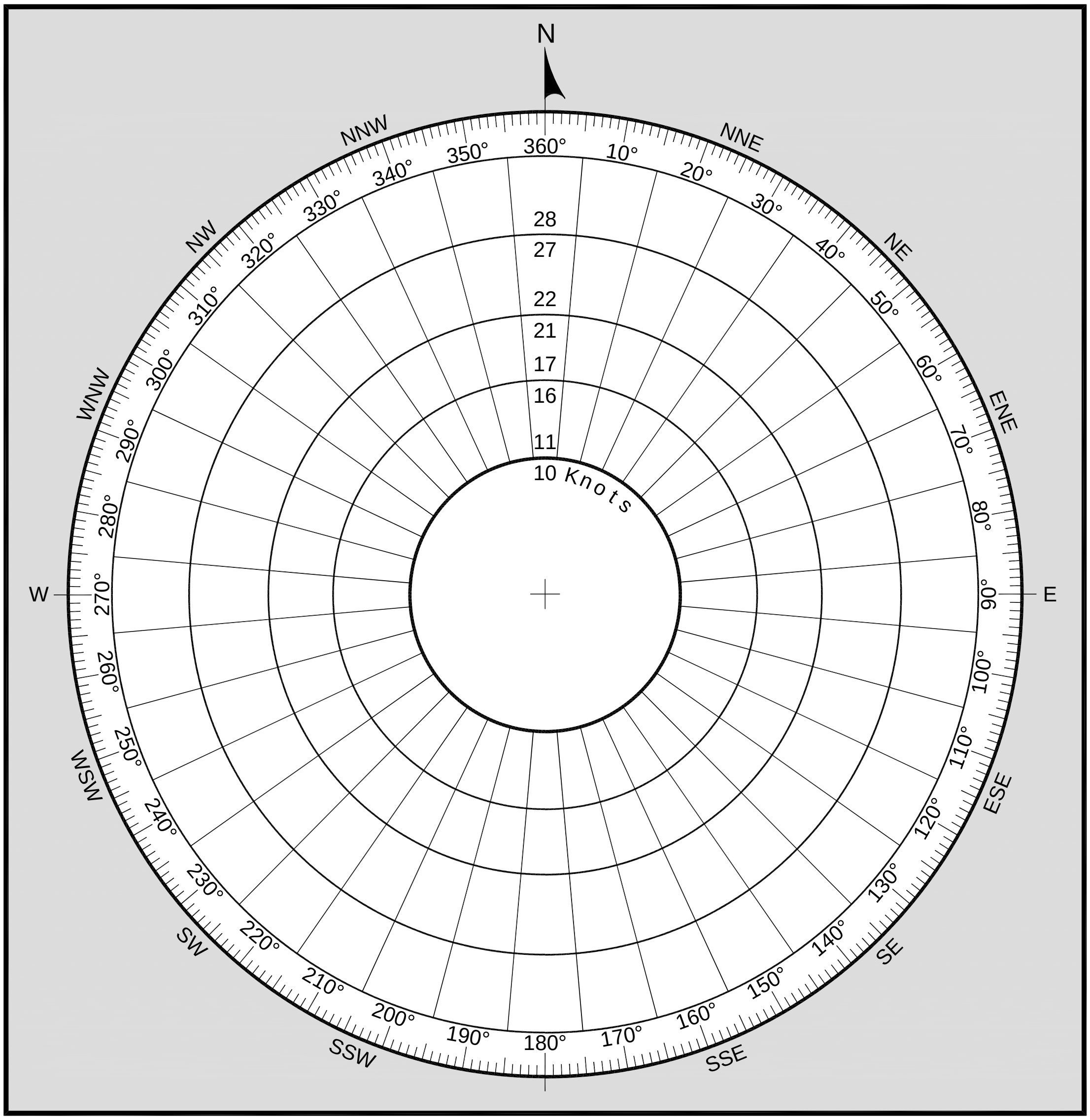
RUNWAY ORIENTATION: 270 DEGREE
CROSSWIND COMPONENT: 13 KNOTS
TAILWIND COMPONENT: 60 KNOTS

WIND COVERAGE: 97.79%

	HOURLY OBSERVATIONS OF WIND SPEED (KNOTS)									
DIRECTION	0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	> 41	TOTAL
10°	174	652	586	247	6	0	0	0	0	1665
20°	213	816	698	221	7	0	0	0	0	1955
30°	235	894	656	158	4	0	0	0	2	1949
40°	167	806	559	88	0	0	0	0	0	1620
50°	182	809	345	44	1	0	0	0	0	1381
60°	199	753	332	30	5	0	0	0	0	1319
70°	158	550	187	20	0	0	0	0	1	916
80°	134	453	194	22	1	0	0	0	0	804
90°	145	373	169	16	2	0	0	0	0	705
100°	103	321	115	19	1	0	0	0	2	561
110°	92	293	138	25	0	0	0	0	0	548
120°	90	283	207	33	3	0	0	0	0	616
130°	93	279	188	28	0	0	0	0	0	588
140°	65	246	195	55	2	0	0	0	1	564
150°	64	213	194	42	4	0	0	0	0	517
160°	61	236	201	105	16	1	0	0	1	621
170°	80	254	306	140	10	2	0	0	1	793
180°	88	372	485	194	25	2	0	0	0	1166
190°	125	499	608	278	17	2	0	0	0	1529
200°	184	717	700	370	27	2	0	0	0	2000
210°	264	950	725	331	26	0	0	0	2	2298
220°	321	1419	1030	445	40	5	0	0	0	3260
230°	396	1658	1355	630	97	9	1	0	0	4146
240°	415	1600	1465	782	83	13	2	0	1	4361
250°	323	1166	1093	730	119	33	5	0	0	3469
260°	311	979	918	715	139	23	4	0	0	3089
270°	248	760	810	660	143	28	3	0	0	2652
280°	226	625	815	666	105	14	2	0	0	2453
290°	162	572	865	710	98	11	0	0	0	2418
300°	130	470	788	590	68	5	0	0	0	2051
310°	82	394	659	325	31	1	0	0	0	1492
320°	97	302	485	246	15	0	0	0	0	1145
330°	66	281	450	196	6	1	0	0	0	1000
340°	85	265	369	151	4	1	0	0	0	875
350°	102	314	323	152	12	0	0	0	0	903
360°	140	394	457	223	16	0	0	0	0	1230
Calm	18705									18705
TOTAL	24725	21968	19670	9687	1133	153	17	0	11	77364

SOURCE: Anytown, USA ANNUAL PERIOD RECORD 1995-2004
REFERENCE: Appendix 1 of AC 150/5300-13, Airport Design, including Changes 1 through 18.

Figure B-2. Blank Windrose Graphic Showing Direction and Divisions



Wind Speed Divisions		Radius of Circle
Knots	MPH	Knots
0 – 3.5	0 – 3.5	*3.5 units
3.5 – 6.5	3.5 – 7.5	*6.5 units
6.5 – 10.5	7.5 – 12.5	10.5 units
10.5 – 16.5	12.5 – 18.5	16.5 units
16.5 – 21.5	18.5 – 24.5	21.5 units
21.5 – 27.5	24.5 – 31.5	27.5 units
27.5 – 33.5	31.5 – 38.5	*33.5 units
33.5 – 40.5	38.5 – 46.5	*40.5 units
40.5 – over	46.5 – over	

Note: * may not be needed for most windrose analyses

Figure B-3. Completed Windrose Graphic Using Table B-2 Data

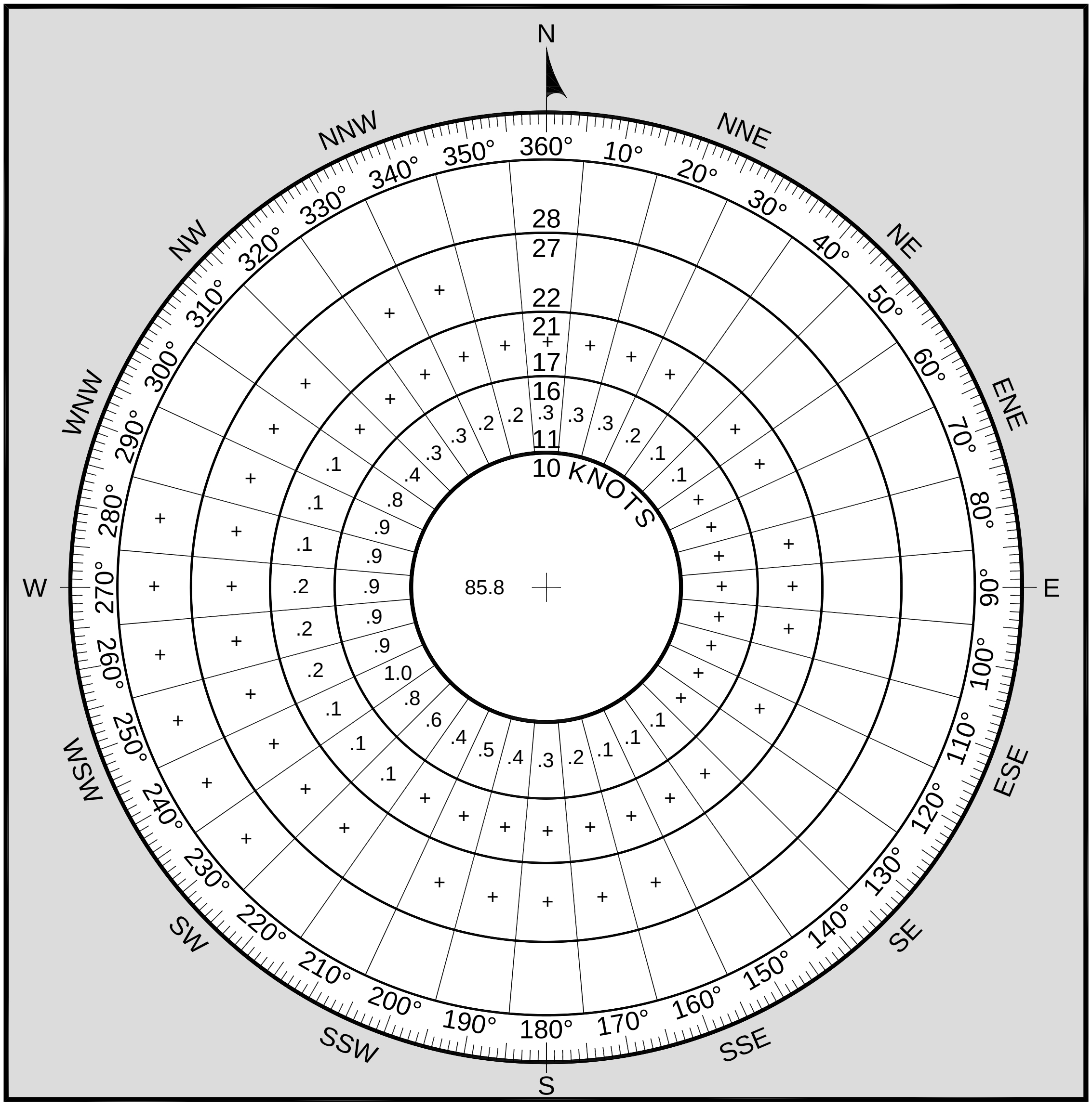
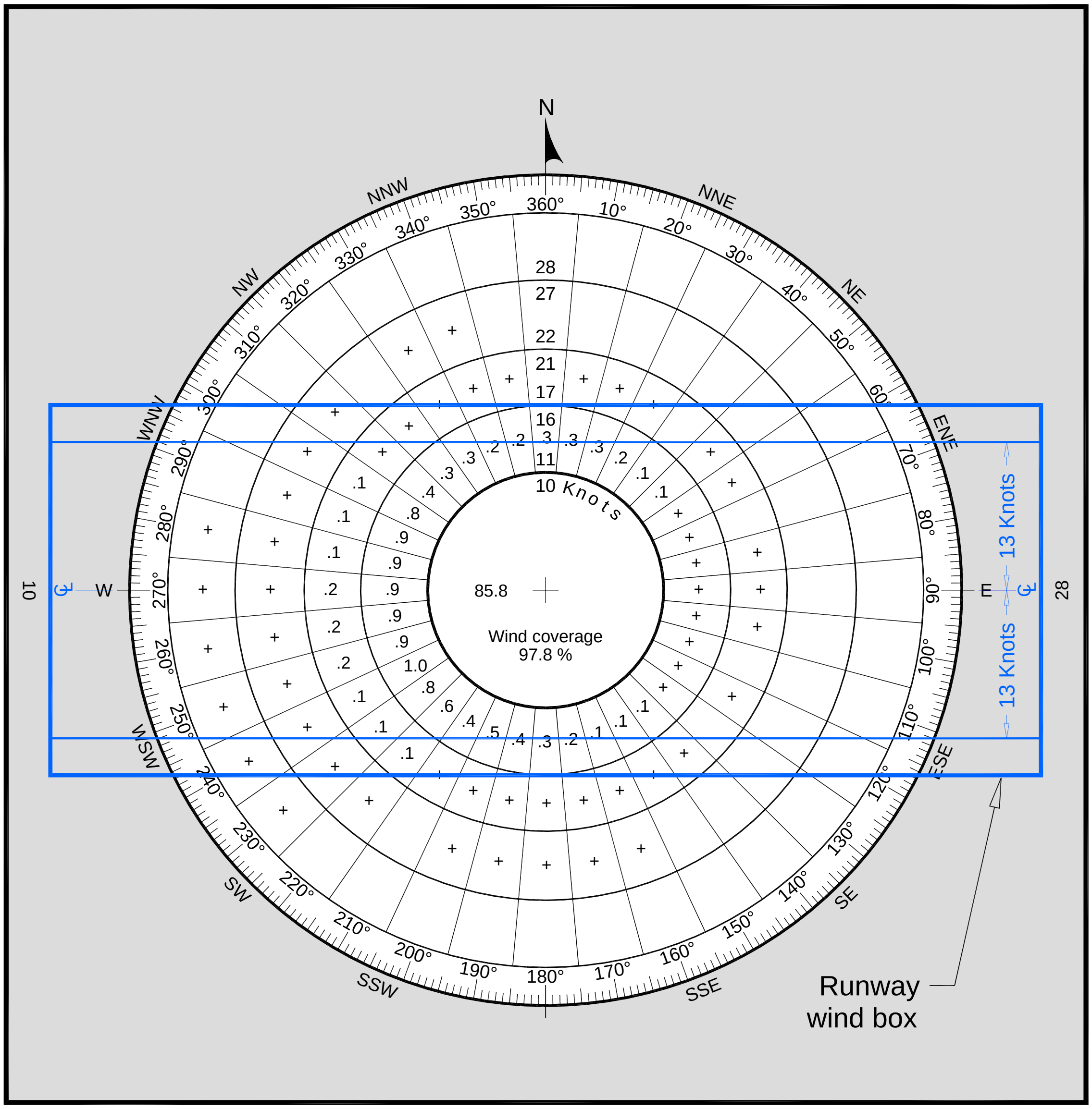


Figure B-4. Windrose Analysis



Note 1: Runway oriented 90 degree – 270 degree (true) would only have 2.2 percent of the winds exceeding the 13-knot crosswind component.

Note 2: Wind directions are recorded based on true north. The magnetic runway headings are determined based on the magnetic declination for the area.

Example: If the magnetic declination is 12 degrees W, the runway designators for the above runway would be 10 – 28.

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APPENDIX C. THE EFFECTS AND TREATMENT OF JET BLAST

C.1 Introduction.

Jet blast (jet exhaust) forces produce very high wind velocities and temperatures. Jet blast is capable of causing bodily injury to personnel; damage to airport equipment and facilities; airfield pavement; and ground erosion along the edge of pavements. This appendix recommends ways to minimize the effects of jet blast.

C.2 Jet Blast Effects.

Jet blast has the potential to affect all aircraft operational areas. Velocities greater than 30 mph (48 km/hr) can cause loose objects on the pavement to become airborne, risking injury to personnel, structures and equipment at considerable distances behind an aircraft. Sudden gusts averaging more than 20 mph (31 km/hr) can be more dangerous than continuous velocities of the same magnitude when striking moving vehicles or aircraft. Aircraft engines operating at takeoff thrust, can produce velocities of this magnitude over 2,000 feet (610 m) to the rear of some aircraft.

C.2.1 Jet Blast Pressures.

Jet exhaust velocities are irregular and turbulent. Consider the vibrations they induce over small areas when designing a building or structure subjected to jet blast. Assume the velocities to be periodic over areas of 10 to 15 ft^2 (1.0 to 1.4 m^2) with peaks occurring at 2 to 6 times per second. These peaks are not continuous laterally or vertically. Use the following equations to compute the pressure produced on a surface perpendicular to the exhaust stream:

$$P = 0.00256\,V^2$$

where:

P = pressure (lbs/ft^2)

V = velocity (mi/hr)

or

$$P = 0.04733\,V^2$$

where:

P = pressure (pascals)

V = velocity (km/hr)

C.2.2 Blast Velocity Distances.

The drag and uplift forces produced by jet engines are capable of moving large boulders. A jet engine operating at maximum thrust is capable of lifting a 2-foot (0.6 m) boulder located 35 feet (10.7 m) behind the aircraft. Forces capable of causing severe erosion decrease rapidly with distance and beyond 1200 feet (366 m) behind some aircraft, only sand and cohesionless soils are affected.

C.2.3 Jet Engine Exhaust Velocity and Temperature.

Aircraft manufacturers provide information on the exhaust velocities and temperatures for their respective aircraft and engine combinations. Typically, contours are provided for ground idle, breakaway (typical taxiing condition), and maximum takeoff power conditions under specific conditions (sea level, static airplane, zero wind, standard day conditions). Airport planning guides and/or airplane characteristics provide this information and are available on the aircraft manufacturer websites. Obtain data on lateral and vertical velocity contours, as well as site specific blast loads on structures, from the engine manufacturers.

APPENDIX D. END-AROUND TAXIWAY (EAT) SCREENS

D.1 Screen Sizing.

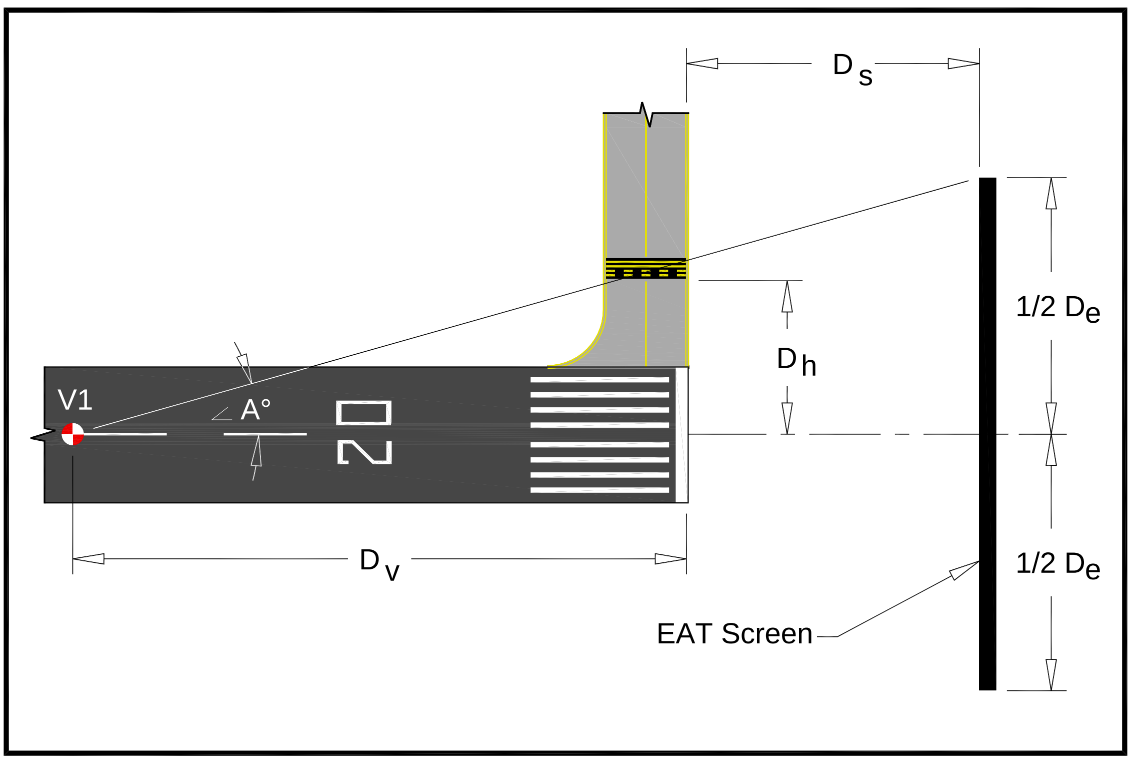
The size of the EAT visual screen is dependent on the runway geometry, the Runway Design Code (RDC) of the aircraft operating on that particular departing runway and EAT, and the relative elevations of the EAT, V_1 point, the ground at the screen, and the stop end of the runway.

D.1.1 Horizontal Geometry.

Base the design of the screen width on a departing aircraft's view from a location at point V_1 through the farthest point on the runway hold line at the stop end of the runway. See Figure D-1. To calculate the screen width:

1. Determine the distance between the screen location and the runway end (D_S).
2. From the runway centerline V_1 point, draw lines through the runway hold line position closest to the stop end of the runway (normally derived from the Hold Line Position in the online Runway Design Standards Matrix Tool.
3. Extend the lines to intersect with a line perpendicular to the runway at the screen location.
4. Using the formula in the Figure D-1 notes, calculate the width of the visual screen.

Figure D-1. End-Around Taxiway (EAT) Screen Sizing and Location



Notes for Figure D-1:

$$\angle A = \arctan \frac{D_h}{D_v}$$

$$\left(\tan \angle A\left(D_v + D_s\right)\right) = \frac{1}{2} D_e$$

Where:

D_V = 0.4 × Runway Length
D_S = Distance from the stop end of the runway to the screen.
D_h = Distance from the runway centerline to the hold line.
D_e = Width of the EAT visual screen.

D.1.2 Vertical Geometry.

Design the height of the screen so the top of the screen will mask that portion of an aircraft that extends up to the top of a engine nacelle of the Airplane Design Group (ADG) taxiing on the EAT, as viewed from the cockpit of the same ADG at the V_1 point on the departure runway (see Figure D-3).

1. Extend the visual screen from the ground to the calculated height.
2. For ADG-III and above, it is permissible to have the lower limit of the visual screen up to two feet (0.5 m) above the stop end of the runway elevation.
3. Consider variations in terrain at the site where the screen is constructed.
4. It may be feasible to grade the site of the visual screen to allow for an additional 2-foot (0.5 m) separation between the visual screen panels and the ground for mowing access.
5. A visual screen is not necessary if terrain masks the engine nacelle of the aircraft on the EAT (see Figure D-4).

D.2 Screen Construction.

Construct the visual screen to perform as designed and be durable, resistant to weather, frangible, and resistant to expected wind load. The visual screen comprises foundations, frame, connection hardware, and front panels.

D.2.1 Foundations.

Design foundation supports to maintain the visual screen in a stable position. Provide a sufficient mow strip around the base of the foundation to provide a safety buffer between mowing equipment and the screen structure.

D.2.2 Frame.

Construct the frame structure of the screen to withstand wind loading with breakaway capability in the event of an aircraft strike. Figure D-4 illustrates examples for constructing the frame structure, depending on the overall height of the structure. Application of the described hollow structural sections (HSS) includes examination and verification of accuracy, suitability and structural sufficiency by a licensed structural engineer. Ensure no HSS damage occurs due to water infiltration and freezing. Construct the visual screen structure to allow the front panels of the screen to be angled upward 12 (±1°) degrees from the vertical plane.

Figure D-2. EAT Screen Vertical Dimension Calculation

To calculate the required height of the screen above grade, H_S:

$$H_s = \frac{(ELEV_{V1} + H_{EYE} - H_{NACELLE} - ELEV_{EAT})\,(D_{EAT} - D_S)}{(D_{EAT} + 0.4 \times L_{RWY})} + H_{NACELLE} + ELEV_{EAT} - ELEV_{GAS}$$

Where:

$ELEV_{V1}$ = MSL elevation of the runway centerline at the V_1 point, 60% of the length of the runway from the takeoff threshold

$ELEV_{SER}$ = MSL elevation of the stop end of the runway (SER).

$ELEV_{TOS}$ = MSL elevation of the top of the screen.

$ELEV_{NACELLE}$ = MSL elevation of the top of the engine nacelle.

$ELEV_{GAS}$ = MSL elevation of the ground at the screen.

$ELEV_{EAT}$ = MSL elevation of the centerline of the EAT.

$H_{NACELLE}$ = Height of the engine nacelle above the taxiway (See Table D-1 below).

H_{EYE} = Height of the pilot's eye above the runway (See Table D-1 below).

L_{RWY} = Length of the runway.

D_S = Distance from the stop end of the runway to the screen.

D_{EAT} = Distance from the stop end of the runway to the centerline of the EAT.

Check that the screen is below the 40:1 departure surface:

$H_s + ELEV_{GAS} < D_S/40 + ELEV_{SER}$,

Figure D-3. Stop End of the Runway/EAT Elevation Difference

A visual screen is not required if the elevation of the EAT is lower than the elevation of the stop end of the runway by at least:

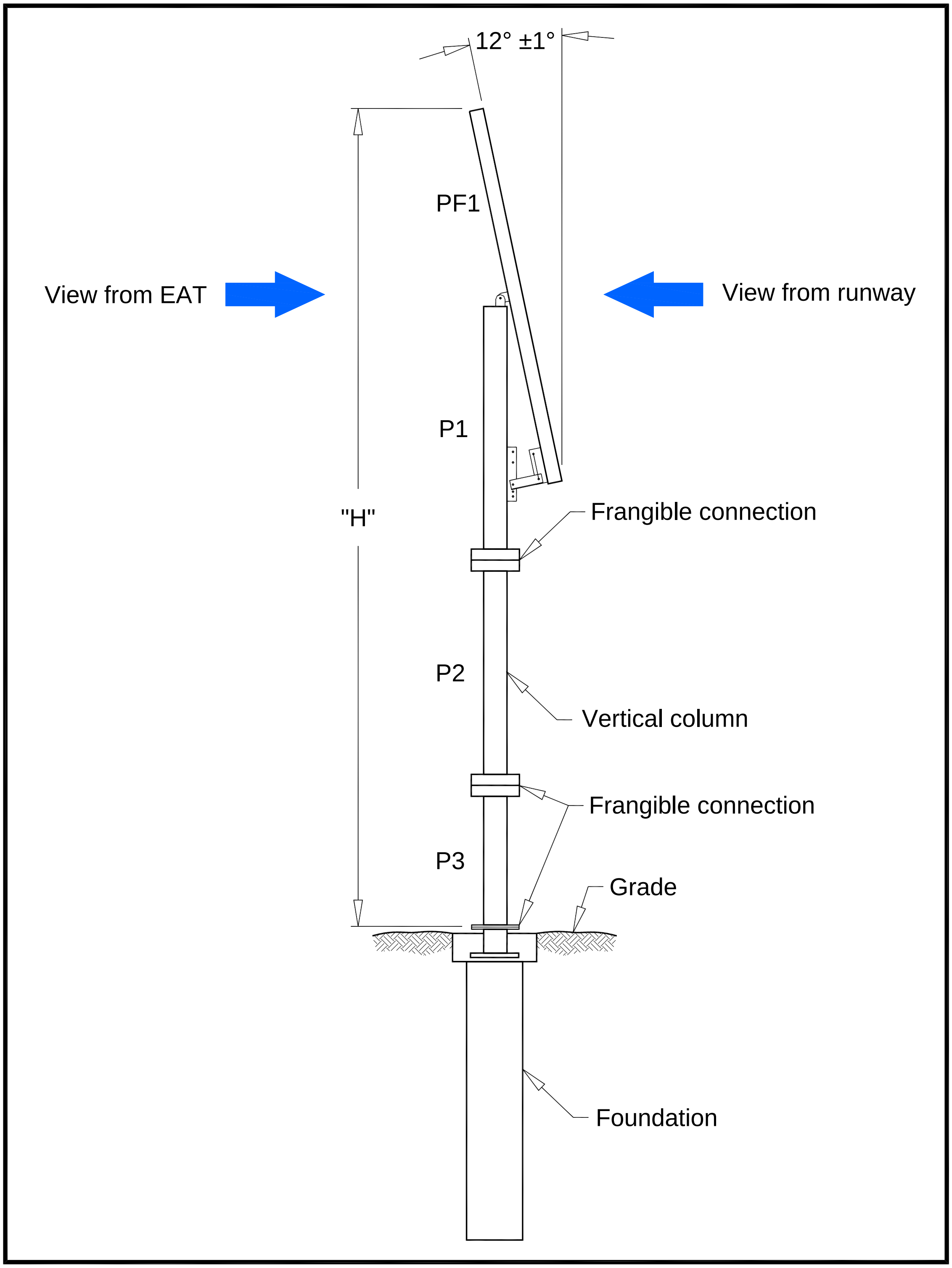
$$\frac{H_{EYE} \times D_{EAT}}{.4 \times L_{RWY}} - H_{NACELLE}$$

Table D-1. Aircraft Characteristics

ADG	Nacelle Height (feet) ($H_{NACELLE}$)	Pilot’s Eye Height (feet) (H_{EYE})
III	9	15
IV	12	21
V	18	29
VI	18	29

Note: 1 ft = 0.305 m

Figure D-4. Example Visual Screen Structure



Note: See Table D-2, Table D-3, and Table D-4 for framing schedules.

Table D-2. Notes for Figure D-4 – High Frame Elevation

Framing Schedule Visual Screen 26 ft (8 m) < H ≤ 32 ft (10 m)			
	Wind Speed (mph)		
Member	90	130	150
P1	HSS 8×6×5/16	HSS 8×8×1/2	HSS 12×8×3/8
P2	HSS 10×6×1/2	HSS 12×8×9/16	HSS 16×8×1/2
P3	HSS 12×6×1/2	HSS 16×8×1/2	HSS 20×8×1/2
PF1	HSS 6×4×3/16	HSS 6×4×5/16	HSS 6×4×5/16

Table D-3. Notes for Figure D-4 – Intermediate Frame Elevation

Framing Schedule Visual Screen 18 ft (5 m) < H ≤ 26 ft (8 m)			
	Wind Speed (mph)		
Member	90	130	150
P1	HSS 8×6×5/16	HSS 8×8×1/2	HSS 12×8×3/8
P2	HSS 10×6×1/2	HSS 12×8×9/16	HSS 16×8×1/2
P3			
PF1	HSS 6×4×3/16	HSS 6×4×5/16	HSS 6×4×5/16

Table D-4. Notes for Figure D-4 – Low Frame Elevation

Framing Schedule Visual Screen H ≤ 18 ft (5 m)			
	Wind Speed (mph)		
Member	90	130	150
P1	HSS 8×6×5/16	HSS 8×8×1/2	HSS 12×8×3/8
P2			
P3			
PF1	HSS 6×4×3/16	HSS 6×4×5/16	HSS 6×4×5/16

D.2.3 Front Panel.

Design the front panel of the visual screen so it is conspicuous from the runway side of the screen. Replaceable front panels 12 feet (3.5 m) long and 4 feet (1 m) high and attached to the frame structure allow easy replacement if necessary. See Figure D-6. The following design is acceptable in meeting design criteria.

D.2.3.1 **Aluminum Honeycomb Criteria.**

The screen panels are constructed of aluminum honeycomb material.

1. The front panel of the screen consists of 4-foot-tall (1 m) panels, with the remaining difference added as needed.
   a. For example, three 4-foot (1 m) high panels plus one 1-foot (0.5 m) tall panel creates a 13-foot (4 m) tall screen.
2. Provide a 0.5-inch space between panels to allow for thermal and deflection movements.
3. Specify the front and back panel faces to:
   a. meet the required deflection allowance, and
   b. be a minimum 0.04 inches (1 mm) thick.
4. Provide honeycomb material is of sufficient thickness to meet the deflection allowance, but not more than 3 inches (76 mm) thick.
5. Design the internal honeycomb diameter for the sufficient strength needed to meet the deflection allowance, but not more than 0.75 inches (19 mm).
6. Provide panel edge closures that consist of aluminum tubing that is:
   a. 1-inch (25 mm) times the thickness of the honeycomb
   b. sealed.
7. The deflection allowance for the screen is 0.5 inches (13 mm) maximum at the center of the panel when supported by four points at the corner of the panel.
8. Provide panel faces with a clear anodized finish on both front and back.

D.2.3.2 **Pattern.**

The front panel of the screen visually depicts a continuous, alternating red and white, diagonal striping of 12-foot (3.5 m) wide stripes set at a 45-degree angle ±5 degrees, sloped either all to the left or all to the right. To provide maximum contrast, the slope of the diagonal striping on the screen is opposite the slope of aircraft tails operating in the predominant flow on the EAT, as shown in Figure D-6.

D.2.3.3 **Color.**

The front panel of the screen is retroreflective red and white. The colors of the retroreflective sheeting used to create the visual screen conform to Chromaticity Coordinate Limits shown in Table D-5, when measured in accordance with FP-85, Section 718.01(a), or ASTM D4956.

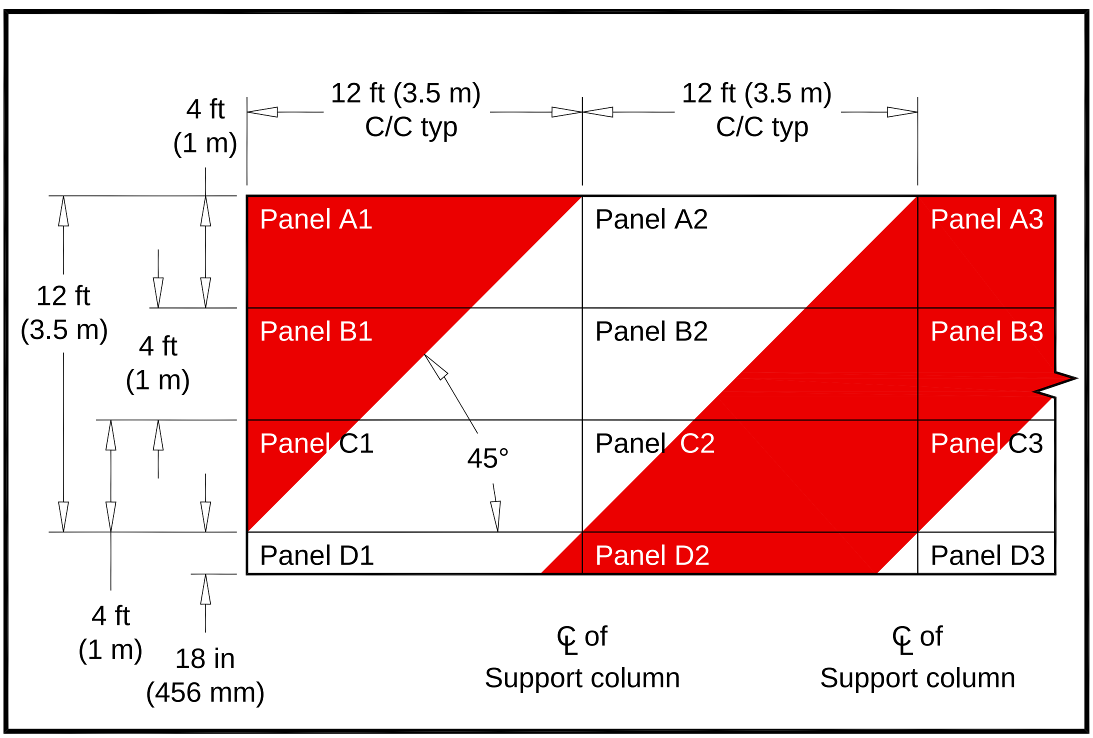
D.2.3.4 **Reflectivity.**

The surface of the front panel is reflective on the runway side of the screen. Perform reflectivity measurements in accordance with ASTM E810. Acceptance requires the sheeting maintain at least 90 percent of its values, as shown in Table D-6, with water falling on the surface, when measured in accordance with the standard rainfall test of FP-85, Section 718.02(a), and Section 7.10.0 of AASHTO M268.

D.2.3.5 **Adhesion.**

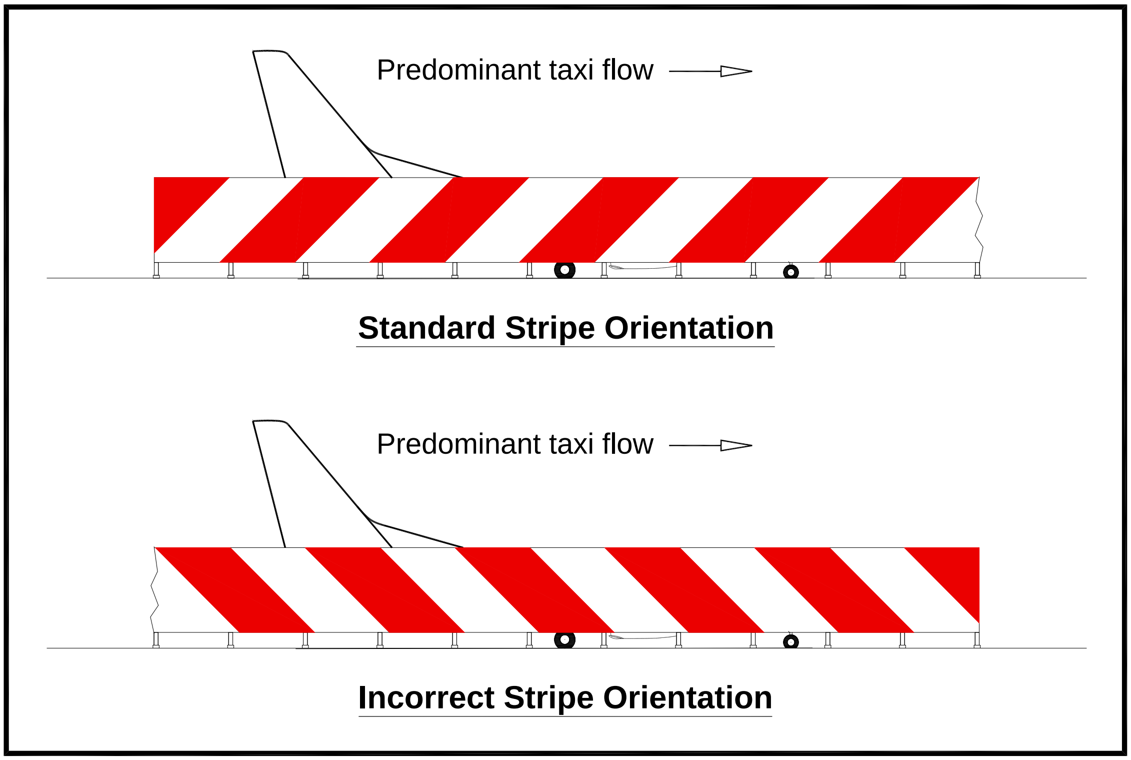
The screen surface material has a pressure-sensitive adhesive, which conforms to adhesive requirements of FP-85 (Class 1) and ASTM D4956 (Class 1).

Figure D-5. Example Panel Layout for 13-foot (4 m) High Screen



Note 1: Unless otherwise noted, dimensions are expressed as feet (meters)
Note 2: The front panels of the screen are retroreflective red and white.
Note 3: Panel A2 is the same as panel C1 rotated 180°
Note 4: Panel B2 is the same as panel B1 rotated 180°
Note 5: Panel C2 is the same as panel A1 rotated 180°

Figure D-6. Visual Screen Stripe Orientations



Note: The front panel of the screen is retroreflective red and white (see paragraph D.2.3.3).

Table D-5. International Committee of Illumination (CIE) Chromaticity Coordinate Limits

Color	x	y	x	y	x	y	x	y	Min	Max	Munsell Paper
White	.303	.287	.368	.353	.340	.380	.274	.316	35		6.3GY 6.77/0.8
Red	.613	.297	.708	.292	.636	.364	.558	.352	8.0	12.0	8.2R 3.78/14.0

Table D-6. Minimum Coefficient of Retroreflection Candelas/Foot Candle/Square Foot/Candelas/Lux/Square Meter

Observation Angle [1] (Degrees)	Entrance Angle [2] (Degrees)	White	Red
0.2	-4	70	14.5
0.2	+30	30	6.0
0.5	-4	30	7.5
0.5	+30	15	3.0

Note 1: Observation (Divergence) Angle – The angle between the illumination axis and the observation axis.
Note 2: Entrance (Incidence) Angle – The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.
Note 3: Reflectivity acceptance criteria: conform to FP-85 Table 718-1 and ASTM D4956.

D.2.4 Environmental Performance.

Design the front panel of the screen and all its components for continuous outdoor use under the following conditions:

D.2.4.1 Temperature.

Design screen surface material to withstand an ambient temperature range of -4°F to +130°F (-20°C to +55°C).

D.2.4.2 Wind Loading.

Design the screen to sustain exposure to a wind speed of at least 90 mph (145 k/h) or the appropriate wind speed anticipated for the specific airport location, whichever is greater. See Table D-7 for wind pressures.

Table D-7. Visual Screen Panel Wind Loads

Wind Speed (mph [k/h]) (3 second gust)	Wind Load (PSI)
90 mph (145 k/h)	0.17
130 mph (209 k/h)	0.35
150 mph (241 k/h)	0.47

D.2.4.3 **Rain.**

Design screen surface material to withstand exposure to wind-driven rain.

D.2.4.4 **Sunlight.**

Design screen surface material to withstand exposure to direct sunlight UV rays without fading outside of Table D-5 criteria.

D.2.4.5 **Lighting.**

If required, the top edge of the visual screen is illuminated with steady burning, L-810 FAA-approved obstruction lighting, as provided in AC 150/5345-43 and positioned as specified in AC 70/7460-1.

D.2.5 Provision for Alternate Spacing of Visual Screen.

If access is necessary through the area where the visual screen is constructed, stagger the various sections of the screen up to 50 feet (15 m) from each other, as measured from the runway end, so an emergency vehicle can safely navigate between the staggered sections of screen. Overlap the sections of screen so the screen appears to be unbroken when viewed from the runway at the V_1 takeoff position.

D.2.6 Frangibility.

Design the screen structure, including all of its components, to be of the lowest mass possible to meet the design criteria while minimizing damage should the structure be struck. Design the foundations at ground level so they will shear on impact; design the vertical supports so they will give way; and design the front panels so they release from the screen structure if struck. Tether the vertical support posts at the base so they will not tumble when struck. See Figure D-4 for an example of structure frangibility. See AC 150/5220-23 for more information.

D.2.7 NAVAIDs Considerations.

When designing the location and orientation of the visual screen, consider the possible effects the screen may have on nearby NAVAIDs. Due to the complexity of various airport configurations, each installation will have different factors and limitations to consider. Implement necessary design actions to mitigate potential impacts to NAVAID performance.

D.2.7.1 **Approach Light Plane.**

No part of the visual screen may penetrate the approach light plane.

D.2.7.2 **Radar Interference.**

Research has shown that a visual screen erected on an airport equipped with Airport Surface Detection Equipment (ASDE) may reflect signals that have an adverse effect on ASDE performance. To avoid this, tilt the visual screen back/away (on the side facing the ASDE) 12 degrees (±1°). This will minimize or eliminate false radar targets generated by reflections off the screen surface. See Figure D-4.

D.2.7.3 Instrument Landing System (ILS) Interference.

Research has shown that a visual screen on a runway equipped with an ILS system (localizer [LOC] and glideslope [GS]) will generally not affect or interfere with the operation of the system. Perform an analysis for GSs, especially null reference GSs, prior to the installation of the screens.

APPENDIX E. GENERAL AVIATION FACILITIES

E.1 Background.

This appendix addresses design considerations and guidelines for general aviation facilities that include:

- General Aviation Aprons
- Hangars
- Terminal buildings
- Airport Support Facilities
- Fencing

E.1.1 Standards.

1. Refer to Chapter 5 for FAA standards that apply to aprons.
2. Refer to Chapter 6 for FAA standards that apply to airfield buildings.

E.1.2 Location.

GA facilities may exist at an airport primarily for GA operations; or within a segregated portion of a commercial service airport.

E.1.3 Basic Design Principles.

Consider the following basic design guidelines when planning and designing GA facilities.

1. Maintain safety of taxiing and parked aircraft.
2. Develop facilities in a manner that does not adversely affect runway surfaces (e.g. approach/departures surfaces, OFZs, etc.), imaginary surfaces for air navigation (see paragraph 3.3.12) and equipment critical areas (e.g. ILS, VOR, etc.).
3. Design facilities to optimize aircraft movement paths between parking positions, hangars, and support facilities (e.g. fueling) and any Fixed Base Operator (FBO) facilities.
4. Provide planning and design to accommodate varying aircraft types and sizes anticipated to use the airport.
5. Develop facilities in a manner that minimizes or precludes reconstruction or relocation of infrastructure in order to accommodate future growth.

E.2 General Aviation Apron.

E.2.1 General Design Considerations.

1. Evaluate apron parking positions and tie-downs for aircraft entry and exit under self-power and by tow.

2. Segregate parking areas for small aircraft (e.g. ADG I) from larger aircraft (e.g. ADG II) to optimize utility and efficiency of apron space.
3. Design separate apron areas to accommodate the critical aircraft intended to use the segment of apron.
4. Account for the effect of jet blast and propeller wash on adjacent aircraft and facilities per guidelines of paragraph 5.17.

E.2.2 Parking Position.

A parking position represents a location where aircraft can park without impeding other aircraft when parking and aircraft taxi operations on adjacent taxilanes.

E.2.2.1 Markings.

Parking positions consist of marked locations (e.g. tie downs and lead-in lines) or unmarked positions.

1. Marked parking positions provide a measure of safety for aircraft maneuvering but reduces flexibility on the size of aircraft able to park at the position.
2. Unmarked positions:
    a. Provide flexibility to handle all types of aircraft.
    b. Requires judgmental maneuvering and possibly assistance from a parking marshal or wing-walkers.

E.2.2.2 Parking Position Sizing.

To optimize space, establish separate parking areas for the different groupings of aircraft anticipated to use the airport. Table E-1 provides areas values based on the common tie down size groupings of paragraph E.2.3.3 plus applicable clearance values of Table 5-1. Airport operators may apply these values or establish custom values based on specific aircraft dimensions using its airport.

Table E-1. Parking Position Sizing

Wingspan	Length	Area
49 ft (15 m)	< 30 ft	2,070 sf (192 m^2)
49 ft (15 m)	30 to 45 ft	2,970 sf (276 m^2)
79 ft (24 m)	45 to 60 ft	5,805 sf (539 m^2)
79 ft (24 m)	60 to 75 ft	7,155 sf (665 m^2)
79 ft (24 m)	75 to 90 ft	8,460 sf (786 m^2)

Notes for Table E-1:

1. Values for area calculated by multiplying the sum of the wingspan dimension plus 10 feet by the sum of the aircraft length plus 5 feet and rounding up to the nearest multiple of 5.
2. Values for area do not include the TLOFA in front of the parking position.

E.2.3 Tiedowns.

A tiedown is a distinct type of parking stand designed to accommodate a specific range of aircraft sizes.

E.2.3.1 Benefits.

Securing aircraft reduces risk of damage to parked aircraft due to wind forces from weather events (i.e. storms, wind gusts, microbursts, etc.) and mechanical forces (i.e. jet blast, propeller wash). Unsecured parking locations expose aircraft to risk of damage from wind forces by becoming airborne, spun around or flipped over.

E.2.3.2 Tiedown Characteristics.

1. The three-point method is a common tiedown involving two tiedown anchors along the wing axis and one anchor at the tail of the aircraft.
2. Commonly includes a 6″ yellow striped marking in the shape of a tee to demonstrate location for wing axis and tail location.
3. Tiedown locations typically occur on paved aprons but may also occur in turf areas (e.g. overflow parking or tail tiedown anchor located off edge of paved apron).

E.2.3.3 Tiedown Sizing.

The sizing of tiedown parking locations at an airport is a function of the aircraft using the airport. Base tiedown area dimensions on aircraft wingspan and length. To determine suitable tiedown area dimensions, each airport operator needs to assess aircraft activity on its apron. The following guidelines show common aircraft groupings based on aircraft lengths for an airport operator to consider for its airport.

1. ADG I aircraft
   a. 30 ft aircraft length
   b. 45 ft aircraft length
2. ADG II aircraft
   a. 60 ft aircraft length
   b. 75 ft aircraft length
   c. 90 ft aircraft length
3. ADG III aircraft

a. 100 ft aircraft length

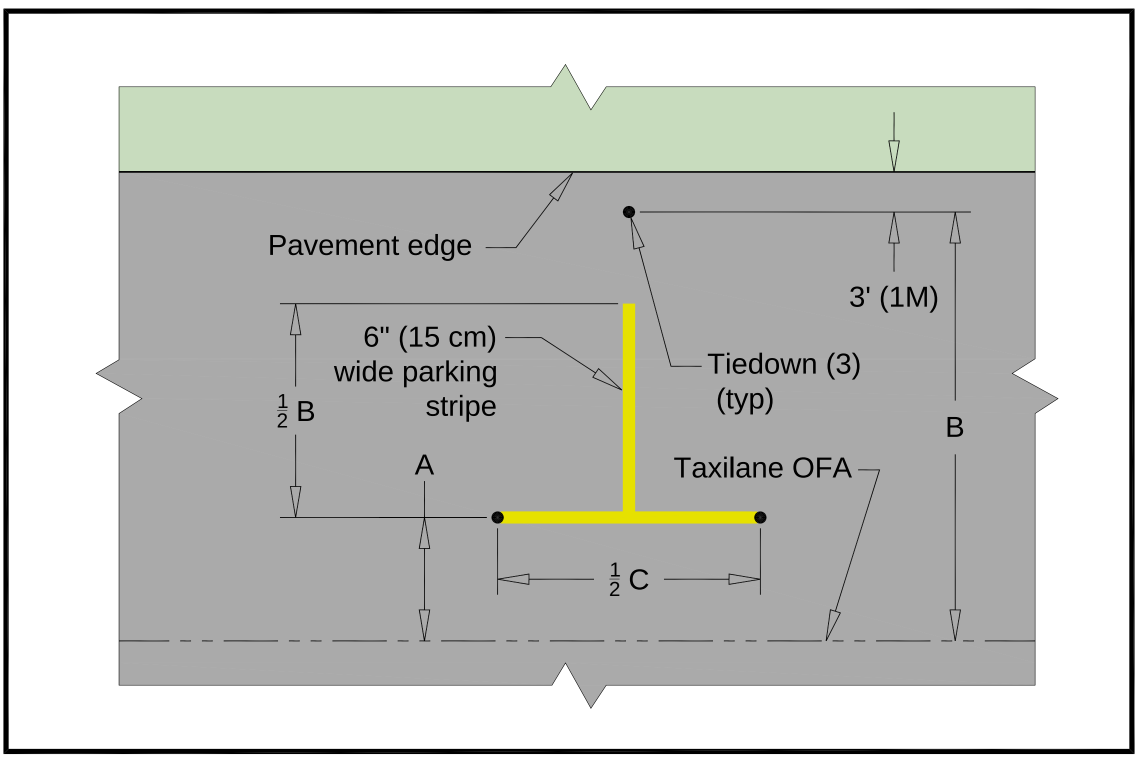
b. 115 ft aircraft length

E.2.3.4 Tiedown Anchor Layout.

Refer to Figure E-1 for an example of a tiedown layout. Airport operators may customize the tiedown layout dimensions to address local needs. Consider providing separate groupings of different tiedown layouts to accommodate varying aircraft sizes the use the airport.

1. Provide two wing tiedown anchors at the end of the marked stripe spaced at least one-half the wingspan of the critical aircraft.
2. From the edge of the TLOFA:
   a. Locate wing tiedown anchors a distance so the nose of aircraft using the tiedown does not penetrate the adjacent TLOFA.
   b. Locate the tail tiedown anchor from the TLOFA a distance not less than the length of the critical aircraft.
3. Ensure no part of the tiedown anchor protrudes above the pavement surface; or no more than 1 inch (2.5 cm) above surrounding turf.

Figure E-1. Tiedown Layout



Notes for Figure E-1:

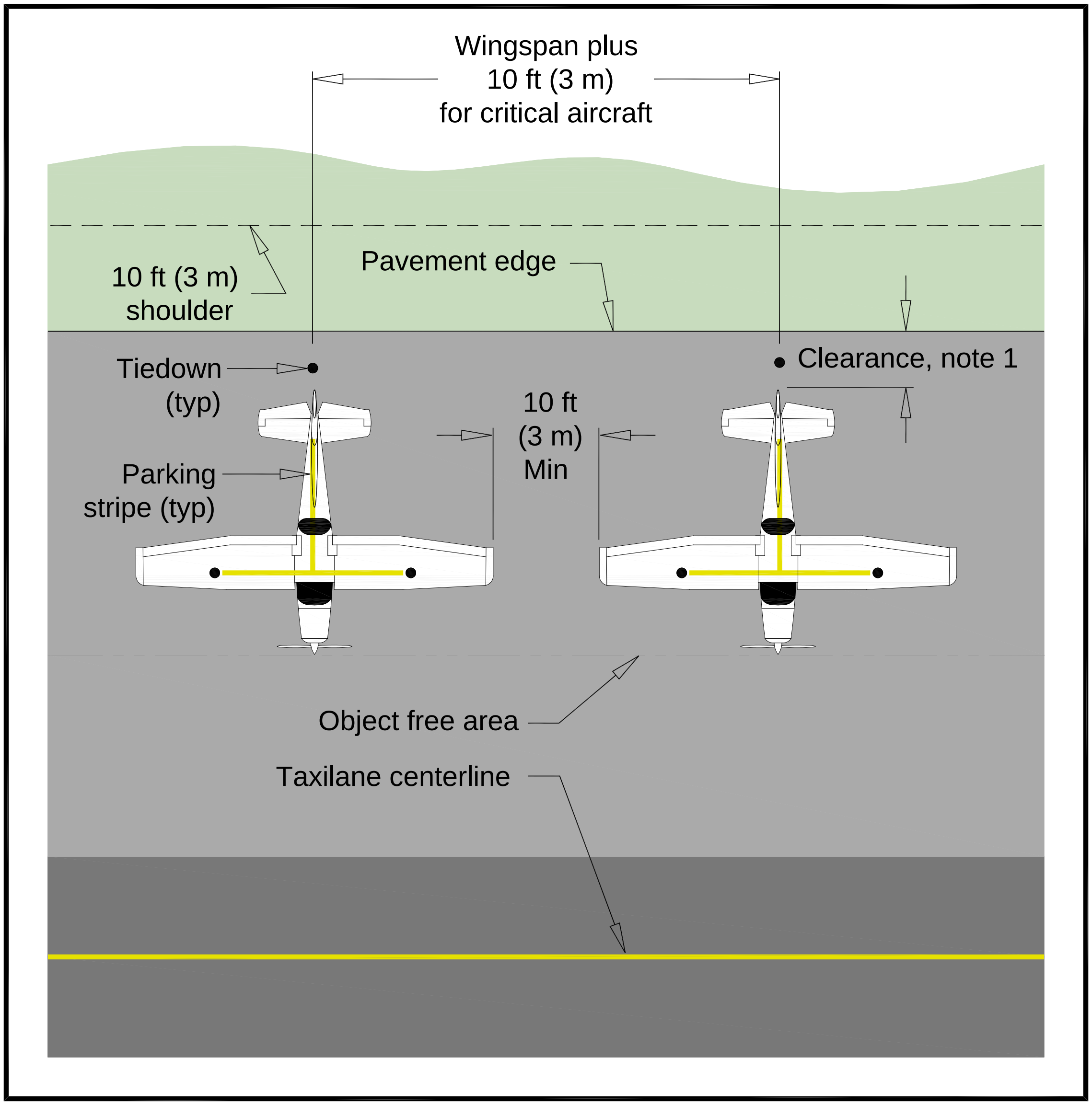
1. Figure keys:
   - A. Distance from main gear to nose of critical aircraft assuming nose of aircraft at the outer edge of the TLOFA.
   - B. Overall length of the critical aircraft.
   - C. Wingspan of the critical aircraft
2. Refer to paragraph E.2.3 for tiedown design considerations.
3. Make adjustments as necessary to ensure nose of aircraft using tie-down do not violate the TLOFA.
4. Take into account the length of tiedown ropes and the risk to propeller entanglement.

E.2.4 Apron Layout Considerations.

E.2.4.1 General.

1. Refer to Figure E-2 for illustration of tiedown spacing relationship.
2. Ensure no part of parked aircraft violates a TOFA or TLOFA.
3. Maintain recommended obstruction clearances per Table 5-1.
4. Orient parking positions to align with the direction of prevailing winds at the airport.
5. Group parking positions for similar aircraft wingspan and length to facilitate efficient layout of the apron.
6. Incorporate flexibility for infrequent operations by large aircraft (e.g. ADG-III) by designating and marking an area capable of accommodating both large and medium (ADG-II) size aircraft.

Figure E-2. Tiedown Spacing



Note 1: Provide sufficient space between pavement edge and tail to permit pilot to walk around aircraft during preflight check.

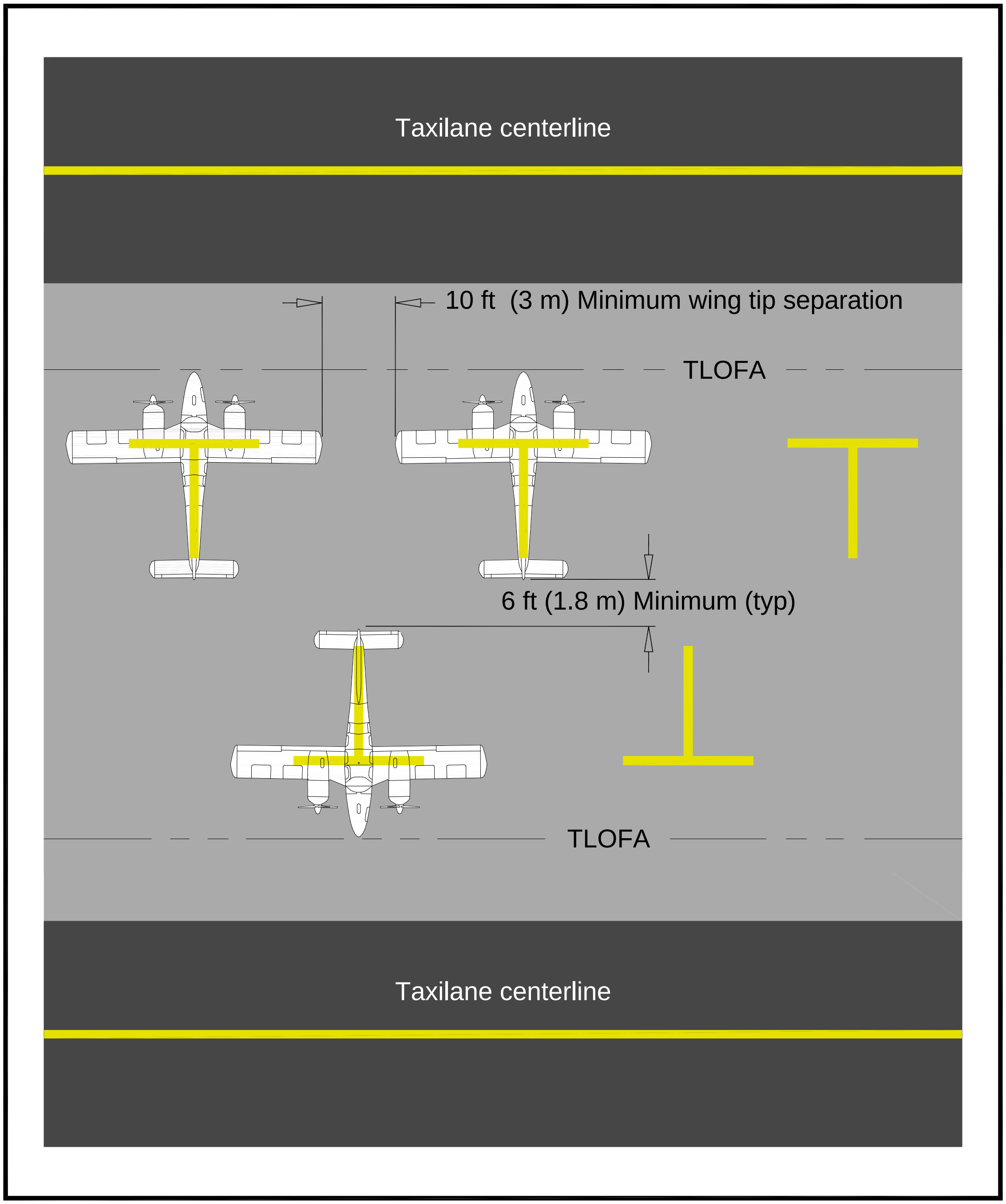
Note 2: Layout tiedowns so that no part of a parked aircraft violates a TLOFA, TOFA or ROFA.

Note 3: Depth of tiedown position is dependent on critical aircraft. Refer to paragraph **E.2.3.3**.

E.2.4.2 Nested Parking Positions.

Applying a nested parking position configuration optimizes available apron space and shortens the length of the associated taxilanes. Refer to Figure E-3. for a typical nested parking position layout. Nested parking positions also offer flexibility by accommodating both small and large aircraft.

Figure E-3. Nested Tiedowns



Note 1: Maintain clearance of TLOFA.

Note 2: Tighter clearances may be suitable when aircraft enter and exit parking position by tug.

E.2.4.3 Transient Aircraft.

1. Provide an area on the apron that enables convenient access to airport facilities (GA terminal, FBO, fuel, etc.) for transient aircraft parking.

2. Design parking positions and taxilanes to accommodate the range of aircraft sizes and types (i.e. single engine, multi-engine and jet) expected to use the airport.
3. Parking stands for transient aircraft sometimes rely on wheel chocks rather than tiedown anchors.

E.2.4.4 Based Aircraft.

1. Design parking positions to accommodate aircraft types and sizes based at the airport with consideration given to forecasted activity.
2. Parking stands for based aircraft commonly rely on tie-downs to secure aircraft.

E.2.4.5 Apron Taxilanes.

Apron activity levels, prevailing winds, the ratio of transient versus based aircraft and available space are critical factors controlling the layout and orientation of apron taxilanes. Assess the optimum layout best serving the airport's needs using these factors and the following considerations:

1. The width of a GA taxilane equals the value of the taxiway width in Table 4-2 for the applicable TDG.
2. The entire TLOFA generally consists of paved surface for interior apron taxilanes.
3. Perimeter taxilanes do not require paved surface beyond one edge of the taxilane width.
4. Single path entry/exit taxilanes are generally suitable for based aircraft parking for extended periods and where there is low potential for taxi conflict. (See Figure E-4.)
5. Dual path entry/exit taxilanes are generally suitable for transient aircraft and aprons where there is high potential for taxi conflicts. (See Figure E-5.)

Figure E-4. Single Path Entry/Exit Taxilane

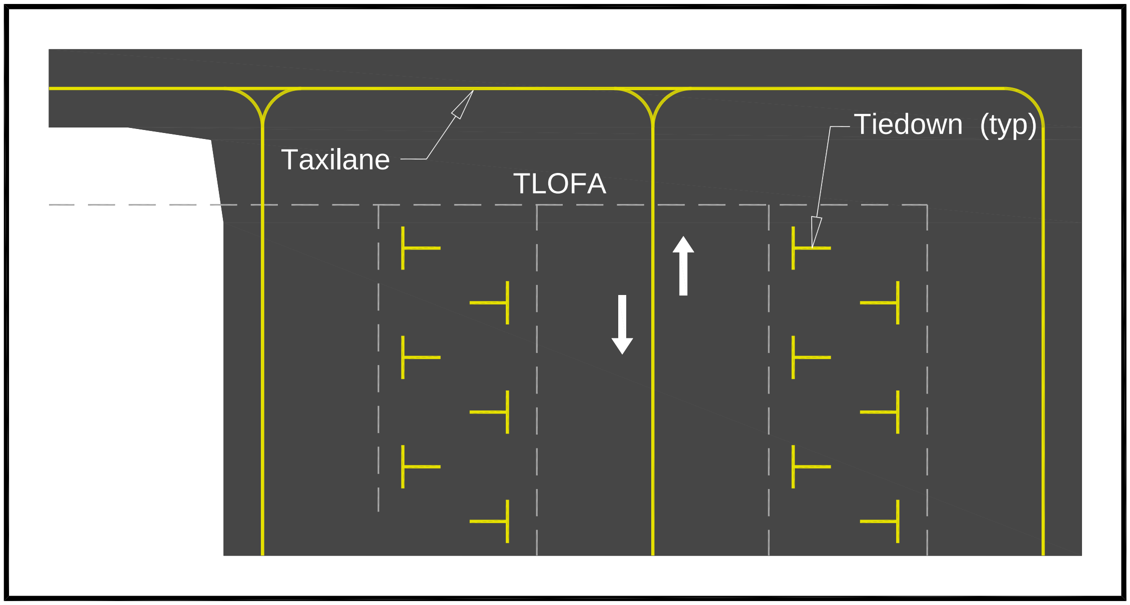
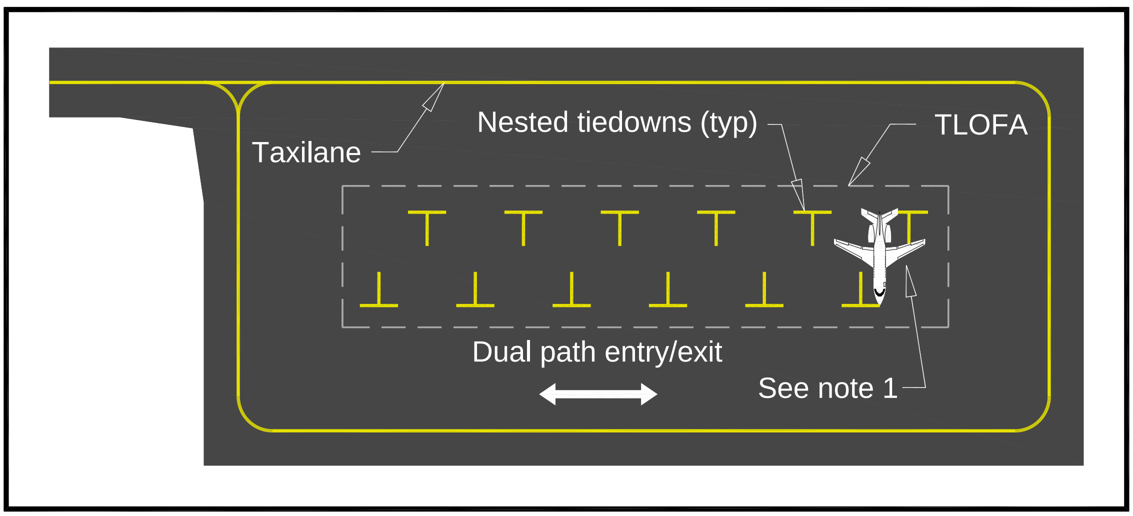


Figure E-5. Dual Path Entry/Exit Taxilane



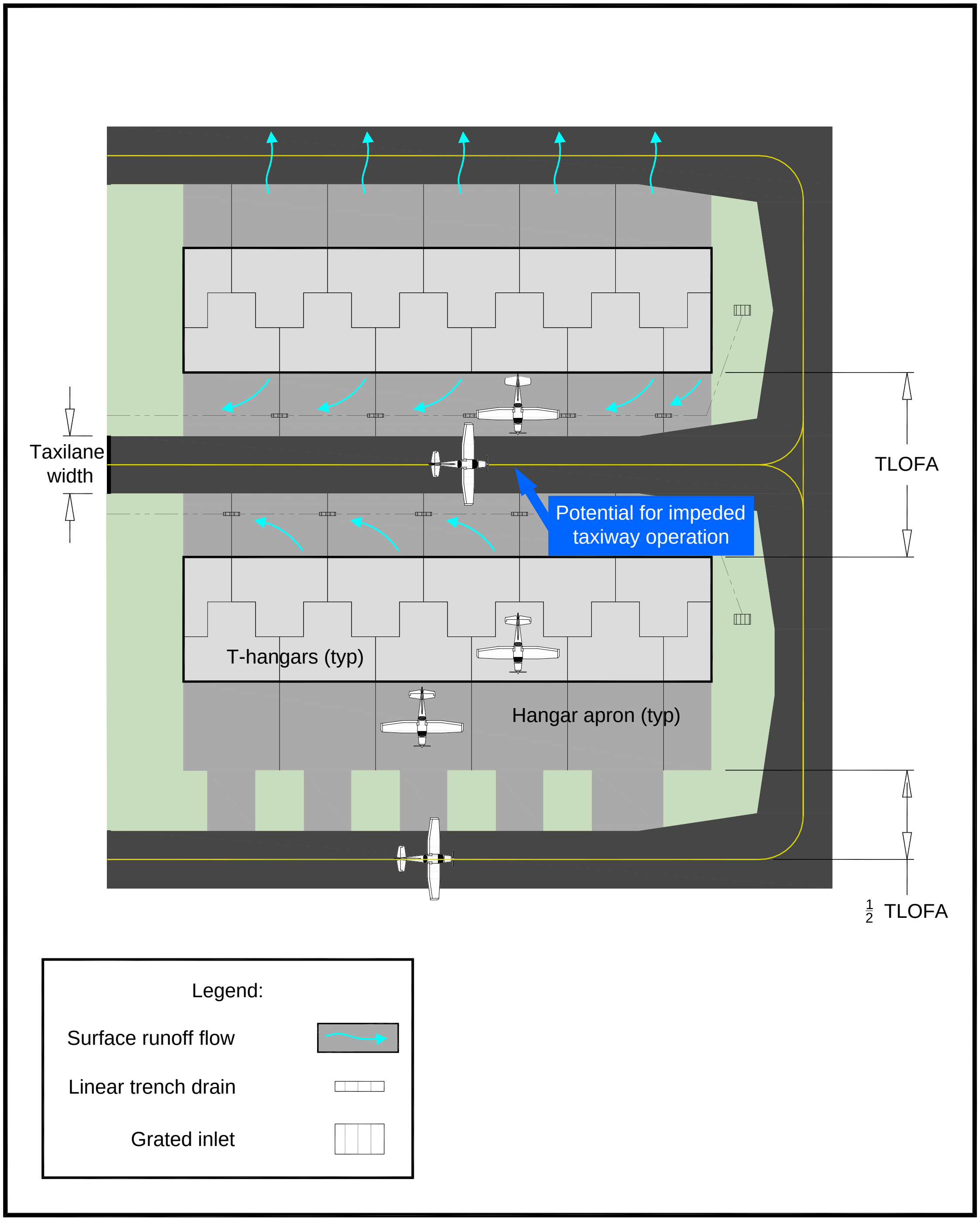
Note 1: Nested parking position can provide flexibility by accommodating parking of larger aircraft. Ensure tiedowns for smaller aircraft do not pose a hazard to larger aircraft.

E.2.4.6 Hangar Aprons and Taxilanes.

Depending on activity level, aircraft or vehicles parked on hangar aprons may affect operations on the associated taxilane as illustrated in Figure E-6. Hangar aprons extending into the TLOFA can impede aircraft taxi operations. This may not be an issue if low activity levels exist at the hangar complex.

1. If space is sufficient and activity levels support the need for uncongested use of the taxilane, locate hangar aprons outside of TLOFA to avoid interfering with taxilane operations.
2. Ensure the TLOFA is clear from the taxilane centerline to the face of the T-hangar of all above ground objects (e.g. utilities boxes, hydrants, bollards, etc.).
3. Locate drainage structures outside of aircraft wheel paths on taxilanes.

Figure E-6. T-Hangar Complex



Note 1: The bottom taxilane illustrates a T-hangar apron configuration clear of aircraft operating on the taxilane. This arrangement may be appropriate when space is available and hangar activities justify unimpeded taxi movements.

Note 2: The center taxilane illustrates how an aircraft positioned in front of the hangar can impede aircraft operations on the taxilane. This configuration may be suitable for low activity hangar complexes and space constrained airports. Consider providing two taxi paths for this configuration.

Note 3: Locate drainage inlets outside of aircraft wheel paths. Consider intermittent trench style inlets to address flat slopes between hangars.

E.2.5 Apron Area Sizing.

Determining a suitable area size for a GA apron varies for each airport. Airport operators need to assess activity at their airport to determine the optimum size of the GA apron. Determining a suitable apron size involves summing the areas for individual parking positions with the area necessary for the TLOFA configuration. The primary factors influencing the GA apron size include:

1. Size and type of parked aircraft groupings per Table E-1.
2. Number of transient aircraft at average peak period.
3. Number of based aircraft not stored in a hangar.
4. Length and orientation of taxilanes.
5. Ancillary services (e.g. fueling area).

E.2.5.1 Transient Aircraft.

Determine the number of suitable parking positions for transient aircraft from observed activity levels and projected growth.

E.2.5.2 Based Aircraft.

Establish the number of parking positions from based aircraft not stored in a hangar, plus an additional 10 percent for supplemental parking positions.

E.2.5.3 Apron Taxilanes.

Determine the area for apron taxilanes by establishing the cumulative length for both interior and perimeter apron taxilanes. Consider different taxilanes may serve specific ADG aircraft.

E.3 Hangars.

GA hangars provide a variety of benefits and uses that include:

1. An enclosed structure to protect parked aircraft from weather elements such as wind, rain, snow and ice.
2. Security for owner protection of aircraft investments.
3. A place to service aircraft for maintenance and repair activities.
4. Combination hangar/office for corporate and FBO entities.

E.3.1 Hangar Construction Regulations and Standards.

Submit Notice of Proposed Construction as required by 14 CFR Part 77 (see paragraph 6.11.4.1) for evaluation of the potential impact on air navigation. Standards applicable for hangar construction include:

1. Building code requirements as adopted by the local governing body or IBC in the absence of formally adopted code.
2. ADA requirements for public accommodation per 28 CFR Part 36.

3. Applicable requirements of NFPA 409.

E.3.2 Hangars Types.

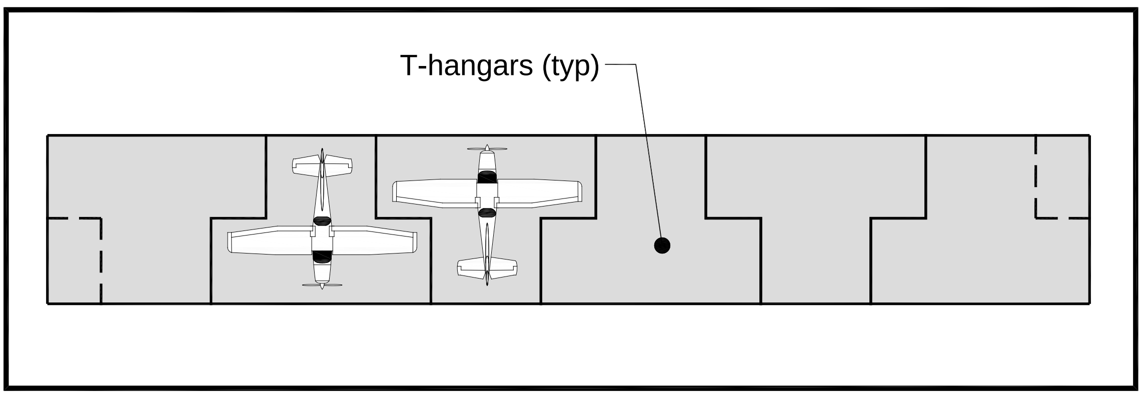
E.3.2.1 Conventional (Box) Hangar.

Square or rectangular hangar sized for protective storage of multiple aircraft types ranging in size and type. Conventional hangars are typically stand-alone structures spaced according to size and separation distance required by fire protection.

E.3.2.2 T-Hangar.

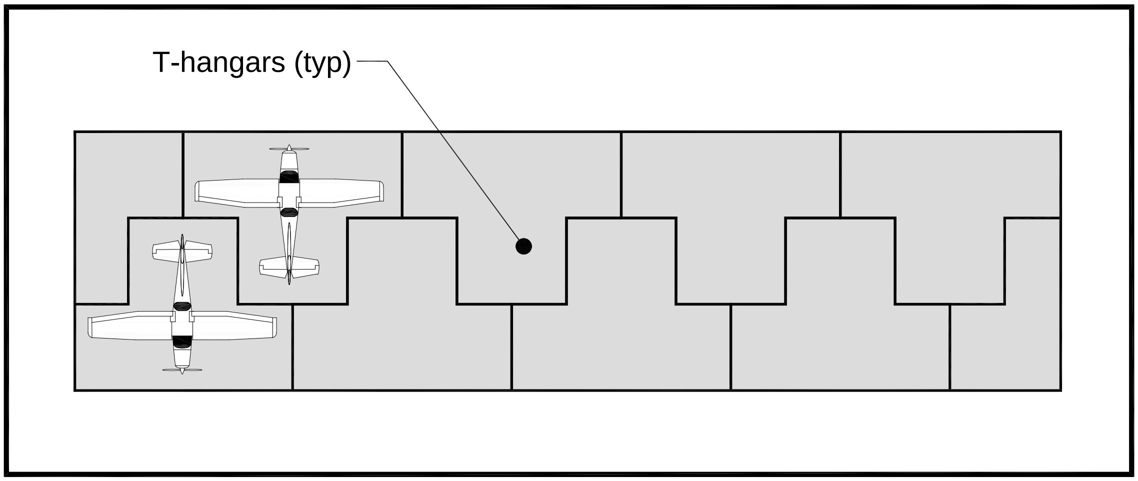
A rectangular structure with a tee shape floorplan primarily used for storage of small aircraft. Common T-hangar bay arrangements include a standard configuration (Figure E-7) or a nested configuration (Figure E-8).

Figure E-7. Standard T-Hangar Layout



Note: The standard T-hangar configuration offers the advantage of minimizing the structure depth when length is not a controlling factor.

Figure E-8. Nested T-Hangar Layout



Note: The nested T-hangar configuration offers the advantage of minimizing the structure length when depth is not the controlling factor.

E.3.2.3 **Corporate Hangar.**

A conventional hangar with office space integrated near the back or the side of the structure.

E.3.2.4 **Shade Shelter.**

An open-air structure with roof that provides limited protection from weather elements (i.e. sun and precipitation). A less common but economical option compared to fully enclosed hangar units.

E.3.3 Hangar Size.

The type and number of aircraft based at an airport are the primary factors in determining hangar width, height, depth and number of bays. Aircraft maneuvering to hangar space is typically under low speed thus allowing precise maneuvering and tighter clearance values

1. Size hangar interior space to provide sufficient clearance between aircraft and structure to limit risk of wingtip conflict.
2. Provide a minimum of five feet (1.5 m) clearance between aircraft and structure to permit the pilot to walk around aircraft when parked in the hangar.
3. For public community hangars, allow for flexibility in design to accommodate various sizes of aircraft.

E.3.4 Hangar Location.

Locate hangars in a manner consistent with the FAA approved airport layout plan avoiding conflict with the building restriction line (BRL) and the standards in Chapter 6. Other design factors to consider include:

1. Locate hangars in a manner that does not adversely affect the use of adjacent taxilanes and aprons.
2. Spacing and clear distance around hangars based upon fire protection ratings per the governing body's adopted building code (e.g. International Fire Code or NFPA 409).
3. Airport growth and expansion to minimize or avoid the need for relocation or special airfield operational controls.
4. Separate vehicle roadways and parking from aircraft movement areas (see Figure E-9) by locating vehicle parking for hangars outside of the AOA.
5. Hangar orientation to address regional environmental and climate factors such as snow/ice accumulation, exposure to solar heating and prevailing winds.
6. Effect of wind eddies from flow around hangar structure on small aircraft during landing operations:
   a. Consider an area of influence due to wind vortices equal to ten times the height of the structure.
   b. Limit taller structures from areas abeam the runway touchdown zone.
7. Line-of-sight from the ATCT to avoid obstructing a controller's view of aircraft that transition to and from the movement area.

E.3.5 Hangar Doors.

Size hangar doors to provide sufficient clearance between the aircraft and the doorframe. Typically, a minimum clearance of 1-2 feet (0.3-0.6 m) is adequate.

E.3.5.1 **Design Considerations.**

1. Consider position of door when in the open position to avoid door becoming a potential wingtip hazard for adjacent taxilanes.
2. Providing a window in the doorframe is a safety feature that allows an operator to view for the presence of objects in front of the hangar before opening the door.

E.3.5.2 **Door Types.**

There are generally four types of basic hangar doors with variants of each type:

1. Sliding hangar doors:
   a. Door panels slide horizontally, typically to opposite sides, to create the necessary clearance opening.
   b. This method generally requires space to the side of the entrance to store the door panels when in the open position.
2. Vertical panel doors:

a. Typically, a single or double panel door that lifts upward to horizontal position.

b. Typically operates with a combination of hydraulic cylinders, counterweights, tracks, steel cables and motor/operator.

3. Bi-fold doors:

a. An articulated, two-panel door that folds up to a horizontal position.

b. Bi-fold doors can create a canopy in front of the hangar when in open position.

4. Fabric doors:

a. An entrance barrier consisting of fabric panels or fabric membrane that typically retracts upward to provide opening clearance.

E.3.6 Hangar Utilities.

E.3.6.1 **Design Considerations.**

1. Route underground utilities in a manner that minimizes or avoids installations under existing and future apron and taxilane pavements.
2. When space constraints require installation under airfield pavements, install underground duct banks with a spare conduit to facilitate future installations.
3. Where aircraft fueling and maintenance activities occur, provide oil/water separator for hangar drainage system and floor grounding receptacles.
4. Lay out and locate above ground facilities such as transformers, fire hydrants, etc. outside of object free areas.

E.4 **GA Terminal Building.**

The terminal area is commonly a focal point of activity at GA airports. GA terminal buildings facilitate transfer of passengers and cargo from the airside to the landside. GA terminals also provide space for pilot preflight planning.

E.4.1 Standards.

Refer to Chapter 6 for discussion on standards applicable to airfield buildings.

E.4.2 Design Considerations.

1. Relationship between the terminal building and aircraft parking areas to facilitate travel paths for passengers and pilots.
2. Provision of clear paths within terminal building from landside to airside that promotes awareness of individuals accessing the AOA.

3. Public waiting area.
4. Secluded area for pilot flight planning.
5. Public restroom accommodations.

E.5 Airport Support Facilities.

E.5.1 Fuel Facilities.

Refer to Chapter 5 for standards applicable for fueling facilities.

E.5.1.1 Siting Considerations.

1. Locate GA fueling facilities at peripheral of apron in position to provide convenient access to aircraft and fuel distribution trucks without interfering with other apron aircraft movements.
2. Locate hydrant fueling to avoid fuel truck deliveries crossing pavements used by aircraft.
3. Locate service roads for fuel delivery trucks to minimize or avoid interaction with aircraft.
4. Install minimum 6-ft high fence around aboveground fuel tanks located on the landside and accessible to the public.

E.5.2 Vehicle Access and Parking.

E.5.2.1 Associated Risks.

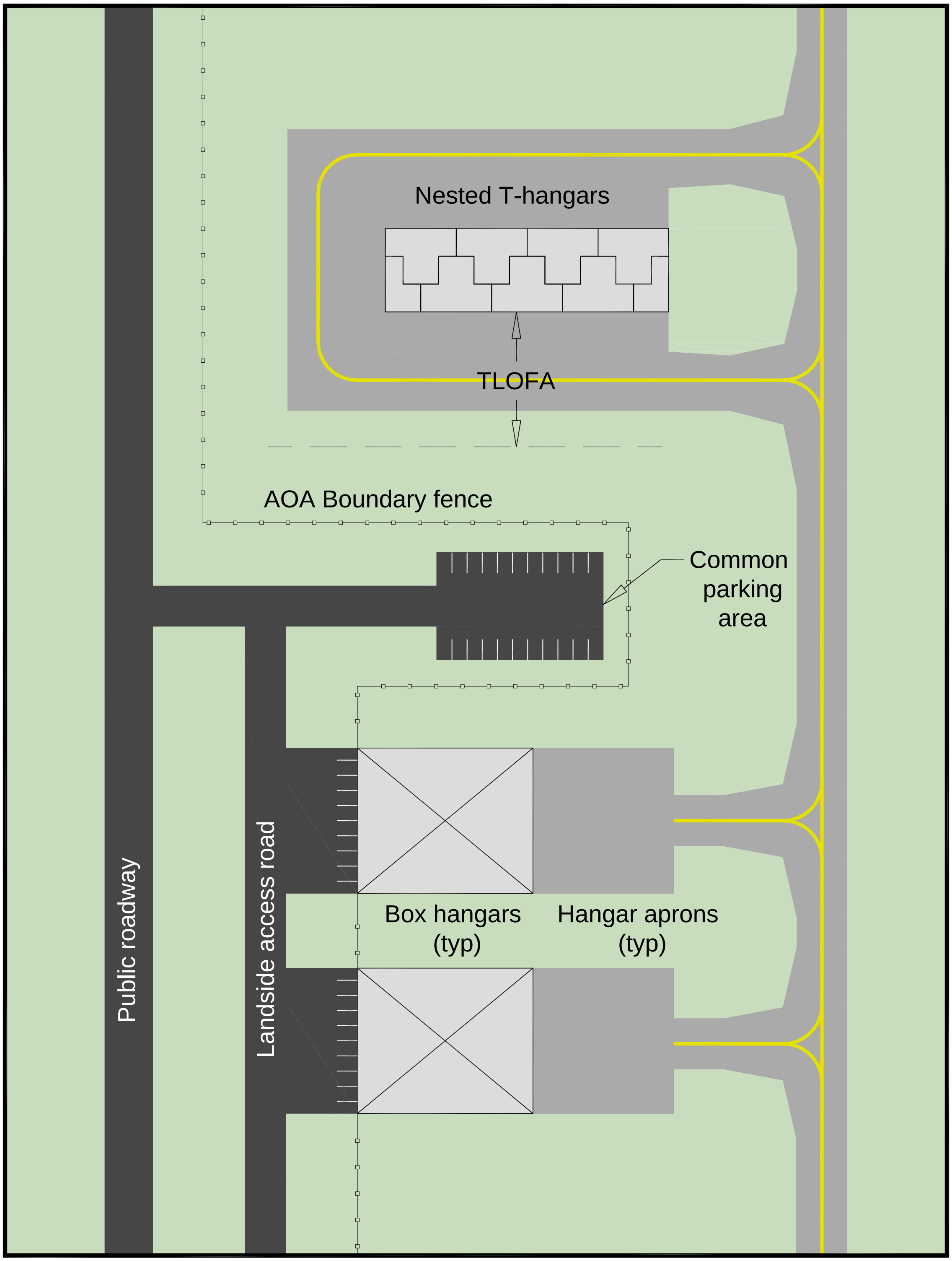
The interaction of vehicles and aircraft within the same area creates a risk for aircraft/vehicle accidents. Limit vehicle operations in the AOA to those necessary to service and maintain aircraft and airport operations.

E.5.2.2 Design Considerations.

Refer to Figure E-9 for an illustration showing separation of vehicle parking from hangar taxi lanes.

1. Locate general public access roads and parking areas outside of the AOA.
2. Locate AOA boundary fence clear of TLOFA limits.
3. Refer to the applicable building code for clearance requirements between parking area and hangar facilities.
4. When vehicle access to AOA is necessary:
    a. locate airside roadways apart from pavement for aircraft operations (i.e. aprons, taxilanes, and taxiways).
    b. Minimize roadway interference with TOFA and TLOFA.

Figure E-9. Separation of Vehicle Parking and Aircraft Pavement



Note 1: Refer to paragraph **E.5.2.2** for design considerations.

Note 2: The layout depicted is an example of separating vehicle pavements from pavements for aircraft movements.

E.5.3 Wash Racks.

Wash racks are designated areas where aircraft owners wash and clean their airplane. Local demand is the primary factor in determining the need for a wash rack facility.

E.5.3.1 Wash Rack Characteristics.

1. May be open air (i.e. no overhead cover) or under a canopy roof (i.e. open sides).
2. Paved platform for aircraft washing that also collects wash water.
3. Typically designed for single aircraft occupancy.

E.5.3.2 Design Considerations.

1. Locate wash rack facility in a manner that:
   a. Avoids overspray affecting other aircraft and airfield facilities.
   b. Isolates the facility to avoid interfering with aircraft movements and other apron facilities.
2. Pavement:
   a. Design strength for most demanding aircraft anticipated to use facility.
   b. Construct pad with materials that will not prematurely deteriorate from frequent exposure to water and cleaning agents.
3. Conform to clearance guidelines of Table 5-1 based on critical aircraft.
4. Design entry and exit of aircraft to be by self-power or by tow.
5. Size the wash rack pad to provide a minimum of 5-feet paved surface around the aircraft for space to walk and for safe maneuvering of aircraft.
6. Locate water hose bibs, control equipment, electric equipment, vacuums, payment systems devices and related accessories in a manner that facilitates cleaning of aircraft but minimizes wingtip conflict hazards during aircraft maneuvering.
7. Consult local governing authorities regarding requirements for treatment of wash water collected from pad:
   a. Provide paved surface and curb with a minimum slope of 0.5% to collect wash water runoff for discharge to drainage system.
   b. The facility may require installation of oil/water separator for collection of degreaser agents.
8. Provide suitable area lighting if facility is available for nighttime use.

E.6 Fencing for GA Airports.

Fencing of the AOA contributes to the safety of the airport by establishing a physical barrier that limits or impedes inadvertent entry of individuals and vehicles into the AOA. Although there are no Transportation Security Administration standards or requirements for GA security, AOA fencing does represent a basic deterrent feature that discourages unauthorized entry.

E.6.1 Design Considerations.

Key factors and considerations for design of GA fencing include:

1. AOA fencing is primary a safety feature that protects the integrity of airfield operations.
2. An appropriate fence height relates to the level of safety risk present at the airport.

E.6.2 Key Risk Factors.

The factors that contribute risks to safety for GA airports vary between types of airports as well as between different areas of the same airport. Common risk factors for GA airports include:

1. Airport activity – The risk to safety will generally be greater at a high activity airport than that at a low activity airport:[5]
    a. High activity (e.g. national and regional airports).
    b. Moderate activity (e.g. local airports).
    c. Low Activity (basic airports).
2. Proximity to populated area – The potential for individuals to enter the AOA and pose a safety risk is generally less at a rural GA airport than a GA airport near a metropolitan area:[6]
    a. Urbanized area (50,000 or more people).
    b. Urban Clusters (2,500 to 50,000 people)
    c. Rural areas (less than 2,500 people)
3. Airport Sensitive Areas – The risk to airport safety varies around the perimeter of the AOA based upon distance to airport sensitive areas such as the following:
    a. Terminal Area
    b. Runways, taxiways and aprons
    c. Hangar complexes
    d. Fuel facilities

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[5] Refer to FAA Report General Aviation Airports: A National Asset -May 2012 for airport category descriptions.
[6] Refer to the U.S. Bureau of Census for definition of urban areas, urban clusters and rural areas (76 FR 53043)

E.6.3 Basic Fencing Guidelines.

The following represents recommended basic fencing guidelines based upon select risk factors that can influence the safety of airport operations:

1. National and Regional GA airports:
   a. Install a minimum 5-foot [1.5 m] high chain link fence around perimeter of AOA boundary.
   b. Consider installation of a gate operator to manage access of authorized vehicles into the AOA.
2. Local and Basic GA airports:
   a. Urban and urban cluster locations – Install a minimum 4-foot [1.2 m] high chain link fence around perimeter of AOA boundary.
   b. Rural locations – Install a minimum 4-foot [1.2 m] high chain link fence out to 500' [152 m] from sensitive areas of the airport; and a minimum 4-foot [1.2 m] high woven wire fence (Class A or Class C fence) around remaining perimeter of AOA boundary.

E.6.4 Managing Access to AOA.

1. Minimize the number of vehicle and pedestrian gates to manage access to the AOA.
2. Locate access points in key visible locations to facilitate monitoring and awareness of individuals entering the AOA.
3. Limit vehicle access gates to vehicles having an aviation need to enter the AOA:
   a. For basic airports, manual gates are appropriate for managing access to AOA.
   b. For local, regional and national airports, consider one class 3 gate operator, as defined by ASTM F2200-17, for access to the terminal apron area and manual gates elsewhere.

E.6.5 Additional Risk Based Measures.

An airport may have unique circumstances increasing the risk to airport safety beyond what the basic fencing guidelines provide. Conducting a risk-based assessment may justify modifications to the basic fencing guidelines to mitigate a specific risk to safety at that airport. This includes increased fence heights, addition of 3-strand barbed wire, smaller fence mesh, etc.

E.6.6 Signage.

Install warning signs at access points and intermediate points along boundary fence to establish notice to individuals they are entering the AOA.

E.6.7 Wildlife Fencing.

For non-139 airports, a wildlife hazard site visit (WHSV) determines whether fencing to deter wildlife is necessary. If an airport's WHSV supports wildlife fencing, the recommendations in the WHSV for fence type, height and location supersede the basic fencing guidelines of paragraph E.6.2. For additional information, refer to AC 150/5200-38, *Protocol for the Conduct and Review of Wildlife Hazard Site Visits, Wildlife Hazard Assessments, and Wildlife Hazard Management Plans*.

APPENDIX F. COMPASS CALIBRATION PAD SURVEY

F.1 Survey of the Compass Calibration Pad.

1. Resurvey the pad after all construction is complete to:
   a. establish the current magnetic headings, and
   b. demonstrate the pad is free of magnetic materials.
2. Mark the center of the calibration pad with a bronze survey marker.
3. Establish a permanent monument at a remote location along the true north radial for future reference.
4. Mark the date of observation and any annual change in direction of magnetic north durably and legibly on the surface of the calibration pad near the magnetic north mark.
5. Any qualified state-registered geophysicist, surveyor or engineer may perform the compass rose survey.
6. The U.S. Geological Survey (USGS) Geomagnetism Group historically provides information on the necessary surveys and equipment to certify a compass rose, as well as, the calibration of magnetometers and other suitable instruments used to measure the magnetic field. Services and contact information is available at the Geomagnetism Group website: https://www.usgs.gov/natural-hazards/geomagnetism.

F.2 Resurvey of In-service Pads.

The FAA recommends:

1. Conducting magnetic surveys of existing compass calibration pads at regular intervals of 5 years or less.
2. Conducting magnetic surveys after:
   a. Major construction of utility lines, buildings, or any other structures within 600 feet (183 m) of the center of the pad, or
   b. Any construction within 150 feet (46 m) of the center of the pad.

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APPENDIX G. RUNWAY DESIGN STANDARDS TABLES

Table G-1. Runway Design Standards Matrix, A/B-I Small Aircraft

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**A/B - I Small Aircraft**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	60 ft	60 ft	60 ft	75 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		80 ft	80 ft	80 ft	95 ft
Blast Pad Length		60 ft	60 ft	60 ft	60 ft
Crosswind Component		10.5 knots	10.5 knots	10.5 knots	10.5 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	240 ft	240 ft	240 ft	600 ft
Length prior to threshold	P	240 ft	240 ft	240 ft	600 ft
Width	C	120 ft	120 ft	120 ft	300 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	240 ft	240 ft	240 ft	600 ft
Length prior to threshold	P	240 ft	240 ft	240 ft	600 ft
Width	Q	250 ft	250 ft	250 ft	800 ft
Obstacle Free Zone (OFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	N/A
Width		N/A	N/A	N/A	N/A
Approach Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,700 ft	2,500 ft
Inner Width	U	250 ft	250 ft	1,000 ft	1,000 ft
Outer Width	V	450 ft	450 ft	1,510 ft	1,750 ft
Acres		8.035	8.035	48.978	79.000
Departure Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Inner Width	U	250 ft	250 ft	250 ft	250 ft
Outer Width	V	450 ft	450 ft	450 ft	450 ft
Acres		8.035	8.035	8.035	8.035
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position		125 ft	125 ft	125 ft	175 ft
Parallel taxiway/taxilane centerline [2, 4]	D	150 ft	150 ft	150 ft	200 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-2. Runway Design Standards Matrix, A/B-I

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**A/B - I**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	60 ft	60 ft	60 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		80 ft	80 ft	80 ft	120 ft
Blast Pad Length		100 ft	100 ft	100 ft	100 ft
Crosswind Component		10.5 knots	10.5 knots	10.5 knots	10.5 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	240 ft	240 ft	240 ft	600 ft
Length prior to threshold	P	240 ft	240 ft	240 ft	600 ft
Width	C	120 ft	120 ft	120 ft	300 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	240 ft	240 ft	240 ft	600 ft
Length prior to threshold	P	240 ft	240 ft	240 ft	600 ft
Width	Q	400 ft	400 ft	400 ft	800 ft
Obstacle Free Zone (OFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	700 ft	700 ft	1,510 ft	1,750 ft
Acres		13.770	13.770	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	700 ft	700 ft	700 ft	700 ft
Acres		13.770	13.770	13.770	13.770
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position		200 ft	200 ft	200 ft	250 ft
Parallel taxiway/taxilane centerline [2, 4]	D	225 ft	225 ft	225 ft	250 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-3. Runway Design Standards Matrix, A/B–II Small Aircraft

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**A/B - II Small Aircraft**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	75 ft	75 ft	75 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		95 ft	95 ft	95 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		13 knots	13 knots	13 knots	13 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	C	150 ft	150 ft	150 ft	300 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	Q	500 ft	500 ft	500 ft	800 ft
Obstacle Free Zone (OFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,700 ft	2,500 ft
Inner Width	U	250 ft	250 ft	1,000 ft	1,000 ft
Outer Width	V	450 ft	450 ft	1,510 ft	1,750 ft
Acres		8.035	8.035	48.978	79.000
Departure Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Inner Width	U	250 ft	250 ft	500 ft	500 ft
Outer Width	V	450 ft	450 ft	700 ft	700 ft
Acres		8.035	8.035	13.770	13.770
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position		125 ft	125 ft	125 ft	175 ft
Parallel taxiway/taxilane centerline [2, 4]	D	240 ft	240 ft	240 ft	300 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-4. Runway Design Standards Matrix, A/B–II

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**A/B - II**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	75 ft	75 ft	75 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		95 ft	95 ft	95 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		13 knots	13 knots	13 knots	13 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	C	150 ft	150 ft	150 ft	300 ft
Object Free Area (OFA)					
Length beyond runway end	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	Q	500 ft	500 ft	500 ft	800 ft
Runway Obstacle Free Zone (ROFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	700 ft	700 ft	1,510 ft	1,750 ft
Acres		13.770	13.770	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	700 ft	700 ft	700 ft	700 ft
Acres		13.770	13.770	13.770	13.770
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position		200 ft	200 ft	200 ft	250 ft
Parallel taxiway/taxilane centerline [2, 4]	D	240 ft	240 ft	240 ft	300 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-5. Runway Design Standards Matrix, A/B-III

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**A/B - III**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	100 ft	100 ft	100 ft	100 ft
Shoulder Width		20 ft	20 ft	20 ft	20 ft
Blast Pad Width		140 ft	140 ft	140 ft	140 ft
Blast Pad Length		200 ft	200 ft	200 ft	200 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	600 ft	600 ft	600 ft	800 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	300 ft	300 ft	300 ft	400 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	600 ft	600 ft	600 ft	800 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Obstacle Free Zone (OFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	700 ft	700 ft	1,510 ft	1,750 ft
Acres		13.770	13.770	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	700 ft	700 ft	700 ft	700 ft
Acres		13.770	13.770	13.770	13.770
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position [7]		200 ft	200 ft	200 ft	250 ft
Parallel taxiway/taxilane centerline [2, 4]	D	300 ft	300 ft	300 ft	350 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-6. Runway Design Standards Matrix, A/B-IV

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**A/B - IV**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width		25 ft	25 ft	25 ft	25 ft
Blast Pad Width		200 ft	200 ft	200 ft	200 ft
Blast Pad Length		200 ft	200 ft	200 ft	200 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft
Object Free Area (OFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Runway Obstacle Free Zone (ROFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	700 ft	700 ft	1,510 ft	1,750 ft
Acres		13.770	13.770	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	700 ft	700 ft	700 ft	700 ft
Acres		13.770	13.770	13.770	13.770
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position [8]		250 ft	250 ft	250 ft	250 ft
Parallel taxiway/taxilane centerline [2]	D	400 ft	400 ft	400 ft	400 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-7. Runway Design Standards Matrix, C/D/E-I

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**C/D/E - I**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	100 ft	100 ft	100 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		120 ft	120 ft	120 ft	120 ft
Blast Pad Length		100 ft	100 ft	100 ft	100 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width [13]	C	500 ft	500 ft	500 ft	500 ft
Object Free Area (OFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Runway Obstacle Free Zone (ROFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Acres		29.465	29.465	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
Acres		29.465	29.465	29.465	29.465
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position		250 ft	250 ft	250 ft	250 ft
Parallel taxiway/taxilane centerline [2]	D	300 ft	300 ft	300 ft	400 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-8. Runway Design Standards Matrix, C/D/E-II

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**C/D/E - II**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	100 ft	100 ft	100 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		120 ft	120 ft	120 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width [13]	C	500 ft	500 ft	500 ft	500 ft
Object Free Area (OFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Runway Obstacle Free Zone (ROFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Acres		29.465	29.465	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
Acres		29.465	29.465	29.465	29.465
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position		250 ft	250 ft	250 ft	250 ft
Parallel taxiway/taxilane centerline [2]	D	300 ft	300 ft	300 ft	400 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

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Table G-9. Runway Design Standards Matrix, C/D/E-III

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**C/D/E - III**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width [12]	B	100 ft	100 ft	100 ft	100 ft
Shoulder Width [12]		20 ft	20 ft	20 ft	20 ft
Blast Pad Width [12]		140 ft	140 ft	140 ft	140 ft
Blast Pad Length		200 ft	200 ft	200 ft	200 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft
Object Free Area (OFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Runway Obstacle Free Zone (ROFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Acres		29.465	29.465	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
Acres		29.465	29.465	29.465	29.465
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position [8]		250 ft	250 ft	250 ft	250 ft
Parallel taxiway/taxilane centerline [2]	D	400 ft	400 ft	400 ft	400 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

7257 **Note:** Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-10. Runway Design Standards Matrix, C/D/E-IV

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**C/D/E - IV**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width		25 ft	25 ft	25 ft	25 ft
Blast Pad Width		200 ft	200 ft	200 ft	200 ft
Blast Pad Length		200 ft	200 ft	200 ft	200 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Obstacle Free Zone (OFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Acres		29.465	29.465	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
Acres		29.465	29.465	29.465	29.465
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position [8]		250 ft	250 ft	250 ft	250 ft
Parallel taxiway/taxilane centerline [2]	D	400 ft	400 ft	400 ft	400 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-11. Runway Design Standards Matrix, C/D/E-V

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**C/D/E - V**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width		35 ft	35 ft	35 ft	35 ft
Blast Pad Width		220 ft	220 ft	220 ft	220 ft
Blast Pad Length		400 ft	400 ft	400 ft	400 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Obstacle Free Zone (OFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Acres		29.465	29.465	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
Acres		29.465	29.465	29.465	29.465
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position [8]		250 ft	250 ft	250 ft	280 ft
Parallel taxiway/taxilane centerline [3, 5]	D	*See footnote 3.*			
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Table G-12. Runway Design Standards Matrix, C/D/E-VI

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		**C/D/E - VI**			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.6.1			
Runway Width	B	200 ft	200 ft	200 ft	200 ft
Shoulder Width		40 ft	40 ft	40 ft	40 ft
Blast Pad Width		280 ft	280 ft	280 ft	280 ft
Blast Pad Length		400 ft	400 ft	400 ft	400 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft
Object Free Area (OFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Runway Obstacle Free Zone (ROFZ)					
Length		*Refer to paragraph* 3.10			
Width		*Refer to paragraph* 3.10			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Acres		29.465	29.465	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
Acres		29.465	29.465	29.465	29.465
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.8			
Holding Position [8]		280 ft	280 ft	280 ft	280 ft
Parallel taxiway/taxilane centerline [2, 6]	D	500 ft	500 ft	500 ft	500 ft
Aircraft parking area	G	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Footnotes:

1. Letters correspond to the dimensions in Figure 3-33.

2. The runway to taxiway/taxilane centerline separation standards are for airports at sea level. For airports at higher elevations, an increase to these separation distances may be required to keep taxiing and holding aircraft clear of the inner-transitional OFZ (refer to paragraph 3.10.5). This standard cannot be used to justify a decrease in runway to taxiway/taxilane separation.

3. The standard runway centerline to parallel taxiway centerline separation distance is 400 feet for airports at or below an elevation of 1,345 feet; 450 feet for airports between elevations of 1,345 feet and 6,560 feet; and 500 feet for airports above an elevation of 6,560 feet.

4. For approaches with visibility less than ½-statute mile, runway centerline to taxiway/taxilane centerline separation increases to 400 feet.

5. For approaches with visibility less than ½-statute mile, the separation distance increases to 500 feet.

6. For approaches with visibility less than 3/4 statute mile, the separation distance may increase by an elevation adjustment. For approaches with visibility less than ½-statute mile, the separation distance increases to 550 feet.

7. Increase this distance 1 foot for each 100 feet above 5,100 feet above sea level.

8. Increase this distance 1 foot for each 100 feet above sea level.

9. The RSA length beyond the runway end begins at the runway end if the runway does not have a stopway. When a runway has a stopway, the length begins at the stopway end.

10. The RSA length beyond the runway end may be reduced to that required to install an Engineered Materials Arresting System (EMAS) (the designed set-back of the EMAS included) designed to stop the critical aircraft exiting the runway end at 70 knots. See the latest edition of AC 150/5220-22 for additional guidance.

11. This value only applies if that runway end is equipped with electronic or visual vertical guidance. ILS, GLS, LPV, LNAV/VNAV, and RNP lines of minima provides electronic vertical guidance. A PAPI or VASI provides visual vertical guidance. If there is no such guidance for that runway, use the value for "length beyond departure end."

12. For airplanes with maximum certificated takeoff weight greater than 150,000 lbs, the standard runway width is 150 feet, the shoulder width is 25 feet, and the runway blast pad width is 200 feet.

13. An RSA width of 400 feet is permissible.

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APPENDIX H. DECLARED DISTANCES

H.1 Application.

Declared distances represent the maximum distances available and suitable for meeting aircraft takeoff, rejected takeoff, and landing distances performance requirements.

1. Declared distances apply to the certification and operation of turbine-engine powered transport category airplanes operating under 14 CFR parts 135, 121, and 91 (turbine include turbojets or turboprop powered aircraft).
2. The declared distances are:
    a. Takeoff Distance Available (TODA) and Takeoff Run Available (TORA), which apply to takeoff;
    b. Accelerate Stop Distance Available (ASDA), which applies to a rejected takeoff; and
    c. Landing Distance Available (LDA), which applies to landing.
3. For turbine powered aircraft operations, the TODA may include a clearway, if present (reference 14 CFR Part 1). The ASDA may include a stopway, if present:
    a. By treating these distances independently, declared distances is a design methodology that results in declaring and reporting the TORA, TODA, ASDA and LDA for each operational direction.
4. While there are not similarly stringent operating rules applicable to other airplane types (e.g. pistons), declared distances are useful as advisory information to assist pilots with becoming familiar with all available information concerning the intended flight (see 14 CFR 91.103).
5. Implementing declared distances is a reasonable alternative to mitigate existing runway shortcomings and thus better meet design standards, even when the critical aircraft is not a turbine-engine powered, transport category airplane:
    a. However, all airport operators still need to review all reasonable alternatives in the master planning effort, and not immediately choose declared distances.
    b. The use of declared distances to satisfy runway design standards is an interim condition ensuring flight safety until the airport implements improvements to the runway.
    c. The full operational use of the paved runway is the optimum state, so declared distances do not limit the usable length available for airplane takeoff and landing operations.
6. The FAA Airports Regional Office or Airports District Office (AD) review and approval is necessary to implement proposals for declared distances not equal to the physical length of the runway.
7. Declared distances are normally published for all runways with turbine operations (even if not the critical aircraft) or runways with charted IFPs that have C and D

minima. At Part 139 airports declared distance data are listed for all runway ends that are specified as Part 139 use.

H.1.1 Using Declared Distances.

H.1.1.1 Using declared distances is one method to:

1. Obtain additional RSA and/or ROFA prior to the runway's threshold (the start of the LDA) and/or beyond the stop end of the LDA and ASDA;
2. Mitigate unacceptable incompatible land uses in the RPZ;
3. Meet runway approach and/or departure surface clearance requirements, in accordance with airport design standards; or
4. Mitigate environmental impacts.

H.1.1.2 Use declared distances as a way for incremental improvements when it is not practical to fully meet these requirements. However, declared distances are only used for these purposes where it is impracticable to meet the airport design standards or mitigate the environmental impacts by other means, and the use of declared distances is practical.

H.1.2 Declared distances either limit or increase runway use. The use of declared distances may result in a displaced runway threshold and may affect the beginning and ending of the RSA, ROFA, and RPZ. For runways without published declared distances, the declared distances are equal to the physical length of the runway unless there is a displaced threshold. With a displaced threshold, the LDA is shortened by the length of the threshold displacement in the direction of landing at that displaced threshold.

H.2 RSA, ROFA, and RPZ Lengths and Related Nomenclature.

The nomenclature referenced in the following paragraphs is used throughout the rest of this section and is always based upon the direction of operation.

H.2.1 RSA, ROFA Standards.

The online Runway Design Standards Matrix Tool specifies the length "R" as the required length of the RSA and ROFA beyond the runway departure end. The tool specifies length "P" as the required length of the RSA and ROFA prior to the threshold. A full dimension RSA and full dimension ROFA extend the length of the runway plus 2 × R when there is no stopway. Where a stopway exists, measure R from the far end of the stopway based upon the takeoff direction, and the RSA and ROFA extend the full length of the runway plus the length of the stopway(s) plus 2 × R.

H.2.2 Existing or Proposed RSA and ROFA beyond the Runway Ends.

As used in the Figure H-8, Figure H-9, Figure H-10, Figure H-11, Figure H-12, Figure H-15, and Figure H-16, the RSA length "S" is the existing or proposed RSA beyond the runway ends. The ROFA length "T" is the existing or proposed ROFA beyond the runway ends.

H.2.3 RPZ Lengths.

The online Runway Design Standards Matrix Tool specifies the standard RPZ length "L" for both the Approach RPZ, which ends 200 ft (61 m) from the threshold based upon the landing direction, and the Departure RPZ, beginning 200 ft (61 m) from the runway end based upon the direction of takeoff. See Figure 3-23, Figure 3-24, and Figure 3-25.

H.3 Background.

H.3.1 It is helpful to understand the relationship between aircraft certification, aircraft operating rules, airport data, and airport design for the application of declared distances in airport design. Aircraft certification provides the aircraft's performance distances.

H.3.2 The takeoff decision speed (V_1), and the following distances to achieve or decelerate from V_1 are established by the manufacturer and confirmed during certification testing for varying climatological conditions, operating weights, etc.:

H.3.2.1 **Takeoff Run.**

The distance to accelerate from brake release to lift-off, plus safety factors. (See TORA, paragraph H.4.1.)

H.3.2.2 **Takeoff Distance.**

The distance to accelerate from brake release past lift-off to start of takeoff climb, plus safety factors. (See TODA, paragraph H.4.2.)

H.3.2.3 **Accelerate-Stop Distance.**

The distance to accelerate from brake release to V_1 and then decelerate to a stop, plus safety factors. (See ASDA, paragraph H.4.3.)

H.3.2.4 **Landing Distance.**

The distance from the threshold to complete the approach, touchdown, and decelerate to a stop, plus safety factors. (See LDA, paragraph H.5.1.)

H.3.3 Aircraft operating rules provide a minimum acceptable level of safety by controlling the aircraft maximum operating weights and limiting the aircraft's performance distances as follows:

- TORA does not exceed the length of runway.
- TODA does not exceed the length of runway plus clearway.
- ASDA does not exceed the length of runway plus stopway.
- LDA does not exceed the length of runway.

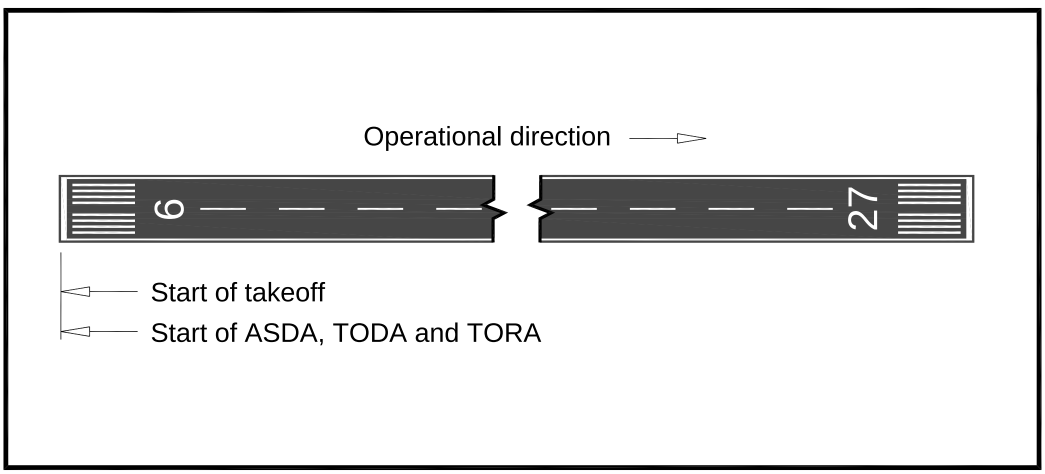
H.3.4 Airport data provide the runway length and/or the following declared distance information for calculating maximum operating weights and/or operating capability.

H.4 For Takeoff.

Start of takeoff ends of runway:

1. The start of takeoff for ASDA, TORA and TODA will always be collocated.
2. Do not consider the threshold locations, the RPZs, nor the RSA and ROFA behind the start of takeoff, in establishing the start of takeoff.
3. The start of takeoff is most often at the beginning of the runway but may also be located farther up the operational takeoff directions of the runway (see Figure H-1).
4. Declare TODA, ASDA and TORA when starting at such a location; start of takeoff may not start behind that point.

Figure H-1. Typical Starting Point for ASDA, TODA, and TORA



H.4.1 TORA.

The TORA is the length of runway declared available and suitable for satisfying takeoff run requirements.

1. Consider for determination of the TORA:
    a. the start of takeoff
    b. the departure RPZ, and
    c. limitations resulting from a reduced TODA.
2. When the full runway beyond the start of takeoff is available for the takeoff run, the departure end of the TORA is located at the end of the runway (see Figure H-2).
3. Reduce the TORA such that it ends prior to the runway to resolve incompatible land uses in the departure RPZ, and/or to mitigate environmental effects.

4. The departure RPZ begins 200 ft (61 m) from the end of the TORA and extends out a distance L (see Figure H-2 and Figure H-3).
5. Since TORA can never be longer than the TODA, whenever the TODA is shortened to less than the runway length to mitigate penetrations to the departure surface, the TORA is limited to the length of the TODA (see Figure H-4).
6. If a clearway exists and it begins prior to the runway end, the TORA ends at the beginning of the clearway (see Figure H-5).

Figure H-2. Typical Location for Departure End of TORA

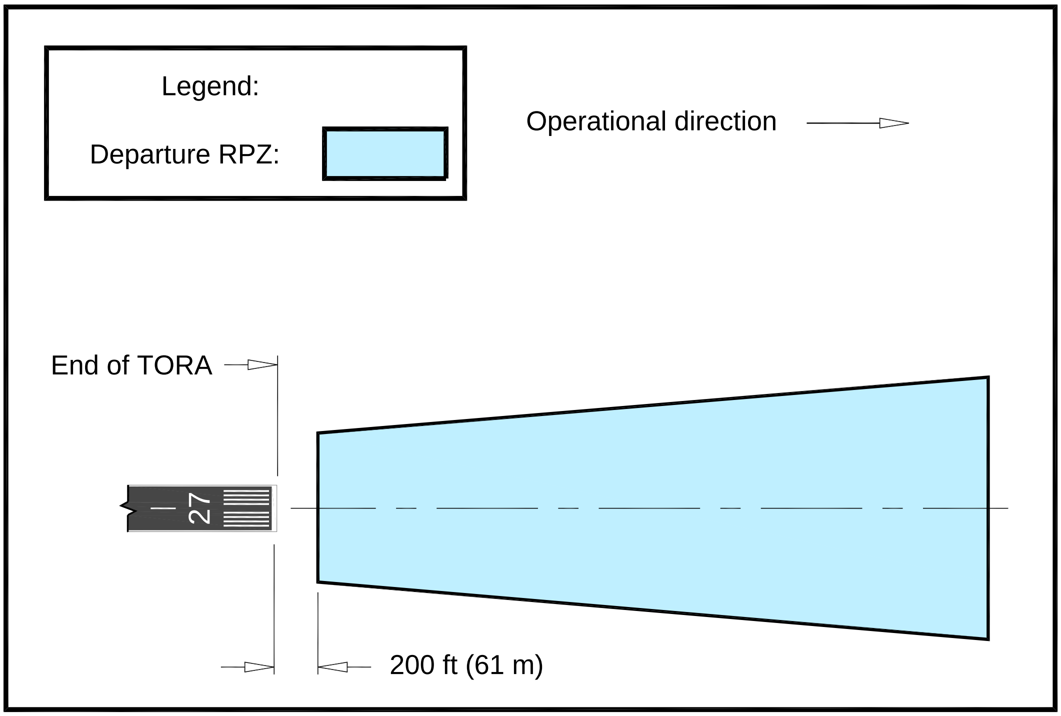
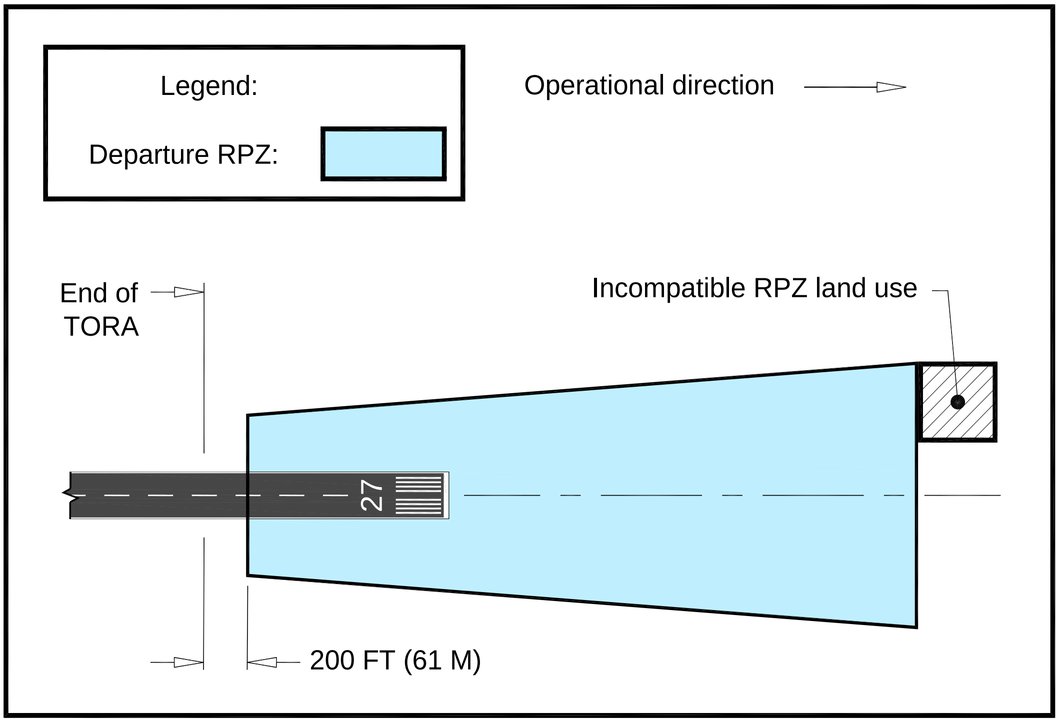
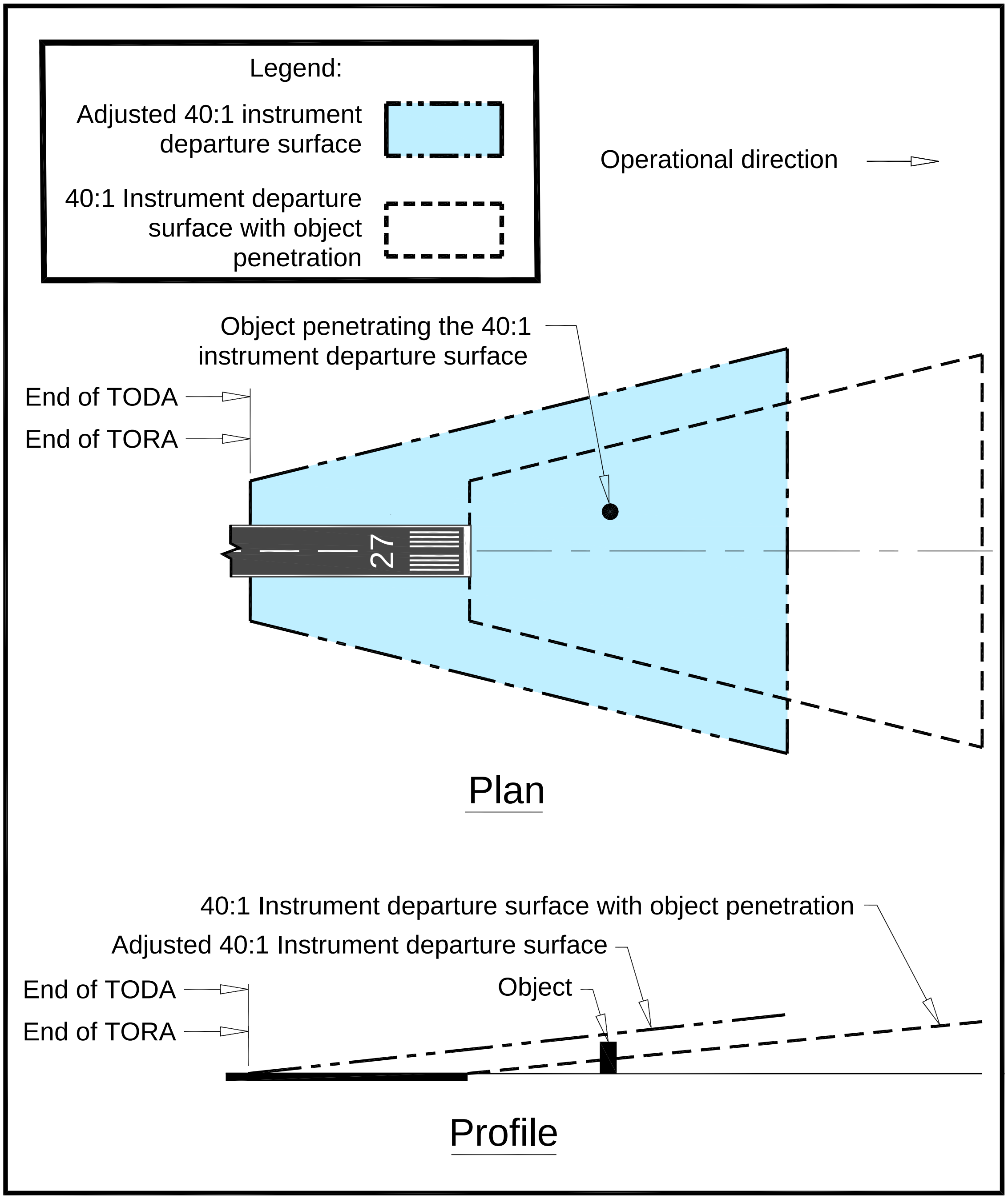


Figure H-3. Modified Departure End of TORA due to Incompatible RPZ Land Use

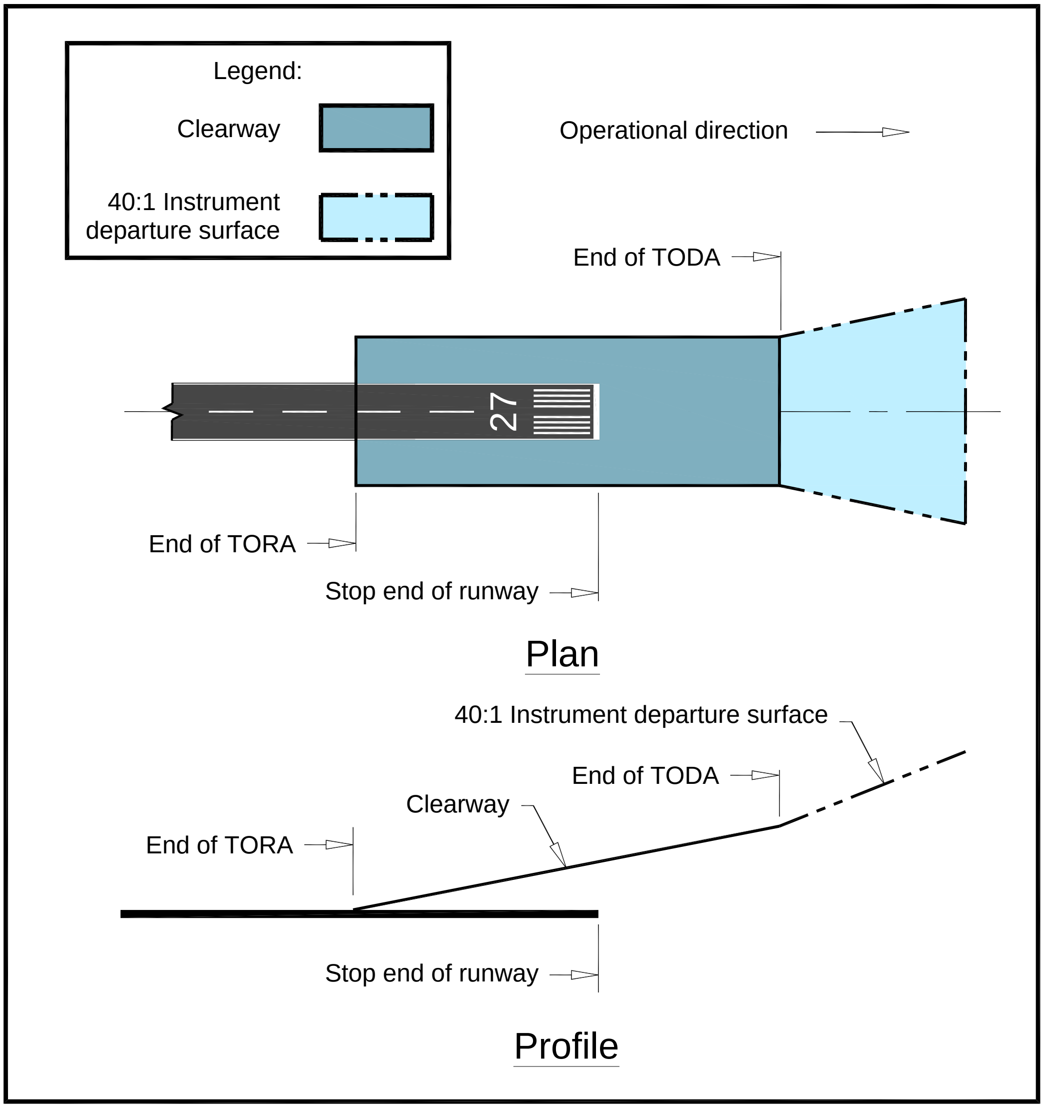


7442
7443
Figure H-4. Modified TODA and TORA due to Object Penetration of 40:1 Surface



7444
7445 **Note 1:** The penetration to the instrument departure surface has been mitigated by the decreased length of
7446 the TODA.
7447 **Note 2:** TORA has been limited by TODA. TORA can never be longer than TODA.

Figure H-5. Extended TODA with Clearway – Shortened TORA



H.4.2 <u>TODA.</u>

The TODA is the TORA plus the length of any remaining runway or clearway beyond the departure end of the TORA available for satisfying takeoff distance requirements.

1. Consider for the determination of the TODA:
   a. the start of takeoff
   b. departure surface requirements, and
   c. any clearway.
2. When only the full runway beyond the start of takeoff is available for takeoff distance, locate the departure end of the TODA at the end of the runway (see Figure H-6).

3. The TODA may be limited from extending to the runway end to mitigate penetrations to the 40:1 instrument departure surface, where applicable (see Figure H-4).
4. This is only one method of mitigating penetrations to the departure surface.
5. The TODA may also extend beyond the runway end through the use of a clearway (see Figure H-5 and Figure H-7).
6. The full length of the TODA may not be usable for a particular operation and may be limited by obstacles in the departure area and aircraft performance.
7. The aircraft operator determines usable TODA length before each takeoff and requires knowledge of each controlling obstacle in the departure area.

Figure H-6. Typical Location of TODA DER – No Clearway

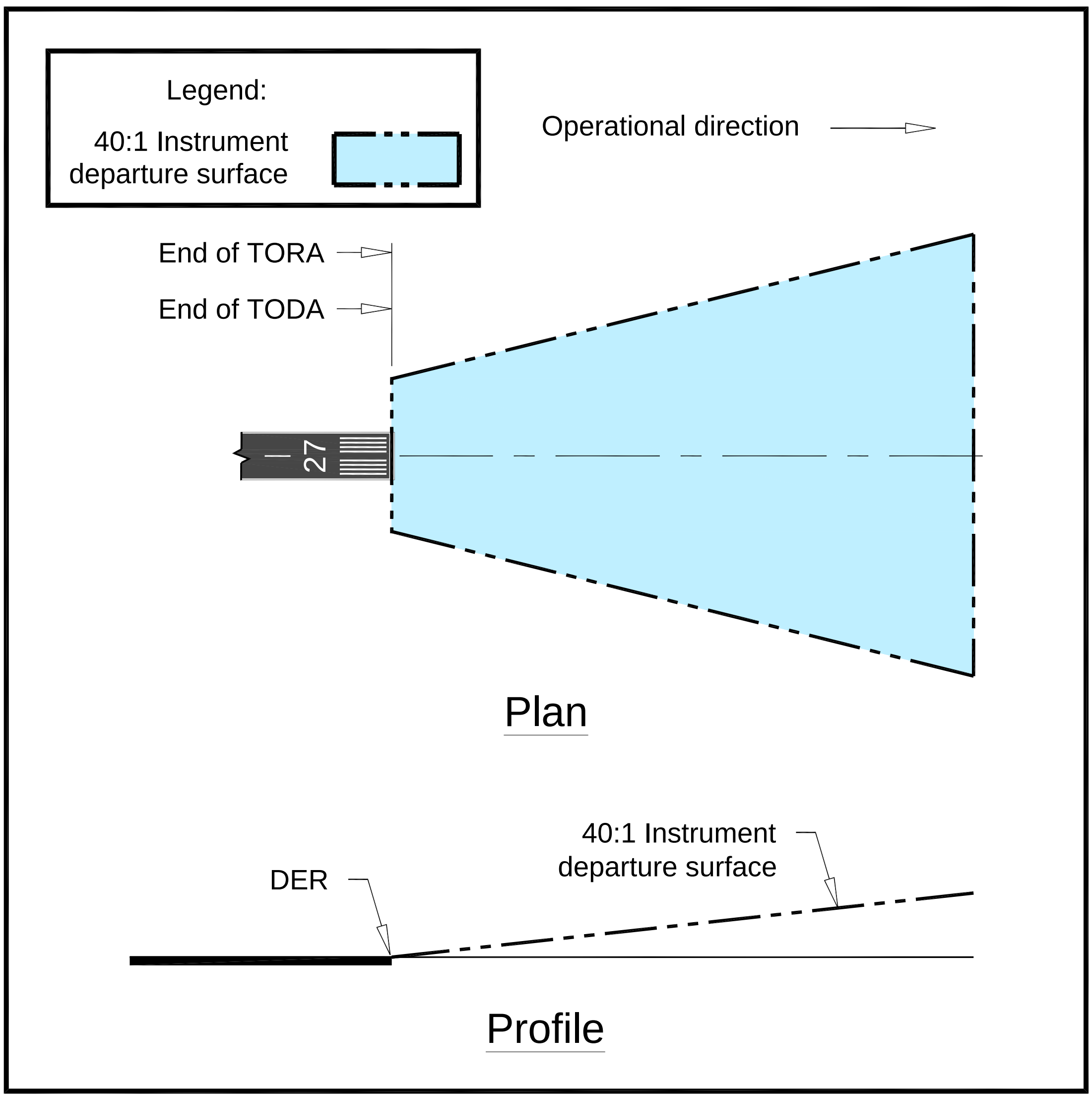
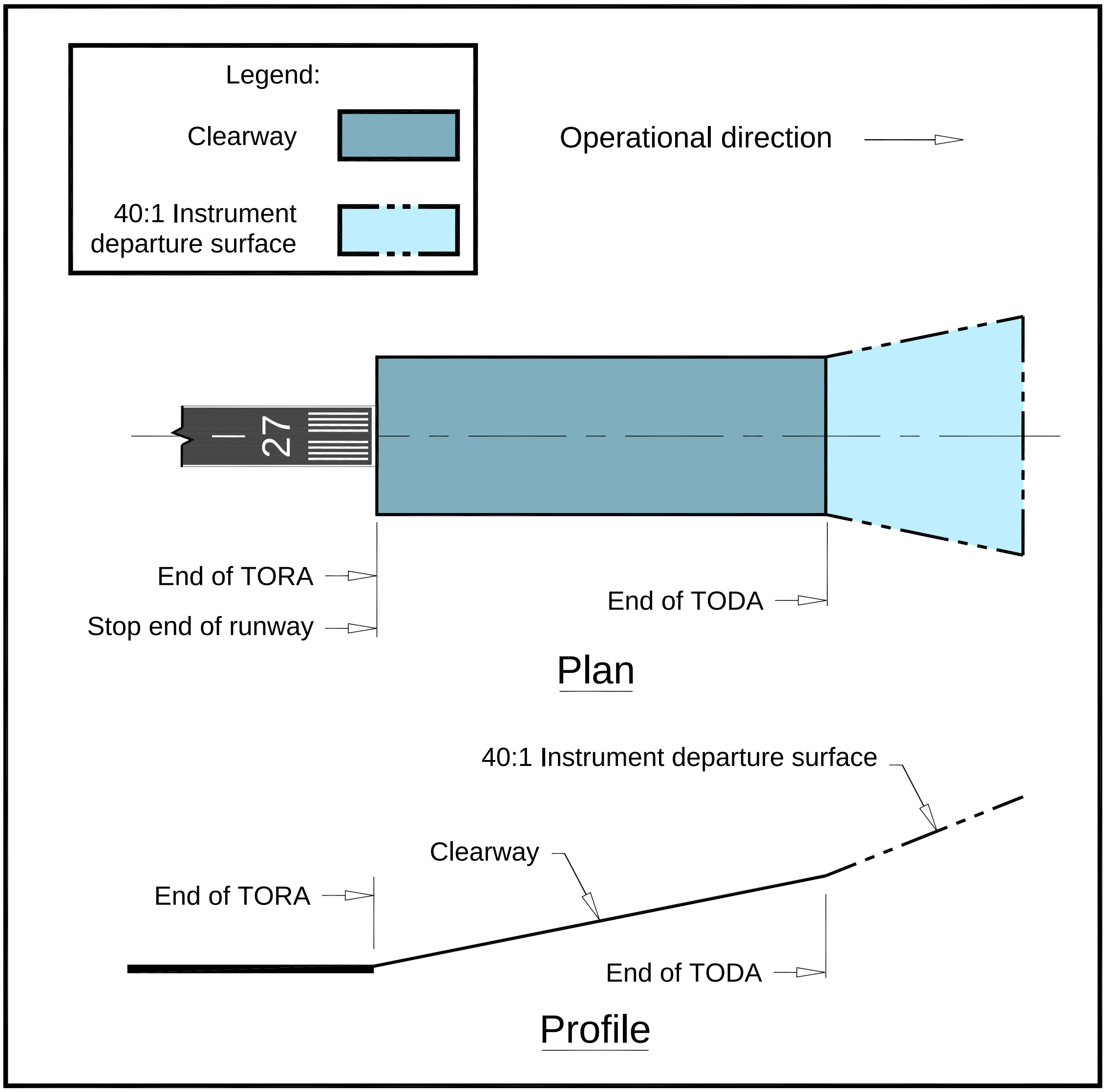


Figure H-7. Extended TODA with Clearway – Typical TORA



H.4.2.1 **Clearway.**

A clearway is only included as part of TODA. It is located at the departure end of the TORA. See paragraph 3.13.

1. When the TORA does not extend to the end of the runway a clearway (if any) extends beyond the runway end.
2. Any portion of the runway extending into the clearway is unavailable and/or unsuitable for takeoff run and takeoff distance computations.
3. Add the length of the clearway to the TORA for takeoff distance calculations.
4. A clearway increases the allowable airplane operating takeoff weight without increasing runway length.

H.4.3 ASDA.

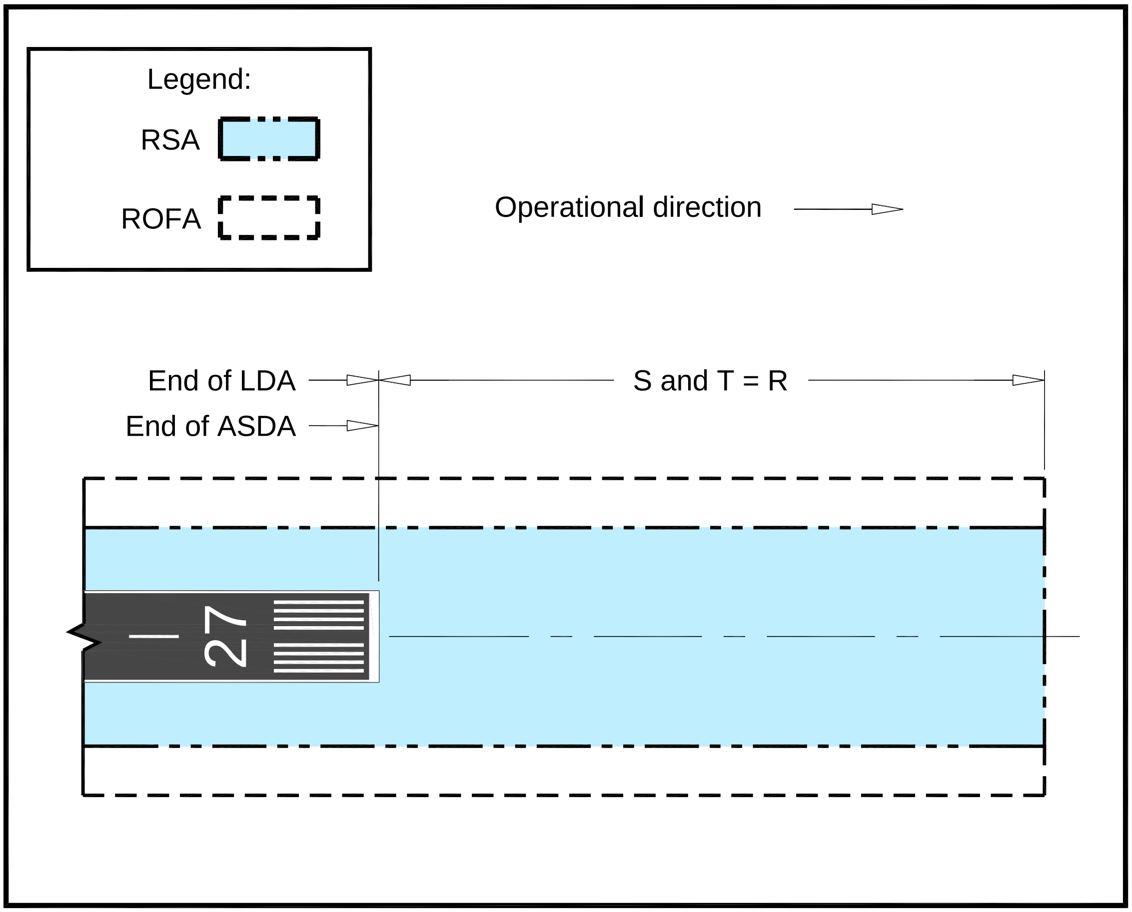
The ASDA extends the length of runway plus stopway (if any) declared available and suitable for satisfying accelerate-stop distance requirements for a rejected takeoff. At the start of takeoff, consider the RSA and ROFA beyond the ASDA in determining the ASDA.

1. When only the full runway beyond the start of takeoff is available for completing a rejected takeoff, locate the stop end of the ASDA at the end of the runway, with the standard RSA and ROFA length R beyond the runway end (see Figure H-8).
2. When the standard RSA length R beyond the end of the runway does not exist or is not obtainable, reducing the ASDA is one way to obtain additional RSA beyond the ASDA as illustrated in Figure H-9.
3. When using declared distances to provide ROFA not obtainable beyond the runway end, and T is less than S, obtain additional ROFA beyond the ASDA by reducing the ASDA as illustrated in Figure H-10.
4. When a runway includes a stopway, the RSA and ROFA extend R beyond the stopway (see Figure H-11).
5. It may be necessary to use EMAS in conjunction with declared distances.
6. The portion of runway beyond the ASDA is unavailable and/or unsuitable for ASDA computations.

H.4.3.1 **Stopway.**

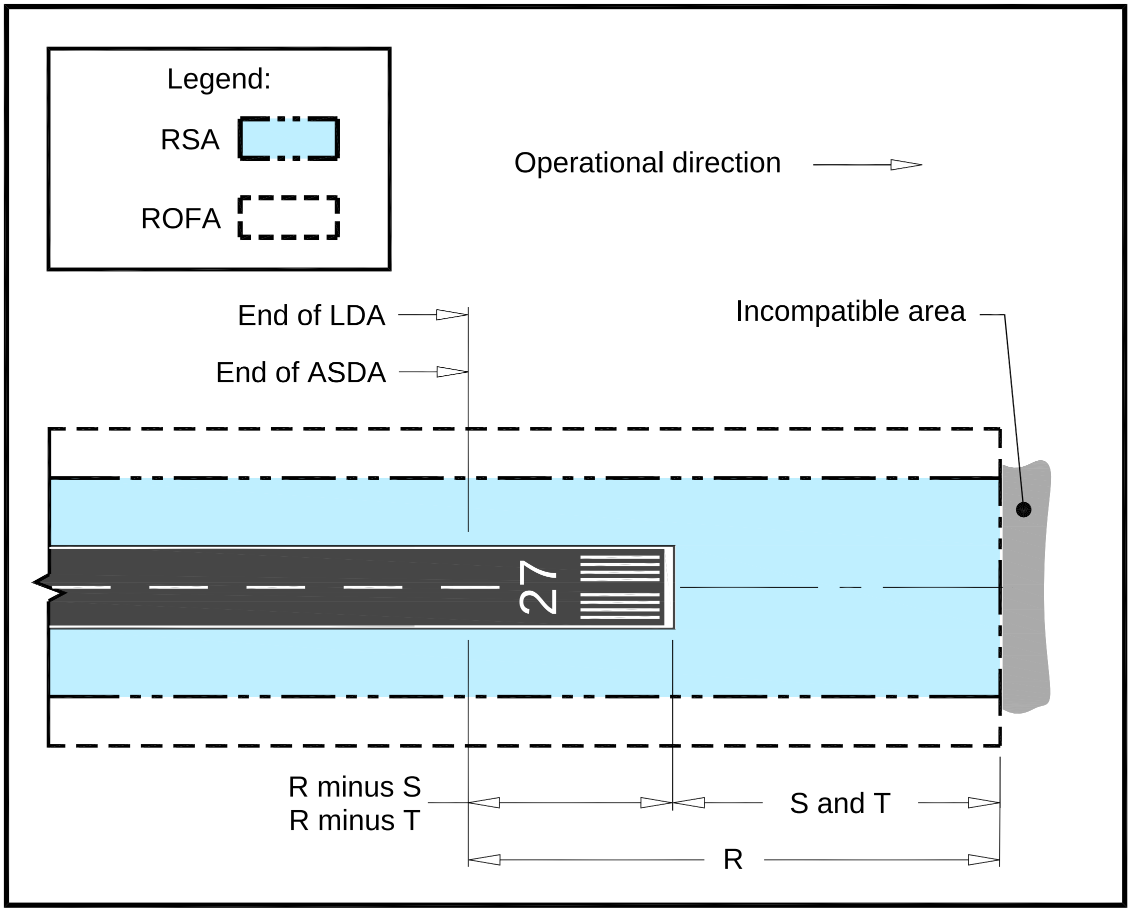
Only include a stopway as part of ASDA. See the definition of a stopway in paragraph 1.5, item 88.

Figure H-8. Typical Location of Stop End of ASDA and LDA



Note 1: When a stopway exists, see Figure H-11 for the stop end of the ASDA.
Note 2: S denotes the existing or proposed length of the RSA beyond the runway end.
Note 3: T denotes the existing or proposed length of the ROFA beyond the runway end.

Figure H-9. Adjusted ASDA and LDA Stop End for the RSA



Note 1: When a stopway exists, see Figure H-11 for the stop end of the ASDA.

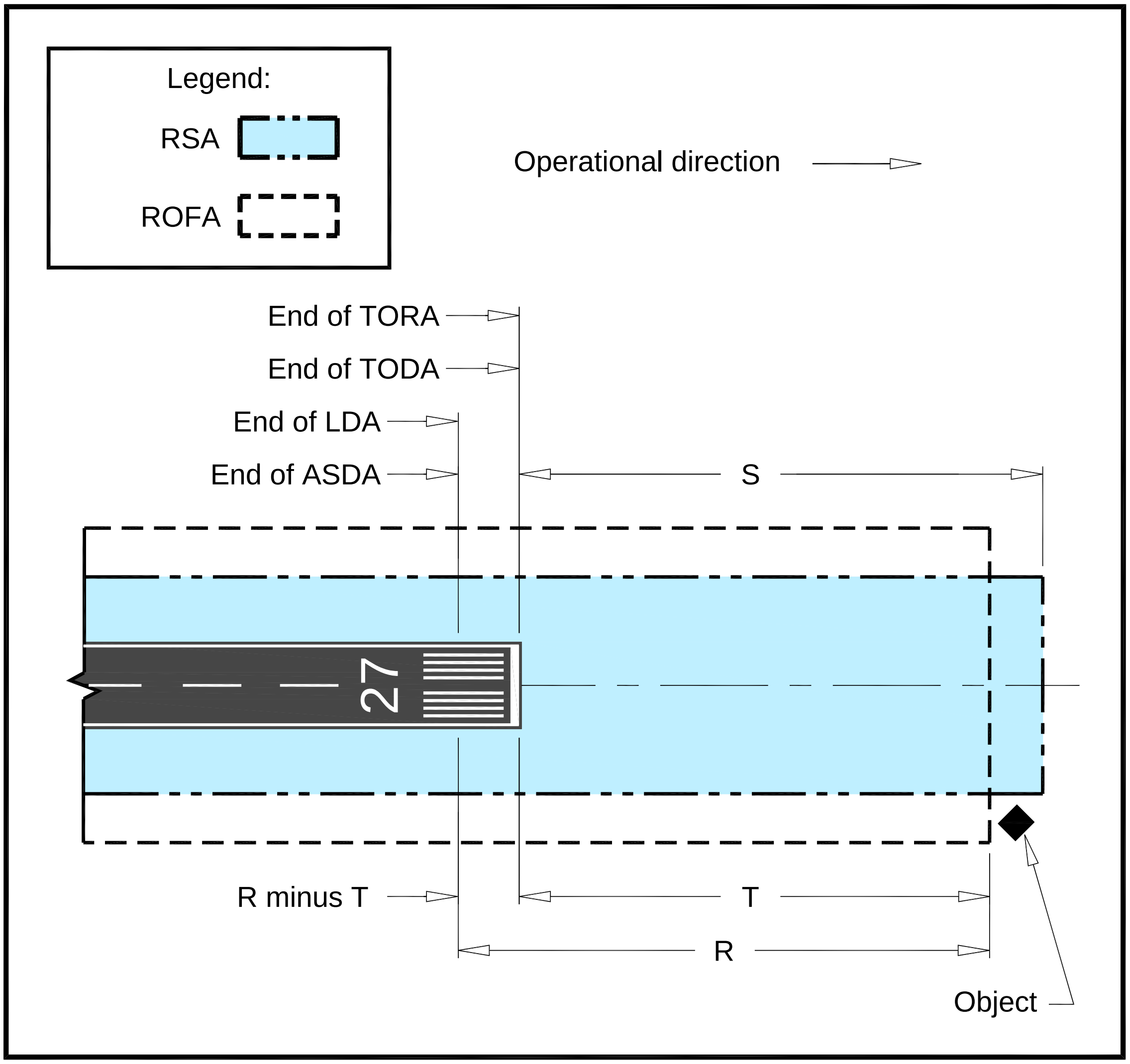
Note 2: S denotes the existing or proposed length of the RSA beyond the runway end.

Note 3: T denotes the existing or proposed length of the ROFA beyond the runway end.

Note 4: When declared distances are used as an incremental improvement and R is not obtainable beyond the LDA, this dimension equals the length of RSA obtainable beyond the ASDA.

Note 5: When declared distances are used as an incremental improvement and R is not obtainable beyond the LDA/ASDA, this dimension may equal the length of RSA obtainable beyond the LDA/ASDA minus S.

Figure H-10. Adjusted ASDA and LDA Stop End for ROFA



Note 1: When a stopway exists, see Figure H-11 for the stop end of the ASDA.

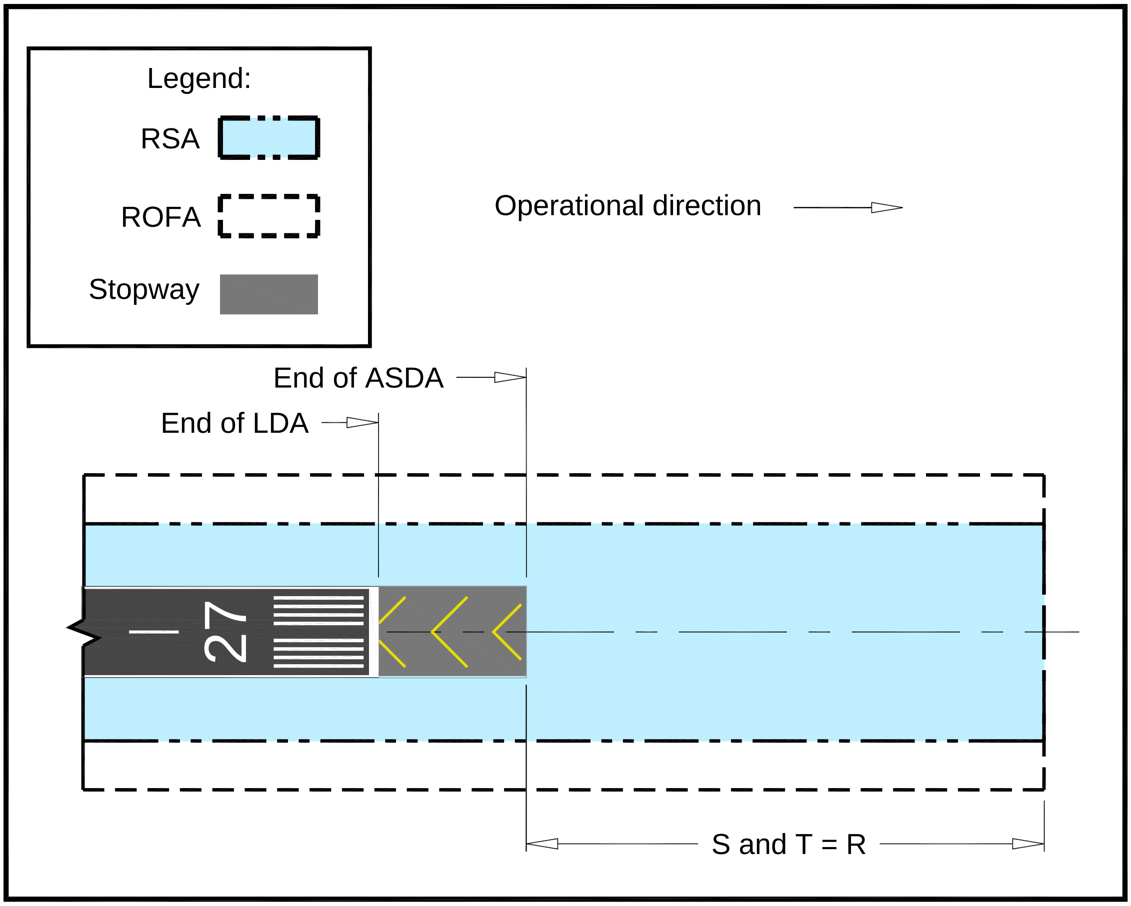
Note 2: S denotes the existing or proposed length of the RSA beyond the runway end.

Note 3: T denotes the existing or proposed length of the ROFA beyond the runway end.

Note 4: When declared distances are used as an incremental improvement and R is not obtainable beyond the LDA/ASDA, this dimension equals the length of ROFA obtainable beyond the LDA/ASDA.

Note 5: When declared distances are used as an incremental improvement and R is not obtainable beyond the LDA/ASDA, this dimension may equal the length of ROFA obtainable beyond the LDA/ASDA minus T.

Figure H-11. Stop End of ASDA with Stopway



Note 1: S denotes the existing or proposed length of the RSA beyond the runway end.
Note 2: T denotes the existing or proposed length of the ROFA beyond the runway end.

H.5 For Landing.

H.5.1 <u>LDA.</u>

The LDA is the length of runway declared available and suitable for satisfying landing distance requirements. Consider the threshold siting criteria, the approach RPZ, the RSA and ROFA prior to the threshold and beyond the LDA in establishing this distance.

H.5.1.1 The Beginning of the LDA.

The LDA begins at the threshold. When the RSA, ROFA, approach RPZ and threshold siting requirements are met the threshold is normally placed at the beginning of the runway. (See Figure H-12). When these standards do not exist, displacing the threshold is an option to attain them.

1. If there are multiple reasons to displace a threshold:
   a. Calculate each displacement requirement.

b. Select the longest displacement.

c. Reevaluate all other criteria from the calculated threshold location to ensure that they are not violated, such as new obstacle penetrations due to the splay of the approach surface that is associated with the new threshold.

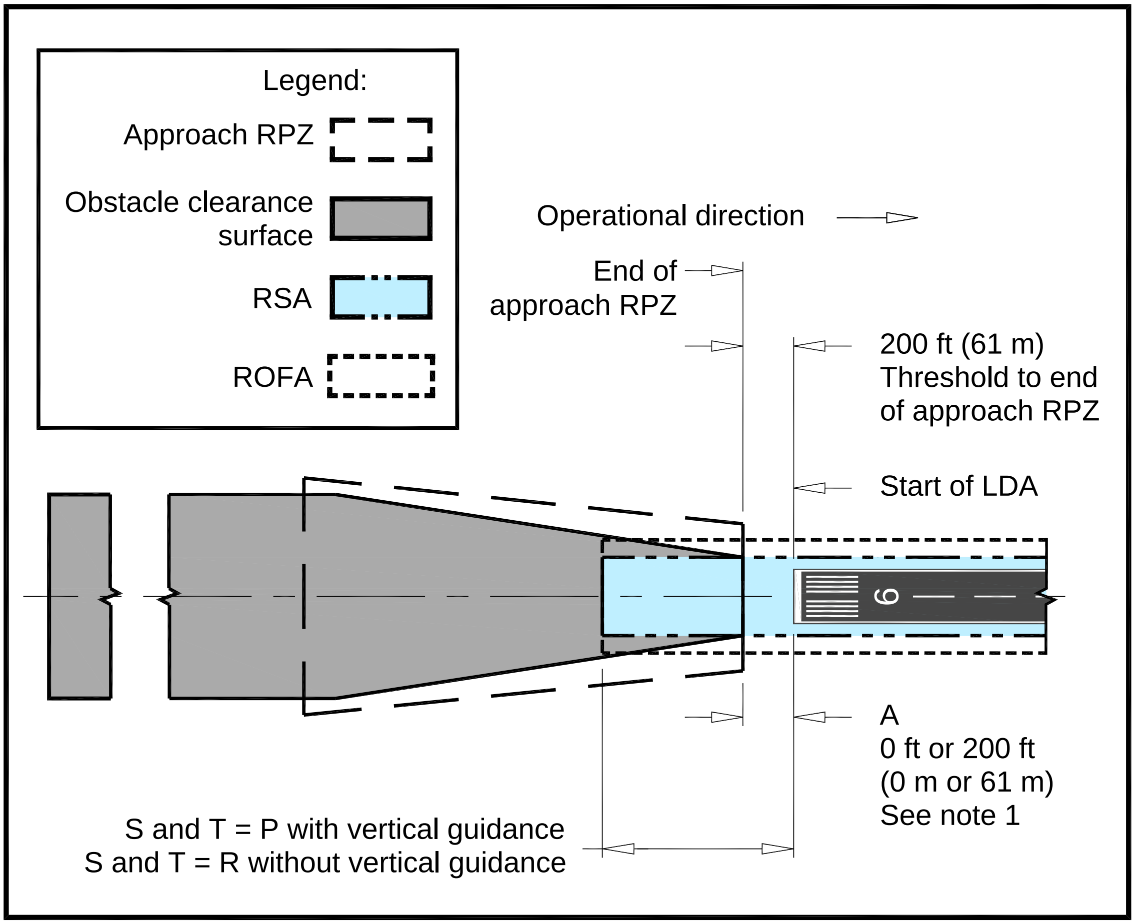
2. Displacing the threshold is an option to obtain additional RSA and ROFA, to mitigate unacceptable incompatible land uses in the RPZ, to meet approach surface requirements, and to mitigate environmental effects (see Figure H-12, Figure H-13, Figure H-14, Figure H-15, and Figure H-16).

H.5.1.2 The End of the LDA.

When the LDA extends to the end of the runway, the full dimension RSA and ROFA extend beyond the runway end by length R.

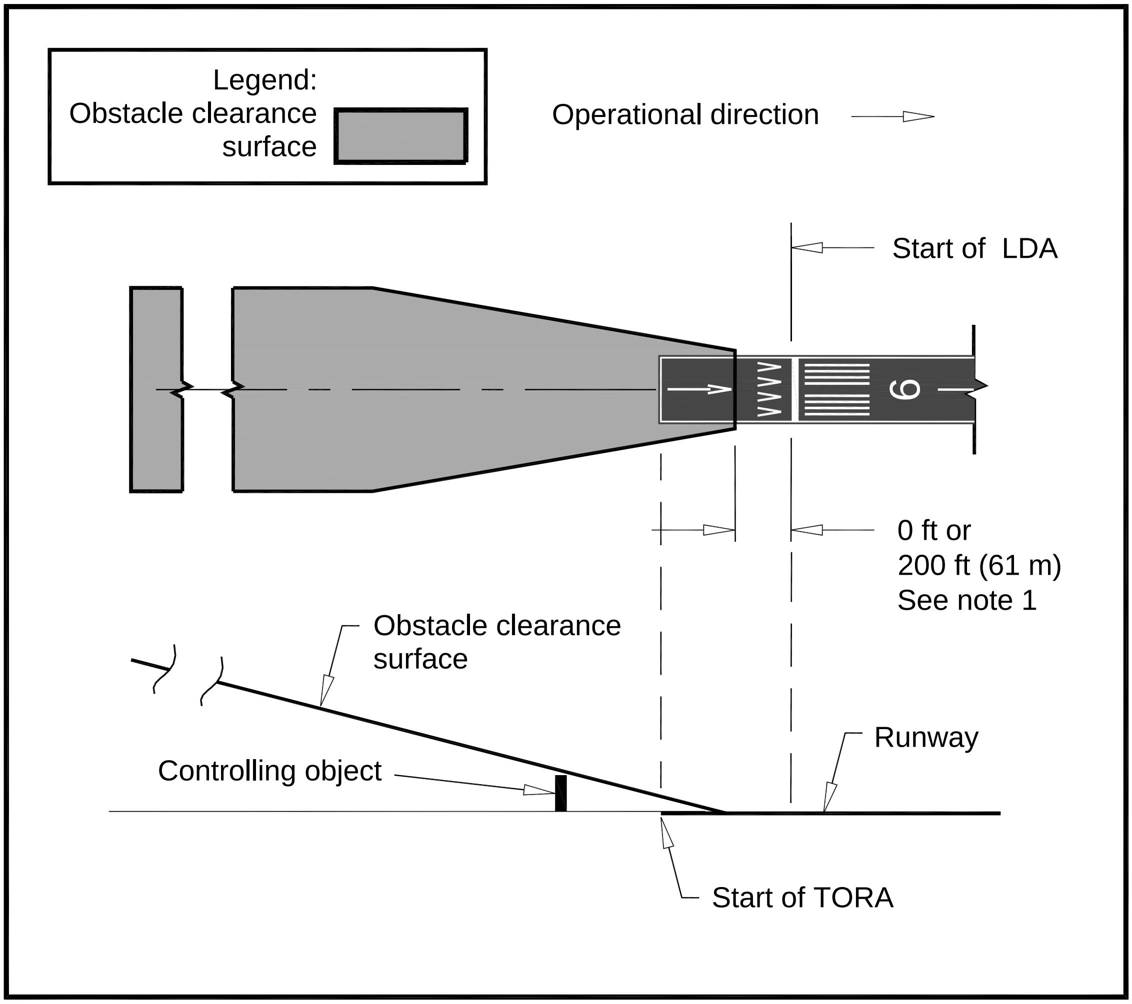
1. Except when a stopway exists as part of the ASDA, the LDA ends at the same location as the end of the ASDA.
2. A stopway cannot be part of the LDA.
3. When the full dimension RSA/ROFA length R beyond the runway end is not obtainable, obtain additional RSA beyond the LDA by reducing the LDA as illustrated in Figure H-9.
4. Where declared distances provide ROFA not obtainable beyond the runway end and T is less than S, obtain additional RSA ROFA beyond the LDA by reducing the LDA as illustrated by Figure H-10.
5. EMAS can be used to meet RSA standards; it may be necessary to use EMAS in conjunction with declared distances.
6. The portion of runway beyond the LDA is unavailable for LDA computations (see Figure H-9 and Figure H-10).

7576 **Figure H-12. Typical Start of LDA**



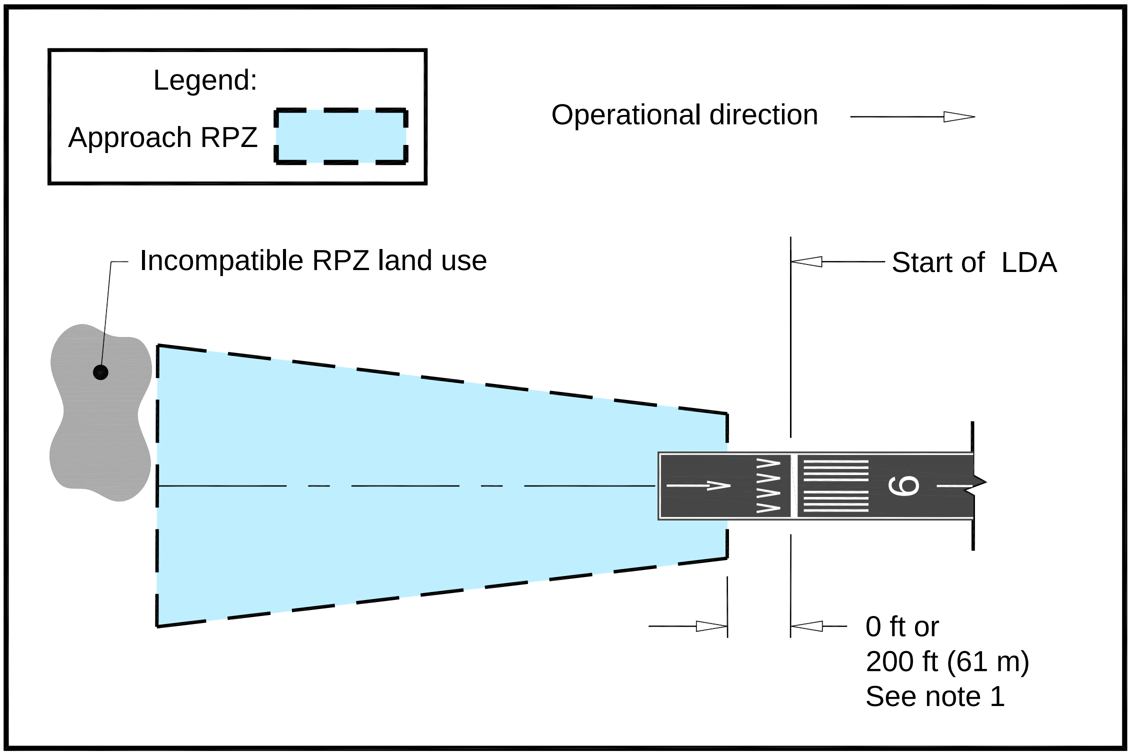
7577
7578 **Note 1:** See Table 3-1.
7579 **Note 2:** S denotes the existing or proposed length of the RSA beyond the runway end.
7580 **Note 3:** T denotes the existing or proposed length of the ROFA beyond the runway end.

Figure H-13. LDA Starting Point – Displaced Threshold for Obstacle Clearance Surface



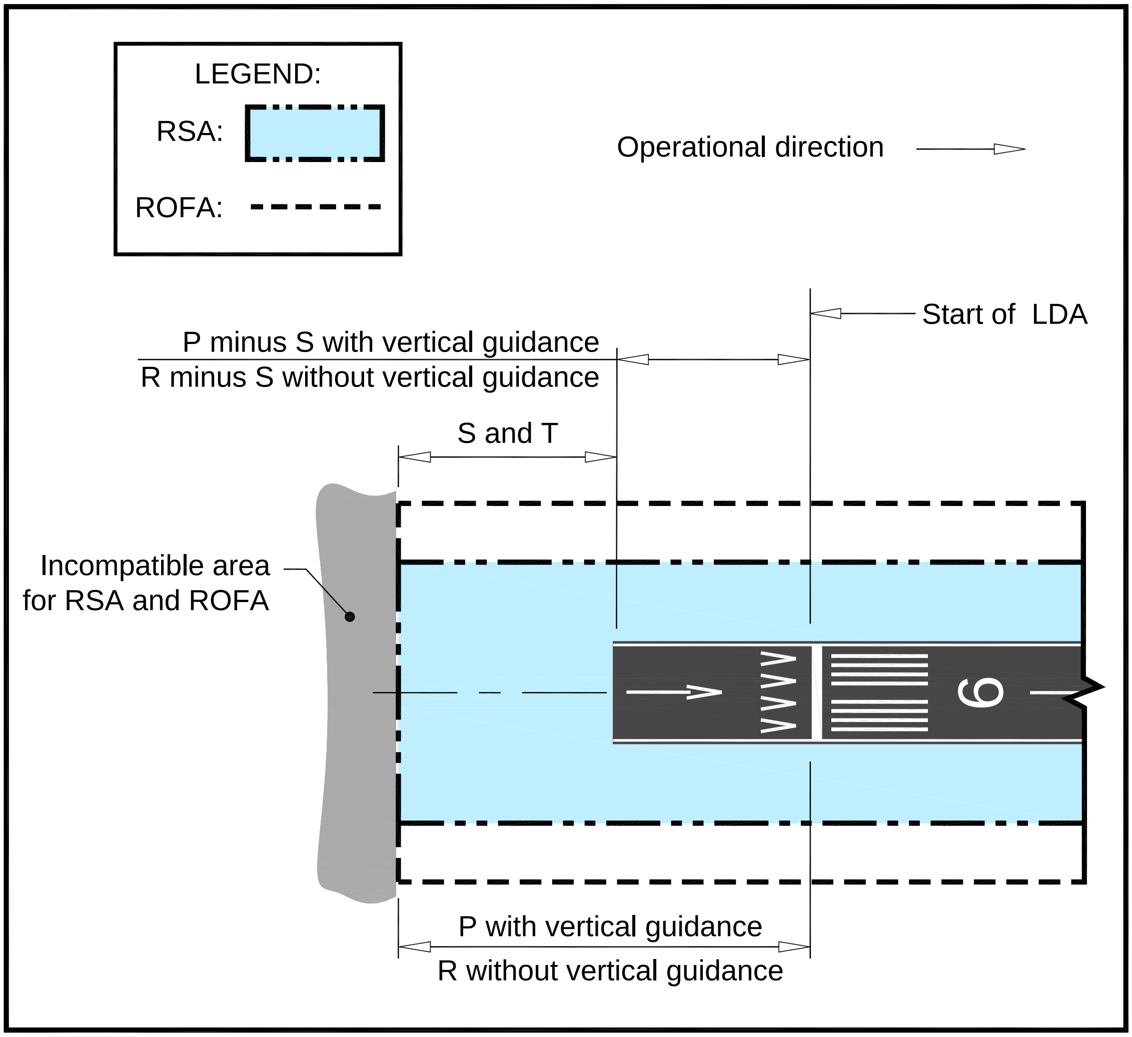
Note 1: See Table 3-1.

7585 **Figure H-14. LDA Starting Point – Displaced Threshold for Adjusted RPZ**



7586
7587 **Note 1:** See Table 3-1.

Figure H-15. LDA Starting Point – Displaced Threshold for Adjusted RSA



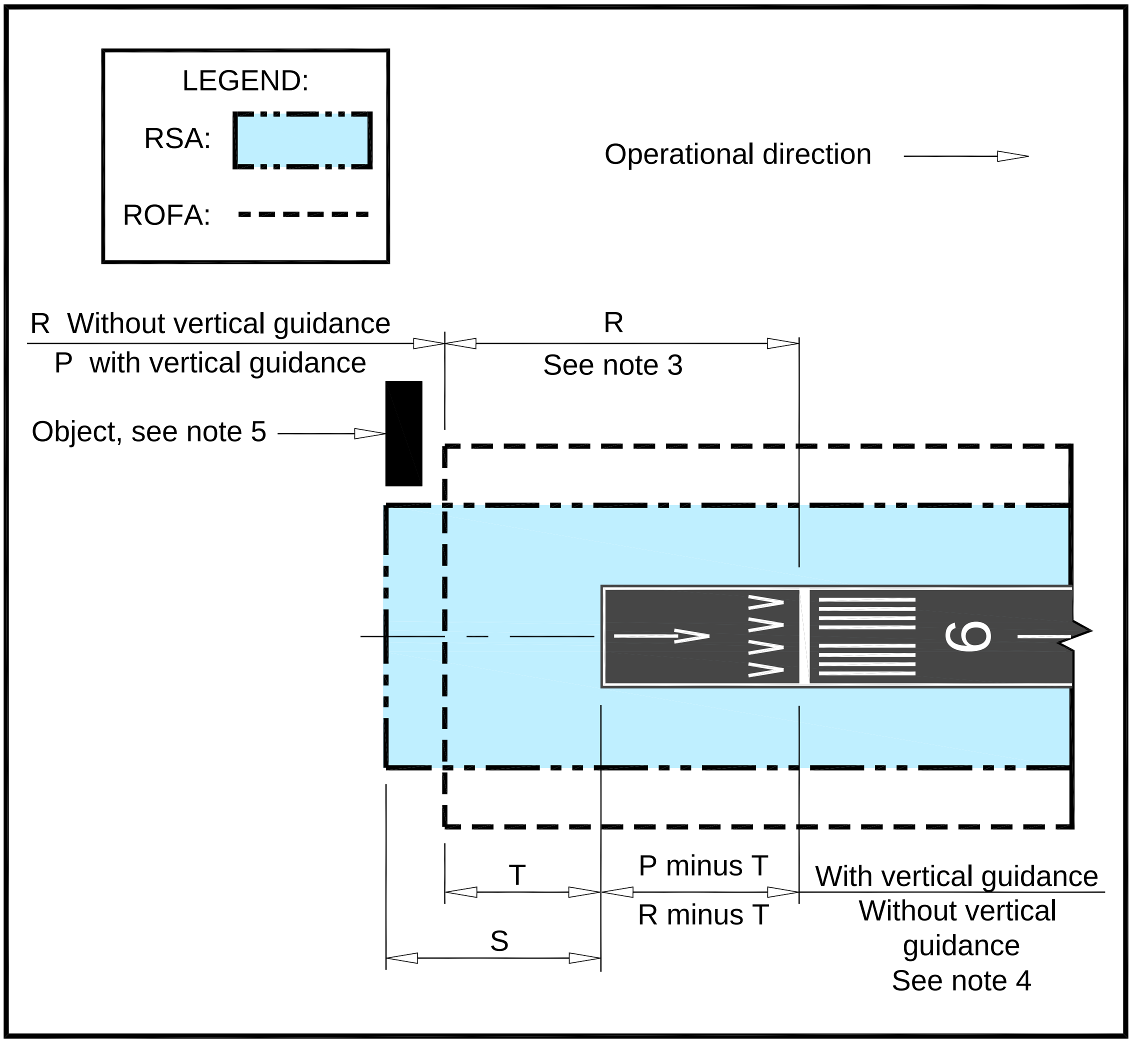
Note 1: S denotes the existing or proposed length of the RSA beyond the runway end.
Note 2: T denotes the existing or proposed length of the ROFA beyond the runway end.
Note 3: When declared distances are used as an incremental improvement and the applicable P or R is not obtainable prior to the LDA, this dimension equals the length of RSA obtainable prior to the LDA.
Note 4: When declared distances are used as an incremental improvement and the applicable P or R is not obtainable prior to the LDA, this dimension equals the length of RSA prior to the LDA minus S.

H.6 Notification.

H.6.1 The airport owner provides the clearway and stopway lengths, if necessary, and declared distances (TORA, TODA, ASDA, and LDA) for inclusion in the Airport Master Record (FAA Form 5010), Chart Supplement (and in the Aeronautical Information Publication, for international airports) for each operational runway direction.

H.6.2 Publish declared distances for all international airports and Part 139 certificated airports, even when the distances are equal to the runway length in both directions. When the threshold siting is for small airplanes, report LDA as “LDA for airplanes of 12,500 lbs (5700 kg) or less maximum certificated takeoff weight.”

Figure H-16. LDA Starting Point – Displaced Threshold for Adjusted ROFA



Note 1: S denotes the existing or proposed length of the RSA beyond the runway end.

Note 2: T denotes the existing or proposed length of the ROFA beyond the runway end.

Note 3: When declared distances are used as an incremental improvement and the applicable P or R is not obtainable prior to the LDA, this dimension equals the length of ROFA obtainable prior to the LDA.

Note 4: When declared distances are used as an incremental improvement and the applicable P or R is not obtainable prior to the LDA, this dimension equals the length of ROFA prior to the LDA minus T.

H.7 Documenting Declared Distances.

Record all standards requiring a threshold displacement.

1. Indicate:
   a. the controlling threshold displacement
   b. the reason for a takeoff starting farther up the runway based upon the takeoff direction (if applicable)
   c. all reasons for limiting the TORA, TODA ASDA and LDA to less than the runway length (if applicable)
2. Document the controlling limitations and the reason for the ASDA or TODA extending beyond the runway end.
3. Where a limitation is removed, check there are no other limiting conditions before extending a respective distance.
4. For obligated airports, provide the information to the responsible FAA Airports office and show the declared distances on the approved ALP.
5. For applicable runways, depict declared distances in both operational directions as an ALP Sheet with plan and profile views showing obstructions.

APPENDIX I. RUNWAY ADDITIONAL INFORMATION

I.1 Runway Safety Area (RSA) Development.

The RSA enhances the safety of aircraft which undershoot, overrun, or veer off the runway, and it provides greater accessibility for fire fighting and rescue equipment during such incidents. Figure I-1 below depicts the approximate percentage of aircraft overrunning the runway which stay within a specified distance from the runway end. The current RSA standards are based on 90% of overruns being contained within the RSA. The RSA is depicted in Figure 3-16 and its dimensions are given in the online Runway Design Standards Matrix Tool.

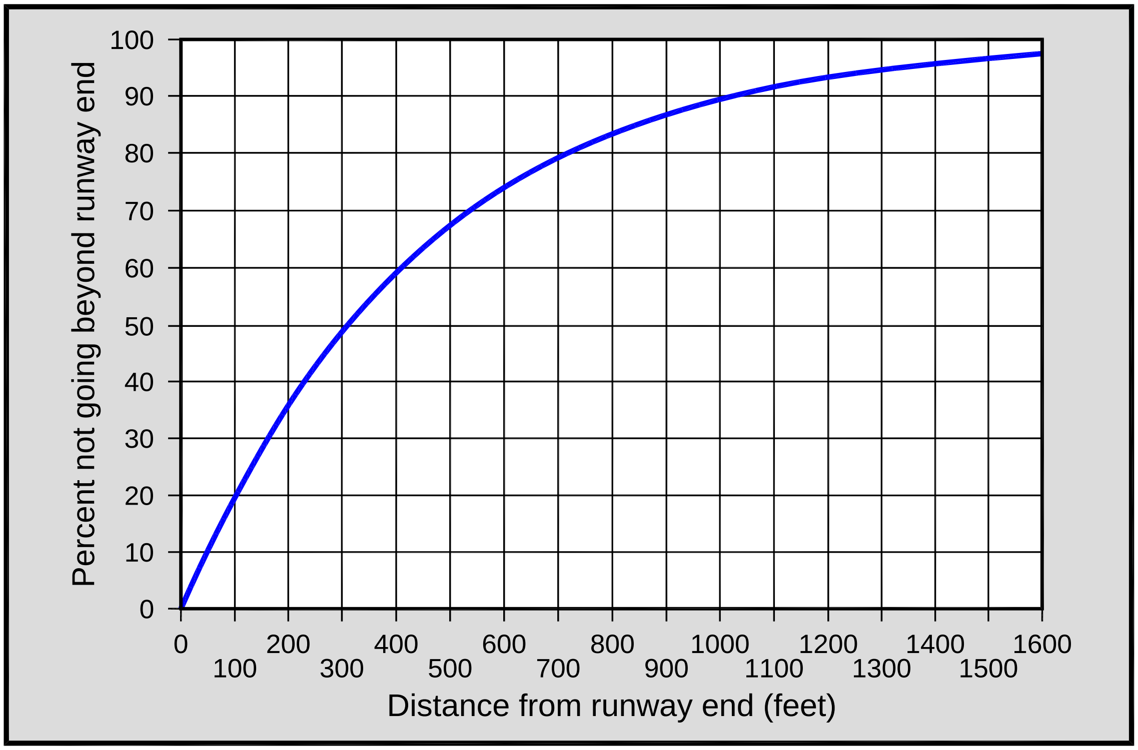
I.1.1 Historical Development.

In the early years of aviation, all aircraft operated from relatively unimproved airfields. As aviation developed, the alignment of takeoff and landing paths centered on a well-defined area known as a landing strip. Thereafter, the requirements of more advanced aircraft necessitated improving or paving the center portion of the landing strip. Retaining the term "landing strip" to describe the graded area surrounding and upon which the runway or improved surface was constructed, the primary role of the landing strip changed to that of a safety area surrounding the runway. This area had to be capable under normal (dry) conditions of supporting aircraft without causing structural damage to the aircraft or injury to their occupants. Later, the designation of the area changed to "runway safety area" to reflect its functional role.

I.1.2 Incremental Improvements.

FAA recognizes incremental improvements inside full RSA dimensions enhance the margin of safety for aircraft. The airport owner and the FAA continually analyze a non-standard RSA with respect to operational, environmental, and technological changes and revise the safety area determination as appropriate. Include incremental improvements in the determination. The concept of incremental improvement precludes the placing of objects within the standard RSA dimensions even if that specific runway does not fully meet RSA standards.

Figure I-1. Percent of Aircraft Overrun Versus Distance Beyond the Runway End



I.2 Runway Protection Zone (RPZ) Background.

Approach protection zones were originally established to define land areas underneath aircraft approach paths in which control by the airport operator was highly desirable to prevent the creation of air navigation hazards. Historical development:

1. A 1952 report by the President's Airport Commission (chaired by James Doolittle), entitled *The Airport and Its Neighbors*, recommended the establishment of clear areas beyond runway ends.
2. Provision of these clear areas was not only to preclude obstructions potentially hazardous to aircraft, but also to control building construction as a protection from nuisance and hazard to people on the ground.
3. The Department of Commerce concurred with the recommendation on the basis that this area was "primarily for the purpose of safety and convenience to people on the ground."
4. The FAA adopted "Clear Zones" with dimensional standards to implement the Doolittle Commission's recommendation.
5. Guidelines were developed recommending that clear zones be kept free of structures and any development creating a place of public assembly.

I.2.1 In conjunction with the introduction of the RPZ as a replacement term for Clear Zone, the RPZ was divided into "extended object free" and "controlled activity" areas. The extended object free area has subsequently been renamed as the "central portion of the RPZ." The FAA has since dropped this designation for differentiating the RPZ into different zones. The extended RSA and ROFA protect the areas most critical to the runway ends.

I.2.2 The RPZ function is to enhance the protection of people and property on the ground. Where practical, airport owners own the property under the runway approach and departure areas to at least the limits of the RPZ. It is desirable to clear the entire RPZ of all above-ground objects to minimize risk to the public. See FAA Memorandum, *Interim Guidance on Land Uses Within a Runway Protection Zone*, dated 9/27/2012, for guidance on incompatible activities.

I.2.3 The following new land uses within the limits of the RPZ are permissible without further evaluation:

1. Farming activities meeting airport design clearance standards.
2. Irrigation channels meeting the standards of AC 150/5200-33 and FAA/USDA manual, *Wildlife Hazard Management at Airports*.
3. Airport service roads, as long as they are not public roads and are under direct control of the airport operator.
4. Underground facilities, as long as they meet other design criteria, such as RSA standards, as applicable.
5. NAVAIDs and aviation facilities, such as equipment for airport facilities considered fixed-by-function in regard to the RPZ.
6. Above-ground fuel tanks associated with back-up generators for unstaffed NAVAIDS.

I.3 Runway as a Taxiway.

A full-length parallel taxiway reduces the risk of both wrong surface events and runway incursions. Using an operationally closed runway as a taxiway, especially when a parallel taxiway exists, creates an elevated risk for these events. Performing taxi operations on a runway creates a potential for pilot confusion due to the wide pavement width and the lack of standard taxiway pavement markings, signage and lighting. Locations routinely needing an operational need for taxi operations on a runway is an indication that may justify development of dual parallel taxiways to eliminate taxiing on the runway. If the operational use of a runway as a taxiway is necessary for airport capacity and local conditions preclude standard parallel taxiways, establish a Letter of Agreement with the ATCT describing the operation. Refer to AC 150/5340-1 for marking holding positions on a runway.

I.4 Object Clearing.

I.4.1 Safe and efficient landing and takeoff operations at an airport require that certain areas on and near the airport are clear of objects or restricted to objects with a certain function, composition, and/or height.[7] These clearing standards and criteria create a safer environment for the aircraft operating on or near the airport. The airport operator is not required to prevent or clear penetrations to the Part 77, Subpart C, imaginary surfaces when the FAA determines these penetrations are not hazards. However, any existing or proposed object, whether man-made or of natural growth that penetrates these surfaces is classified as an "obstruction" and is presumed to be a hazard to air navigation. These obstructions are subject to an FAA aeronautical study, after which the FAA issues a determination stating whether the obstruction is in fact considered a hazard. The airport operator conducts a detailed analysis considering the requirements of FAA Order 8260.3, *United States Standard for Terminal Instrument Procedures (TERPS)*, to ensure all applicable surfaces are captured.

I.4.2 OFZs require clearing of object penetrations including aircraft fuselages and tails. Frangible NAVAIDs that need to be located in the OFZ because of their function are exempt from this standard. Paragraph 3.10 specifies OFZ standard dimensions.

I.4.3 Remove penetrations or locate the runway end such that there are no penetrations to the OCS. See paragraphs 3.4 and 3.5 for runway end establishment and OCSs.

I.5 Threshold Displacement on a Visual Runway.

A displacement to a runway threshold may be necessary to ensure vertical separation from obstructions by arriving aircraft, or to remove incompatible land uses from the RPZ.

I.5.1 The pavement prior to the displaced threshold (marked by arrows) remains available for departures from either end.

I.5.2 Applying the relevant approach surface at the two surfaces shown in Figure I-2 provides vertical protection for both landing (Surface 1) and takeoffs (Surface 2).

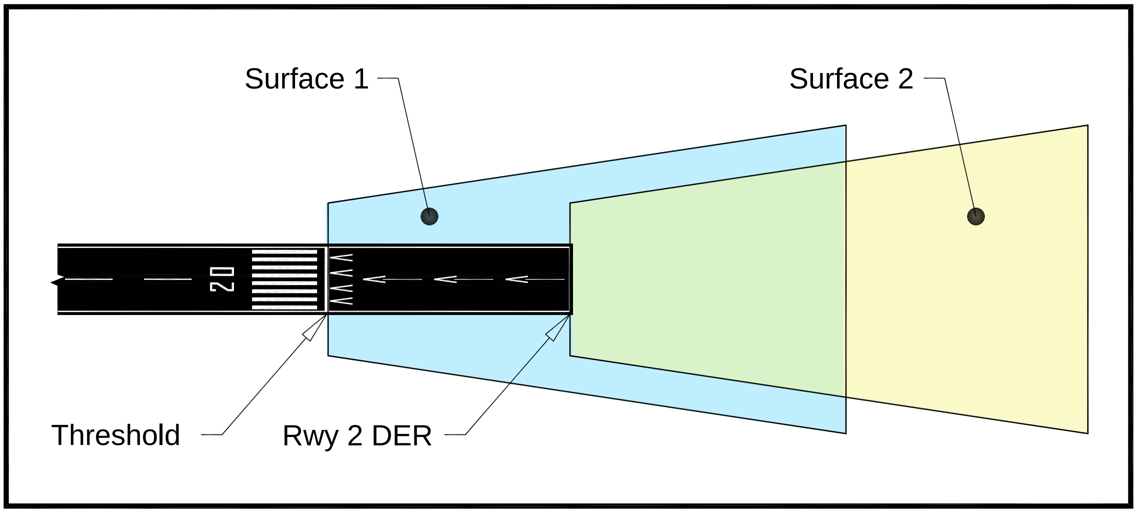
I.5.3 Do not consider existing objects as obstacles to air navigation that penetrate Surface 2, unless otherwise identified as a hazard to air navigation through an aeronautical study.

[7] The heights of traverse ways are adjusted as explained in14 CFR Part 77, paragraph 77.9(c): "Any highway, railroad, or other traverse way for mobile objects, [is] adjusted upward 17 feet for an Interstate Highway that is part of the National System of Military and Interstate Highways where overcrossings are designed for a minimum of 17 feet vertical distance, 15 feet for any other public roadway, 10 feet or the height of the highest mobile object that would normally traverse the road, whichever is greater, for a private road, 23 feet for a railroad, and for a waterway or any other traverse way not previously mentioned, an amount equal to the height of the highest mobile object that would normally traverse it…"

I.5.4 Protecting the Surface 2 area is a recommended practice to guard against the introduction of objects penetrating the surface. If future mitigation actions succeed in removing the limiting obstacle causing the threshold displacement, then restoration of the threshold to the full runway length can occur without clearing new objects clear of Surface 1 but penetrating Surface 2. With the application of Surface 2 to guard against new objects, the approach surface from the physical end of the runway will already be clear of obstacles.

I.5.5 The FAA recommends airports enact local zoning, easements, or other means to prevent future airport encroachment that can adversely affect aircraft operations.

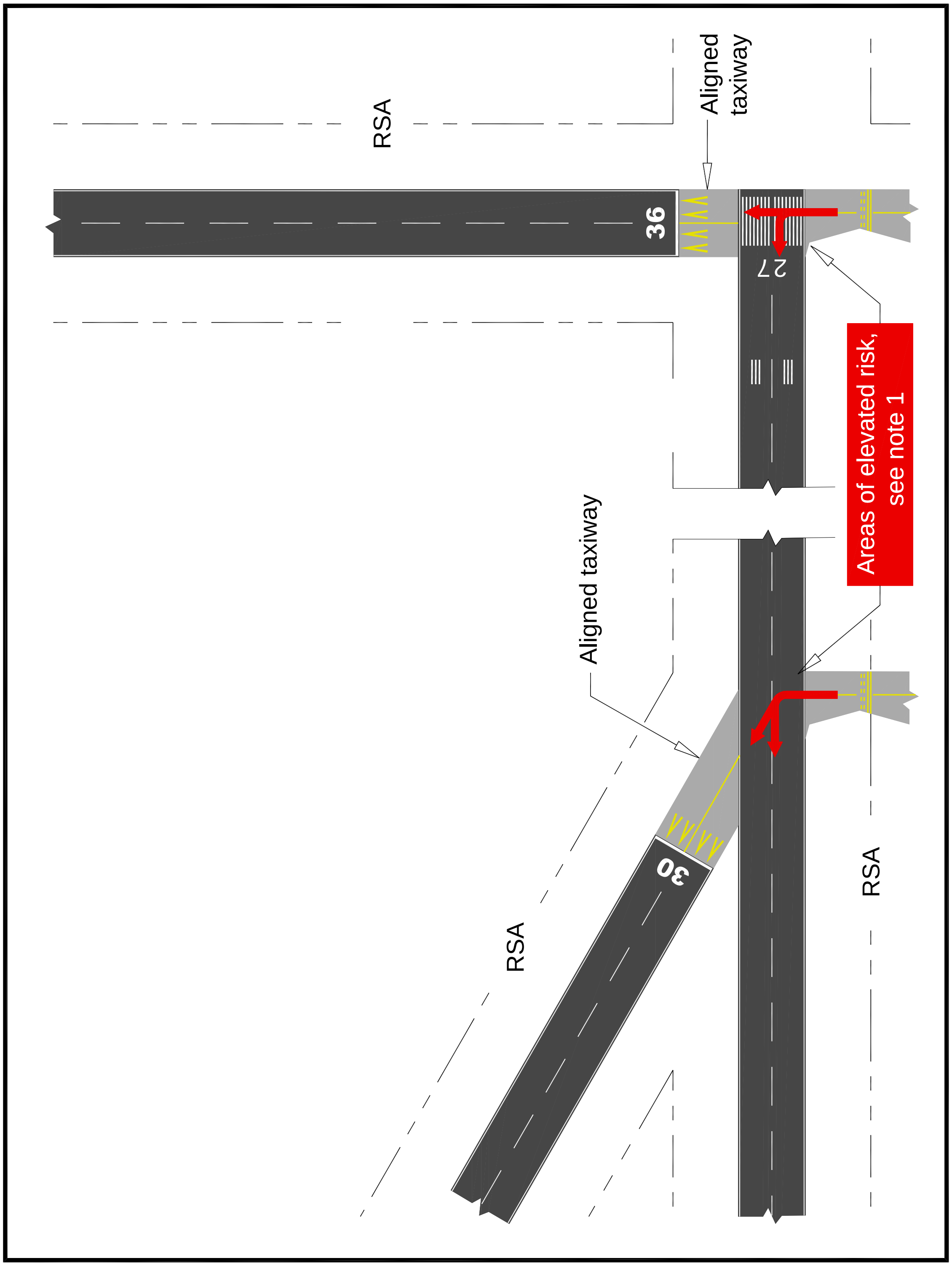
Figure I-2. Threshold Displacement on a Visual Runway



I.6 Overlapping RSAs.

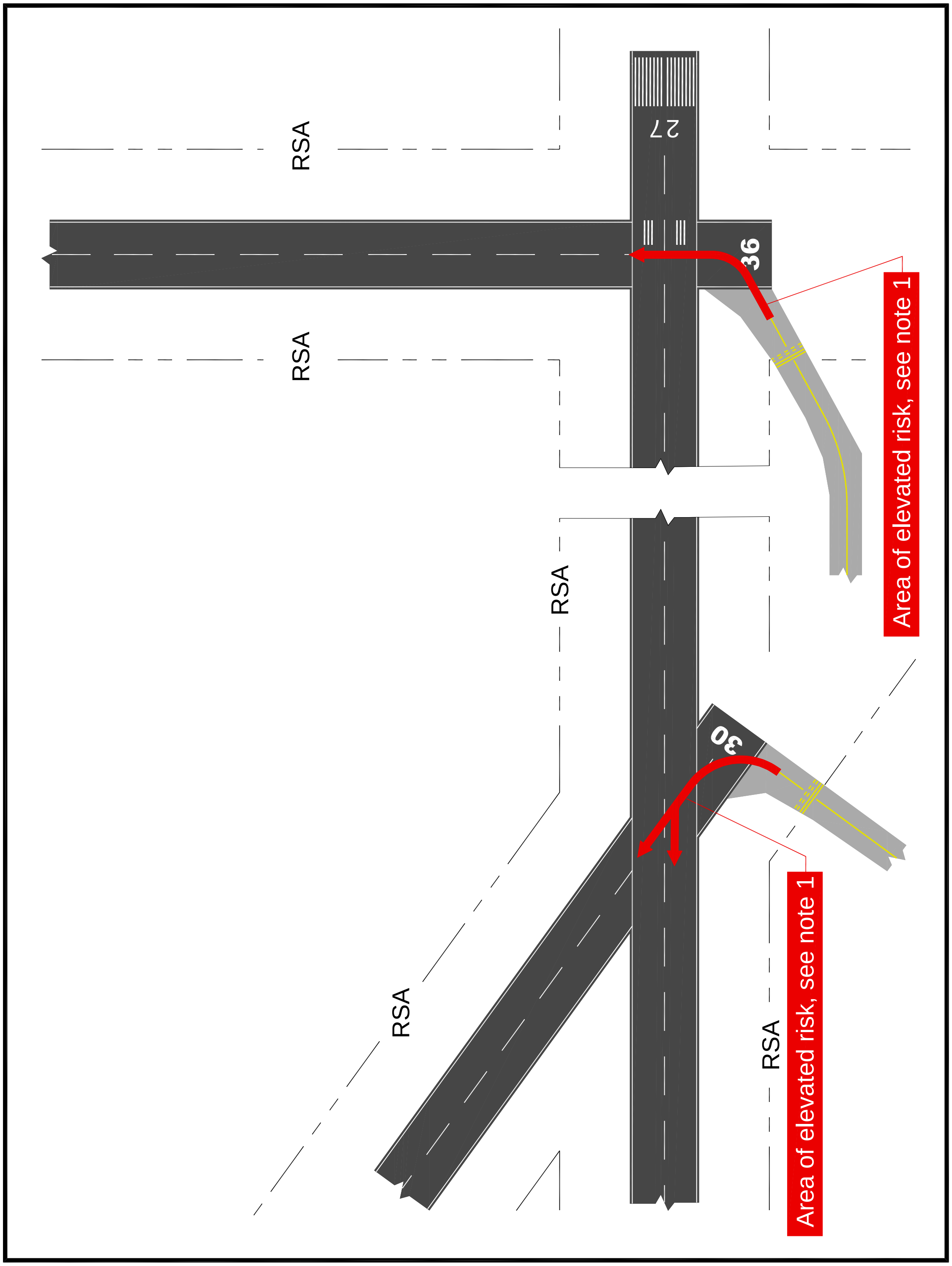
Runway configurations resulting in a runway threshold being located in close proximity to another runway or runway threshold create an elevated risk for runway incursions and wrong surface events. Two typical scenarios are: the runways intersect (Figure I-3) or the RSAs overlap (Figure I-4). These configurations do not provide sufficient physical space for design of entrance taxiways or associated marking and signage thus increasing the potential for pilot confusion and loss of situational awareness. Refer to Chapter 3 for standards addressing converging and intersecting runways.

Figure I-3. Overlapping Runway Safety Areas – Elevated Risk



Note 1: These configurations present an elevated risk for pilot loss of situational awareness that can contribute to a wrong runway takeoff.

Figure I-4. Intersecting Runways – Elevated Risk



Note 1: These configurations present an elevated risk for pilot loss of situational awareness that can contribute to a wrong runway takeoff or runway incursion.

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APPENDIX J. TAXIWAY ADDITIONAL INFORMATION

J.1 Purpose.

This appendix provides additional taxiway design guidance including:

1. Additional information and guidance on taxiway fillet design supplementing the design standards and recommended practices in paragraph 4.7.
2. Background and rationale for fillet design, including a step-by-step fillet design example.
3. Tables containing intersection details and dimensions for a range of turn angles for all TDG groups.
4. Discussion and examples of taxiway geometries with elevated runway incursion and other safety risks.

J.2 Taxiway Fillet and Turn Design.

J.2.1 Description.

As an airplane maneuvers through a turn designed for cockpit over centerline taxiing, the main gear require additional pavement in the form of fillets to maintain the Taxiway Edge Safety Margin (TESM).

1. Design the fillets based on combinations of the longest CMGs and widest MGWs in the TDG.
2. Base the outer radius of the curve design on the centerline radius.
3. The nose gear is not a factor in pavement requirements for a taxiway turn.

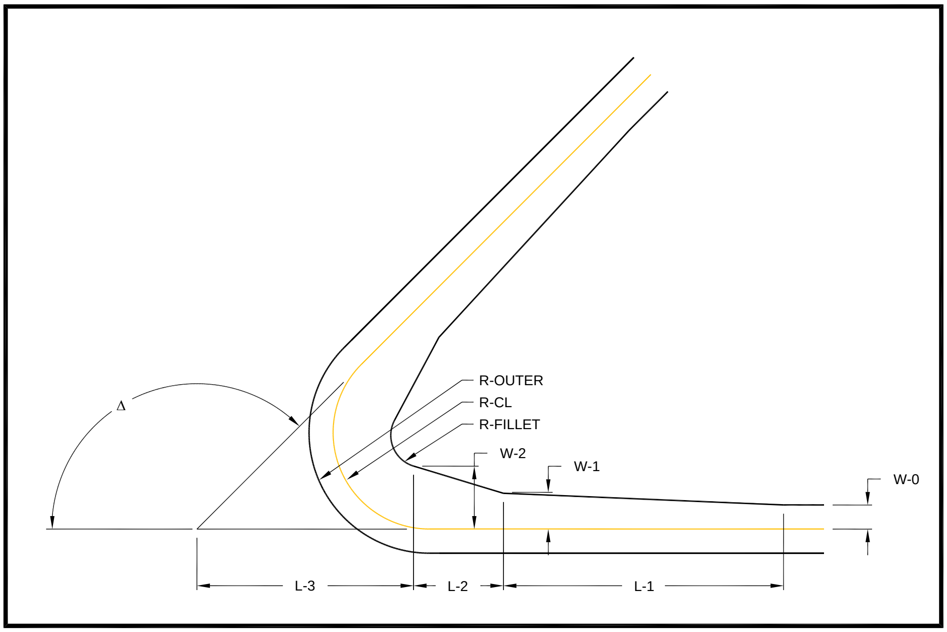
J.2.2 Fillet Design Rationale.

Refer to Figure J-1 for the following fillet design rationale:

1. At the start of the turn, the taxiway taper starts on the inside of the turn for a length L-1, with the distance from the taxiway centerline to the pavement edge tapering from W-0 to W-1.
2. As the airplane continues, the distance from the taxiway centerline to the pavement edge taper increases further, for a length L-2, from width W-1 to W-2, ending at a distance L-3 from the point of intersection.
3. The tapers associated with the dimensions L-1 and L-2 are symmetrical about a line bisecting the angle between the two centerlines and the "L-2" tapers connect by a fillet of radius R-Fillet, tangent to both.
4. The track of the main gear controls the fillet dimensions as the airplane exits the turn and the main gear returns to a symmetrical track about the taxiway centerline.

5. Since the main gear follows an asymptotic curve, it can take over 1000 ft (305 m) for the airplane to become re-centered. For this reason, the end of the "L-1" taper relies on a TESM 6 inches (15 cm) less than the applicable standard.

Figure J-1. Fillet Design Example



J.2.3 Taper Transitions.

Base the transition point from the "L-1" taper to the "L-2" taper on minimizing excess pavement, maximizing constructability, and ensuring compatibility with taxiway edge lighting standards. Determine W-1 by the location of this transition point.

J.2.4 Common Turning Angles.

Table J-1 through Table J-8 provide dimensions for a range of common turning angles, assuming sufficient distance is available to develop lead-in lengths.

J.2.5 Adjoining Taxiway Turns.

The standard fillet dimensions may not be suitable for taxiway turns in close proximity to each other. An indication of this is when the "L-1" tapers overlap, thus not allowing the critical aircraft to straighten out before entering the second turn. This often is the case for 90-degree runway entrances and exits located near a connecting taxiway. Applying the standard fillet dimensions may not adequately maintain the TESM and/or maximum 50-degree nose gear steering angle. Refer to Table 4-3, Table 4-4, Table 4-5, Table 4-8, and Table 4-9 for common combinations of TDGs for taxiway-to-taxiway separations.

J.2.6 Design Tools.

J.2.6.1 Microsoft Excel spreadsheets to determine the radius and taper lengths for single turns and two closely space turns are available on the FAA web site at: https://www.faa.gov/airports/engineering/airport_design/.

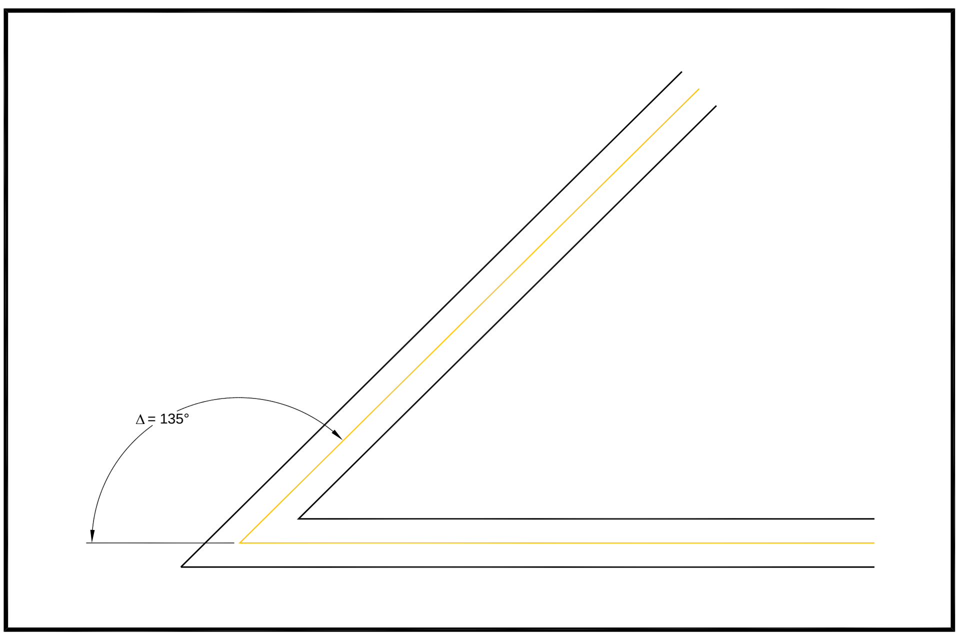
J.2.6.2 CAD modeling assists with selection of the centerline turn radius, outer pavement and fillet dimensions for separation distances and turns not listed in the tables located in this appendix.

J.2.7 Examples Using CAD Modeling.

Refer to Figure J-2 through Figure J-10 for examples of curve designs that were generated using CAD modeling of aircraft ground maneuvering.

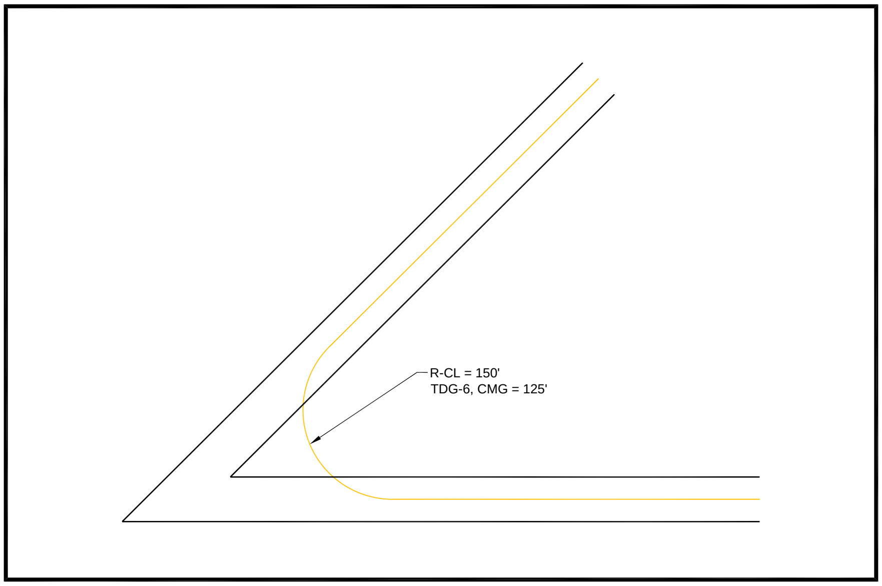
J.2.7.1 Figure J-2 illustrates the design of a curve for an angle of intersection (i.e. delta) of 135 degrees for TDG 6 aircraft.

Figure J-2. Angle of Intersection (Delta)



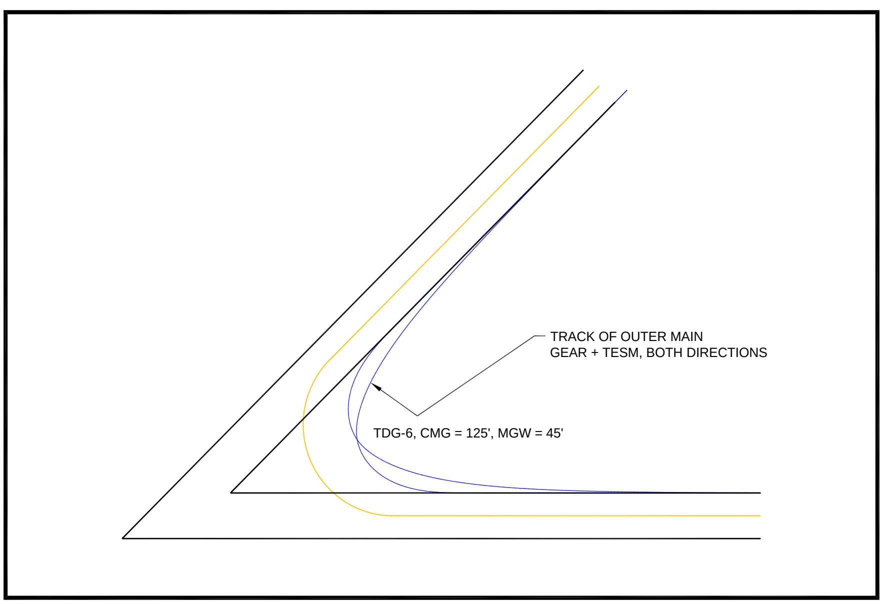
J.2.7.2 Per Figure J-3, connect the two centerlines with a radius calculated that will not result in a steering angle of no more than 50 degrees based on the maximum CMG of the TDG. Per Figure 1-1, the maximum CMG for TDG 6 is 125 feet.

Figure J-3. Steering Angle of No More Than 50 Degrees



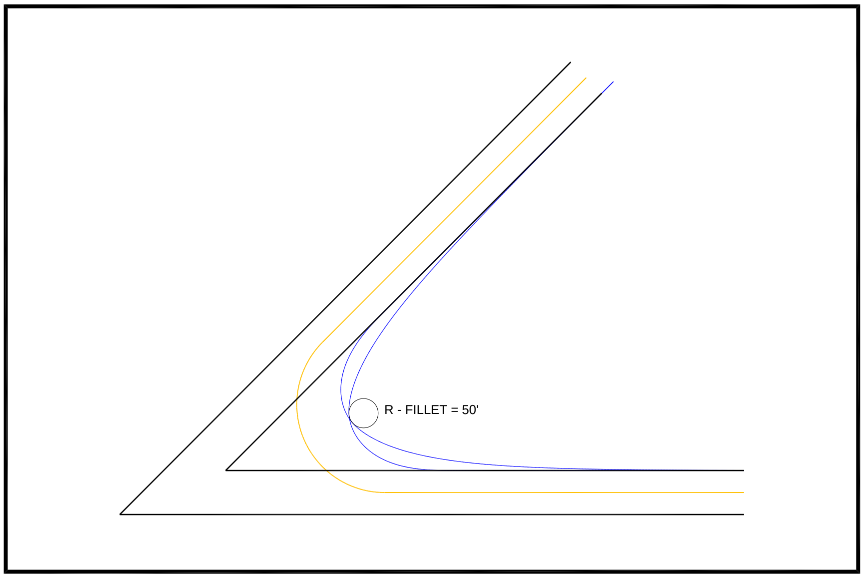
J.2.7.3 As shown in Figure J-4, model the track of the main gear of the longest CMG and widest MGW using an offset equal to the TESM. For TDG 6, the TESM is 14 feet (4.25 m).

Figure J-4. Track of the Main Gear is Modeled, Offset by the TESM



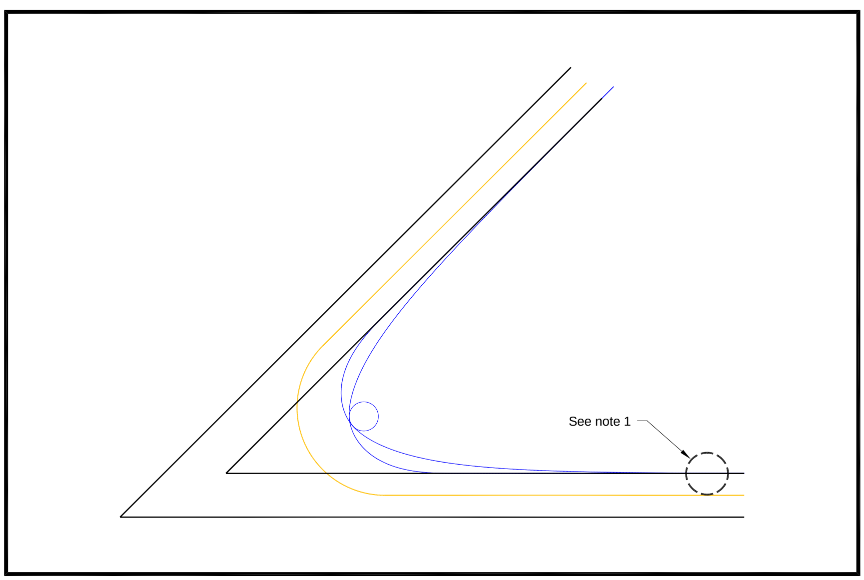
J.2.7.4 Per Figure J-5, select a fillet radius minimizing excess pavement while providing the standard TESM. This example uses an R-FILLET equal to 50 feet (15.2 m).

Figure J-5. Minimize Excess Pavement While Providing the Standard TESM



J.2.7.5 In Figure J-6, the pavement edge (or main gear track + TESM) is offset by 6 inches (15 cm), for the determination of the intersection between the main gear track and the pavement edge. Either method may be used to apply the 6-inch reduction in TESM noted in paragraph J.2.2.

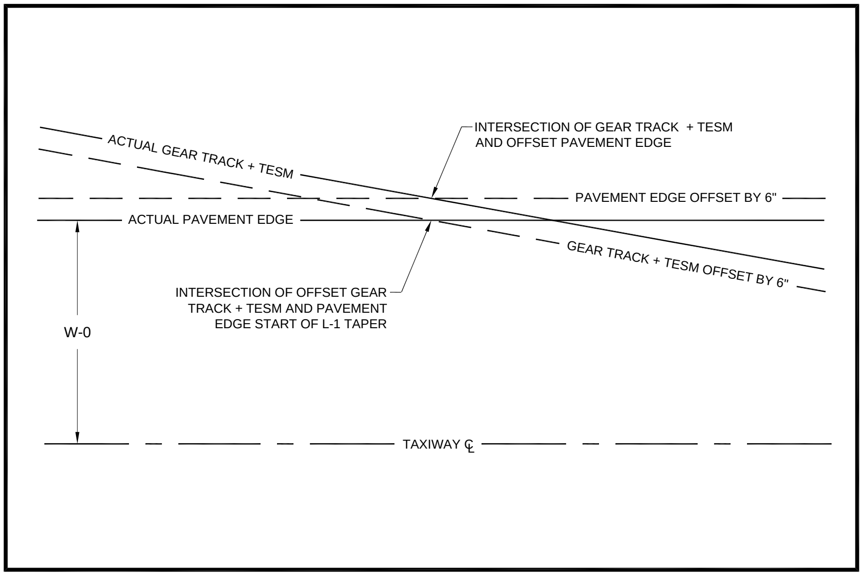
Figure J-6. Pavement Edge (Main Gear Track + TESM) Offset by 6 inches (15 cm)



Note: See Figure J-7.

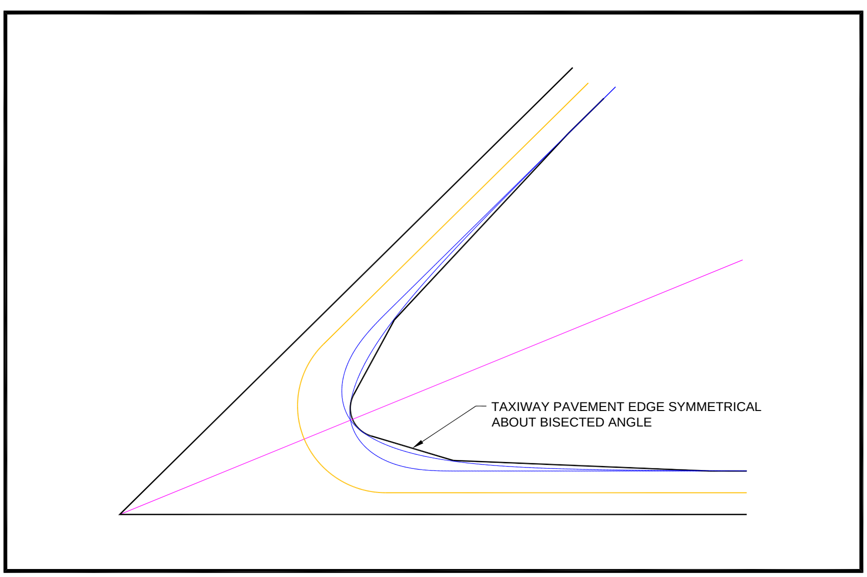
J.2.7.6 Figure J-7 shows offsetting either the actual pavement edge or the gear track plus TESM. As noted in paragraph 4.7.1, calculating this point recognizes the asymptotic nature of an airplane aligning with the taxiway centerline upon exiting a turn.

Figure J-7. Detail of Figure J-6



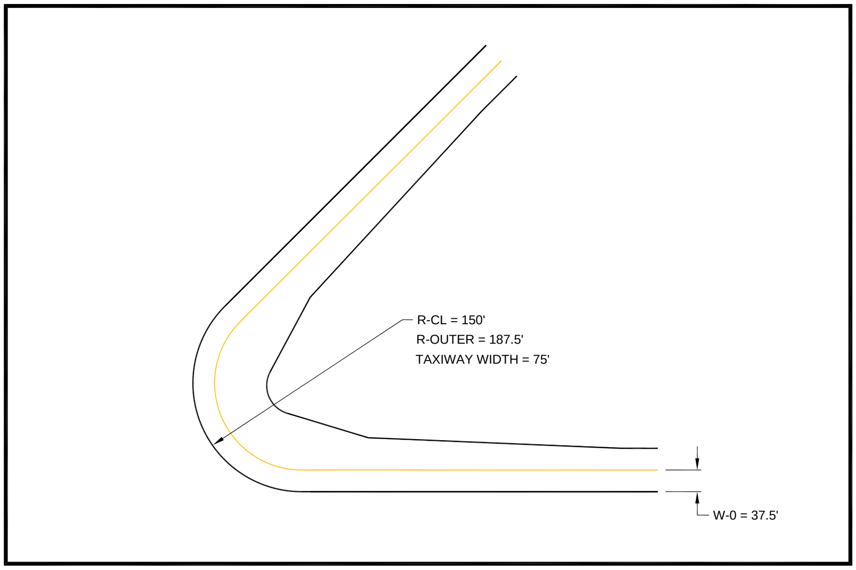
J.2.7.7 In Figure J-8, select tapers to minimize excess pavement while considering constructability. The point of intersection of the tapers determines the dimension W-1, as shown in Figure J-1.

Figure J-8. Taper Selection to Minimize Excess Pavement with Consideration for Constructability



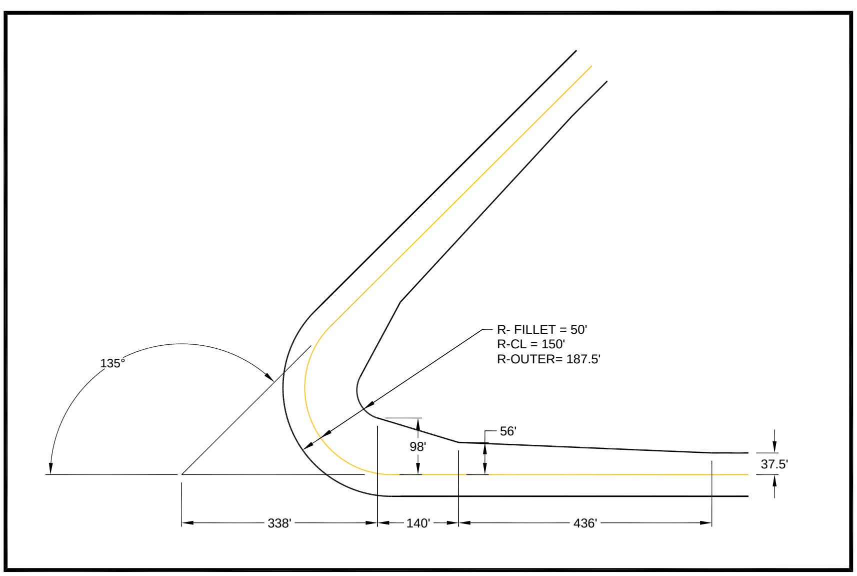
J.2.7.8 Per Figure J-9, establish the outer radius for the taxiway by adding one-half the taxiway width (W-0) for a given TDG to the taxiway centerline curve radius.

Figure J-9. Establishing Radius of Outer Taxiway Pavement Edge Based on the Centerline Radius and Taxiway Width for Each TDG



J.2.7.9 Per Figure J-10, identify applicable fillet dimensions.

Figure J-10. Dimensioning the Fillet Design



J.3 TDG Tables for Common Intersection Angles.

The following tables provide dimensions for a common range of intersection angles (deltas). The FAA's Taxiway Fillet Design Tool is available to calculate fillet dimensions for intersection angles not shown in the tables below. This design tool provides curve design for turning angle (delta) between 5 degrees and 175 degrees. Visit the FAA website at https://www.faa.gov/airports/eingineering/airport_design/.

Table J-1. Taxiway Intersection Dimensions for TDG 1A

Dimension (see note)	Δ (degrees)						
	30	**45**	**60**	**90**	**120**	**135**	**150**
W-0 (ft)	12.5	12.5	12.5	12.5	12.5	12.5	12.5
W-1 (ft)	17	19	21	21	22	23	24
W-2 (ft)	17	19	21	21	22	23	24
L-1 (ft)	40	47	53	52	55	56	57
L-2 (ft)	0	0	0	0	0	0	0
L-3 (ft)	5	8	12	21	38	55	87
R-Fillet (ft)	0	0	0	0	0	0	0
R-CL (ft)	50	50	50	19	23	24	24
R-Outer (ft)	62.5	62.5	62.5	31.5	35.5	36.5	36.5

Note: See Figure 4-12, Figure 4-13, and Figure 4-14. Dimensions shown rounded to the nearest foot.
1 foot = 0.305 meters.

Table J-2. Taxiway Intersection Dimensions for TDG 1B

Dimension (see note)	Δ (degrees)						
	30	45	60	90	120	135	150
W-0 (ft)	12.5	12.5	12.5	12.5	12.5	12.5	12.5
W-1 (ft)	21	24	27	18	18	18	18
W-2 (ft)	21	24	27	31	29	29	30
L-1 (ft)	107	121	130	94	89	89	92
L-2 (ft)	0	0	0	47	45	46	45
L-3 (ft)	6	10	16	31	78	112	177
R-Fillet (ft)	0	0	0	0	20	20	20
R-CL (ft)	50	50	50	37	45	47	48
R-Outer (ft)	62.5	62.5	62.5	49.5	57.5	59.5	60.5

Note: See Figure 4-12, Figure 4-13, and Figure 4-14. Dimensions shown rounded to the nearest foot.
1 foot = 0.305 meters.

Table J-3. Taxiway Intersection Dimensions for TDG 2A

Dimension (see note)	Δ (degrees)						
	30	45	60	90	120	135	150
W-0 (ft)	17.5	17.5	17.5	17.5	17.5	17.5	17.5
W-1 (ft)	25	28	22	23	20	20	20
W-2 (ft)	25	28	31	35	23	22	20
L-1 (ft)	105	119	85	91	61	54	48
L-2 (ft)	0	0	44	45	30	25	9
L-3 (ft)	7	12	18	35	121	168	257
R-Fillet (ft)	0	0	0	0	50	50	50
R-CL (ft)	50	50	50	37	45	47	48
R-Outer (ft)	67.5	67.5	67.5	54.5	62.5	64.5	65.5

Note: See Figure 4-12, Figure 4-13, and Figure 4-14. Dimensions shown rounded to the nearest foot.
1 foot = 0.305 meters.

Table J-4. Taxiway Intersection Dimensions for TDG 2B

Dimension (see note)	Δ (degrees)						
	30	45	60	90	120	135	150
W-0 (ft)	17.5	17.5	17.5	17.5	17.5	17.5	17.5
W-1 (ft)	30	36	24	25	23	23	23
W-2 (ft)	30	36	41	48	30	37	36
L-1 (ft)	205	228	162	176	156	155	152
L-2 (ft)	0	0	82	84	78	70	78
L-3 (ft)	8	15	24	48	141	199	310
R-Fillet (ft)	0	0	0	0	50	50	50
R-CL (ft)	75	75	75	60	73	76	78
R-Outer (ft)	92.5	92.5	92.5	77.5	90.5	93.5	95.5

Note: See Figure 4-12, Figure 4-13, and Figure 4-14. Dimensions shown rounded to the nearest foot. 1 foot = 0.305 meters.

Table J-5. Taxiway Intersection Dimensions for TDG 3

Dimension (see note)	Δ (degrees)						
	30	45	60	90	120	135	150
W-0 (ft)	25	25	25	25	25	25	25
W-1 (ft)	29	30	31	32	32	32	33
W-2 (ft)	37	43	47	54	52	53	55
L-1 (ft)	132	149	159	171	169	171	173
L-2 (ft)	71	77	81	83	81	80	80
L-3 (ft)	10	18	27	54	125	180	286
R-Fillet (ft)	0	0	0	0	25	25	25
R-CL (ft)	75	75	75	60	73	76	78
R-Outer (ft)	100	100	100	85	98	101	103

Note: See Figure 4-12, Figure 4-13, and Figure 4-14. Dimensions shown rounded to the nearest foot. 1 foot = 0.305 meters.

Table J-6. Taxiway Intersection Dimensions for TDG 4

Dimension (see note)	Δ (degrees)						
	30	45	60	90	120	135	150
W-0 (ft)	25	25	25	25	25	25	25
W-1 (ft)	31	32	34	36	35	35	36
W-2 (ft)	45	52	60	73	67	70	72
L-1 (ft)	239	261	280	303	294	300	302
L-2 (ft)	119	133	138	140	135	135	135
L-3 (ft)	12	22	35	73	188	272	435
R-Fillet (ft)	0	0	0	0	50	50	50
R-CL (ft)	110	110	110	92	111	117	120
R-Outer (ft)	135	135	135	117	136	142	145

Note: See Figure 4-12, Figure 4-13, and Figure 4-14. Dimensions shown rounded to the nearest foot.
1 foot = 0.305 meters.

Table J-7. Taxiway Intersection Dimensions for TDG 5

Dimension (see note)	Δ (degrees)						
	30	45	60	90	120	135	150
W-0 (ft)	37.5	37.5	37.5	37.5	37.5	37.5	37.5
W-1 (ft)	43	45	46	48	46	47	47
W-2 (ft)	57	65	71	82	74	75	76
L-1 (ft)	237	261	276	298	282	286	287
L-2 (ft)	118	128	135	136	133	133	132
L-3 (ft)	16	27	41	82	202	288	453
R-Fillet (ft)	0	0	0	0	50	50	50
R-CL (ft)	110	110	110	92	111	117	120
R-Outer (ft)	147.5	147.5	147.5	129.5	148.5	154.5	157.5

Note: See Figure 4-12, Figure 4-13, and Figure 4-14. Dimensions shown rounded to the nearest foot.
1 foot = 0.305 meters.

Table J-8. Taxiway Intersection Dimensions for TDG 6

Dimension (see note)	Δ (degrees)						
	30	**45**	**60**	**90**	**120**	**135**	**150**
W-0 (ft)	37.5	37.5	37.5	37.5	37.5	37.5	37.5
W-1 (ft)	44	46	48	50	50	50	51
W-2 (ft)	62	72	82	95	92	96	100
L-1 (ft)	317	347	372	398	393	400	407
L-2 (ft)	158	172	175	179	175	174	173
L-3 (ft)	17	30	47	95	231	336	538
R-Fillet (ft)	0	0	0	0	50	50	50
R-CL (ft)	150	150	150	115	139	146	150
R-Outer (ft)	187.5	187.5	187.5	152.5	176.5	183.5	187.5

Note: See Figure 4-12, Figure 4-13, and Figure 4-14. Dimensions shown rounded to the nearest foot. 1 foot = 0.305 meters.

J.4 Methodology and Calculations for Reductions in Taxiway Standards.

Studies on aircraft wander during taxi operations indicate taxi deviations from centerline and taxiway excursions are infrequent and of limited severity. The FAA taxiway standards for clearance to fixed or moveable objects provide an acceptable level of safety by establishing object free areas and taxiway separation values. The FAA's methodology applies the following:

1. A lateral deviation from the taxiway centerline.
2. A safety buffer to provide wingtip clearance in the event of a lateral deviation of the aircraft from the taxiway centerline.

J.4.1 Taxiway/Taxilane OFA Standards.

Taxiway/taxilane OFA of Table J-9 and Table J-10 apply a lateral deviation and safety buffer distance for each ADG. Figure J-11 illustrates this methodology. Due to lower aircraft taxi speeds on taxilanes versus taxiways, the applied lateral deviation and safety buffer distances for taxilanes are less than for taxiways.

Figure J-11. Taxiway/Taxilane OFA Width

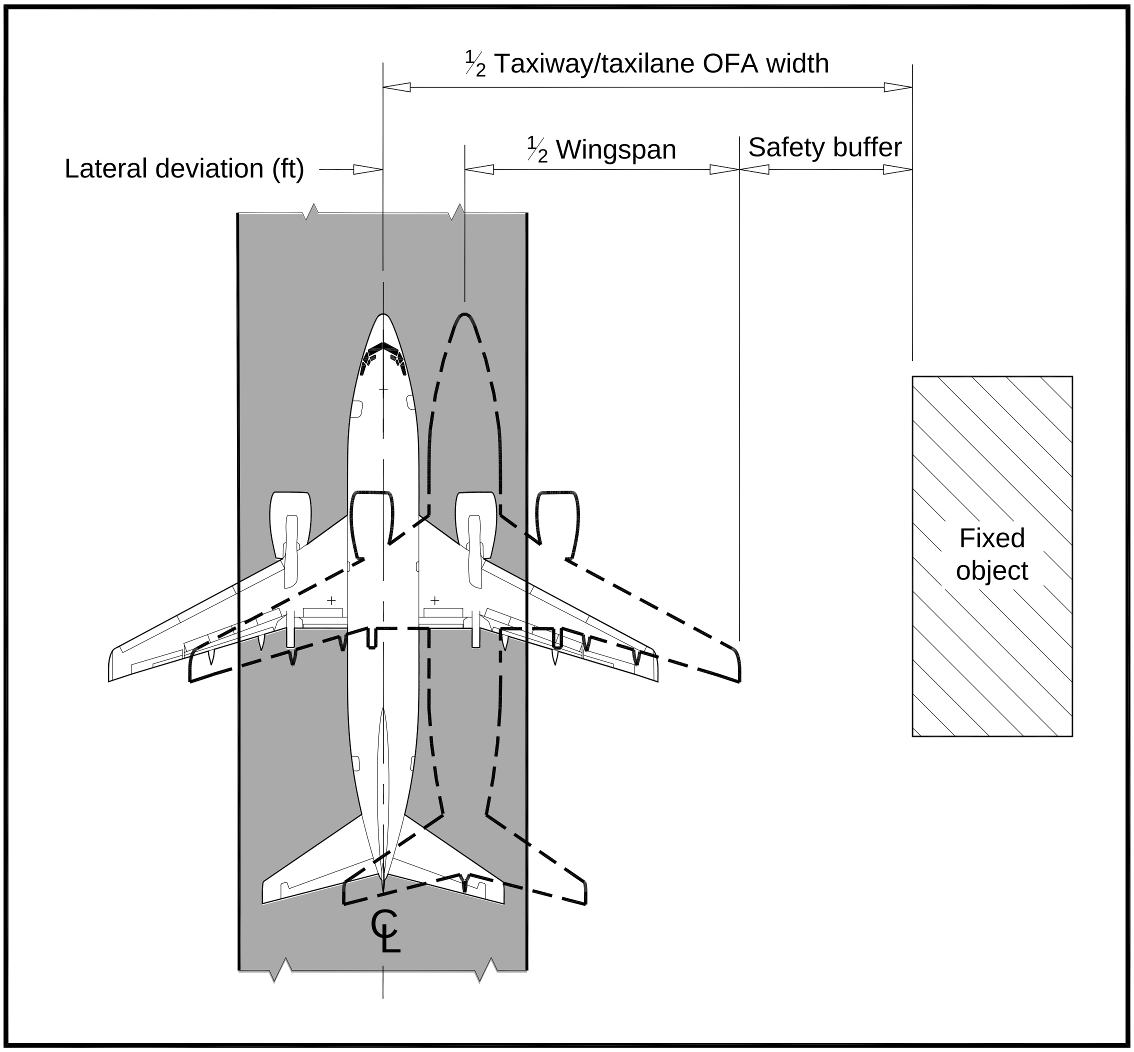


Table J-9. Taxiway OFA Calculations (feet)

ADG	1/2 ADG WS	Lateral Deviation	Safety Buffer	1/2 Taxiway OFA	Full Taxiway OFA
I	24.5	5	15	44.5	89
II	39.5	7.5	15	62	124
III	59.0	10	16.5	85.5	171
IV	85.5	15	21	121.5	243
V	107.0	14.5	21	142.5	285
VI	131.0	14.5	22	167.5	335

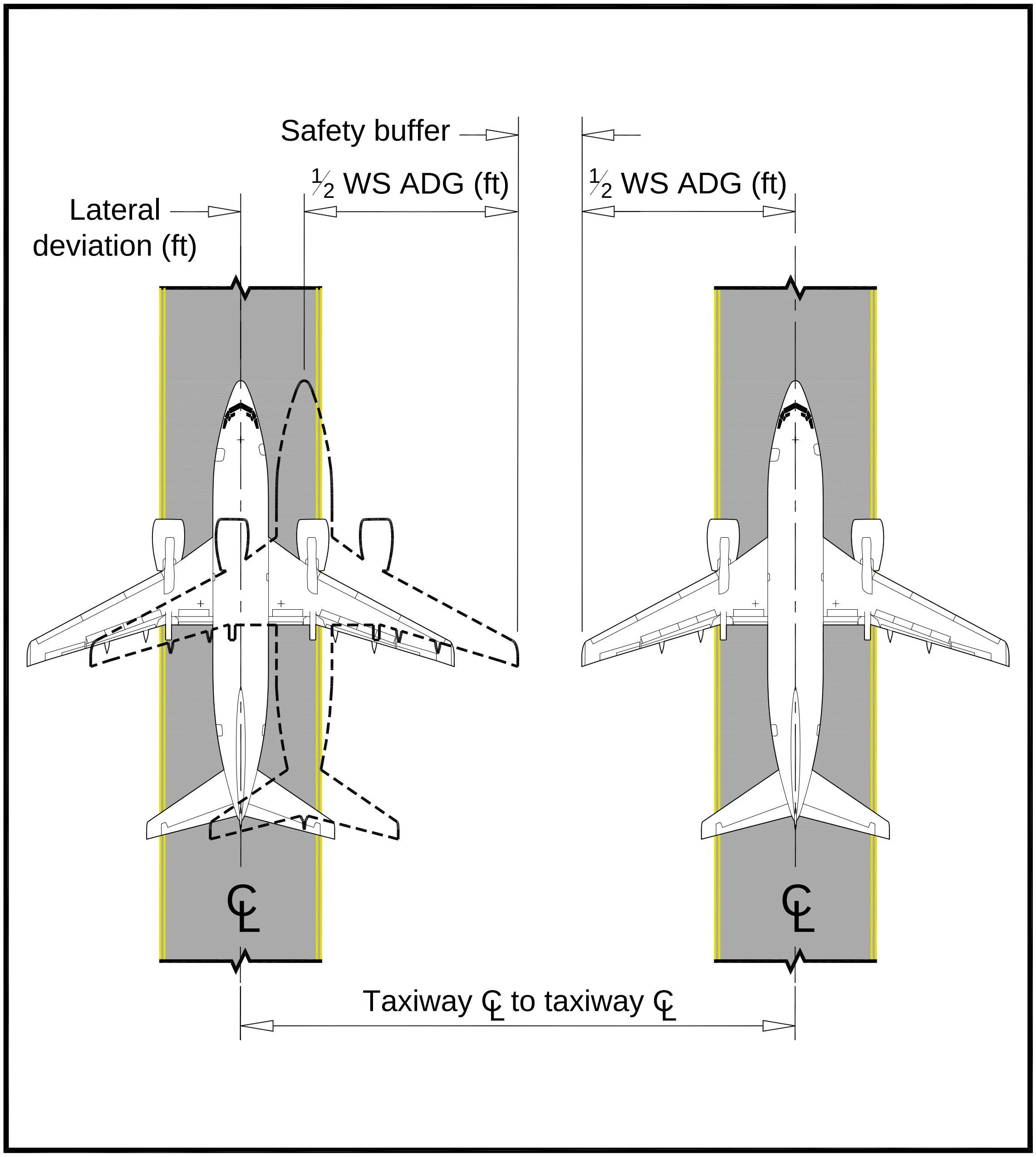
Table J-10. Taxilane OFA Calculations (feet)

ADG	1/2 ADG WS	Lateral Deviation	Safety Buffer	1/2 Taxilane OFA	Full Taxilane OFA
I	24.5	5	10	39.5	79
II	39.5	5	10.5	55	110
III	59.0	8	12	79.0	158
IV	85.5	10	16.5	112	224
V	107.0	10	18	135.0	270
VI	131.0	10	20	161.0	322

J.4.2 Taxiway/Taxilane Centerline to Parallel Taxiway/Taxilane Centerline Separation.

The calculation of the separation distance between parallel taxiways/taxilanes for each ADG assume a lateral deviation from centerline for one aircraft with the second aircraft remaining on the centerline of the parallel taxiway. The separation distance equals ½ the OFA of the first parallel taxiway plus ½ the wingspan of the ADG on the second taxiway.

Figure J-12. Separation Distance between Parallel Taxiways/Taxilanes



J.5 Taxiway Geometries with Elevated Risk to Safety.

This section identifies taxiway geometries with an elevated risk to safety (e.g. Runway incursions, wrong surface events, etc.). Understanding the risks associated with these undesirable configurations is beneficial when planning and designing the relationship between taxiways, aprons and runways. This information supplements the design standards on taxiways and taxilanes provided in Chapter 4. Refer to AC 150/5340-1, *Standards for Airport Markings*, for information on select mitigation measures including "no-taxi" islands.

J.5.1 Background.

The information presented in this section originates from previous studies and reports that address: (1) data and incident analysis on past runway incursions, and (2) the impact of specific runway, taxiway and apron configurations on the likelihood of runway incursions. These reports include:

- Engineering Brief 75, *Incorporation of Runway Incursion Prevention into Taxiway and Apron Design*
- Report DOT/FAA/TC-18/2, *Problematic Taxiway Geometry Study Overview*

J.5.2 Select Risk Configurations.

The following list, which is not all-inclusive, identifies select pavement configurations that introduce a risk to safety:

1. Wide Expanse of Pavement at Runway-Taxiway Interface
2. Entrance Taxiway Intersecting Runway at Other Than a Right Angle
3. Complex Runway-Taxiway and Taxiway-Taxiway Intersections
4. Direct Access from the Apron to a Runway
5. High-Speed Exit Crossing Another Taxiway
6. High-speed exits leading directly into or across another runway
7. Wide Expanse of Pavement at Apron-Taxiway Interface
8. Short (stub) Taxiway Connection to a Runway
9. Wide Expanse of Holding Bay Pavement
10. Collocated High-speed Exit Taxiways
11. Fillet pavement between Parallel Taxiways
12. Aligned Taxiways
13. Taxiway Connections to V-shaped Runways

J.5.3 Existing Sub-Standard Configuration.

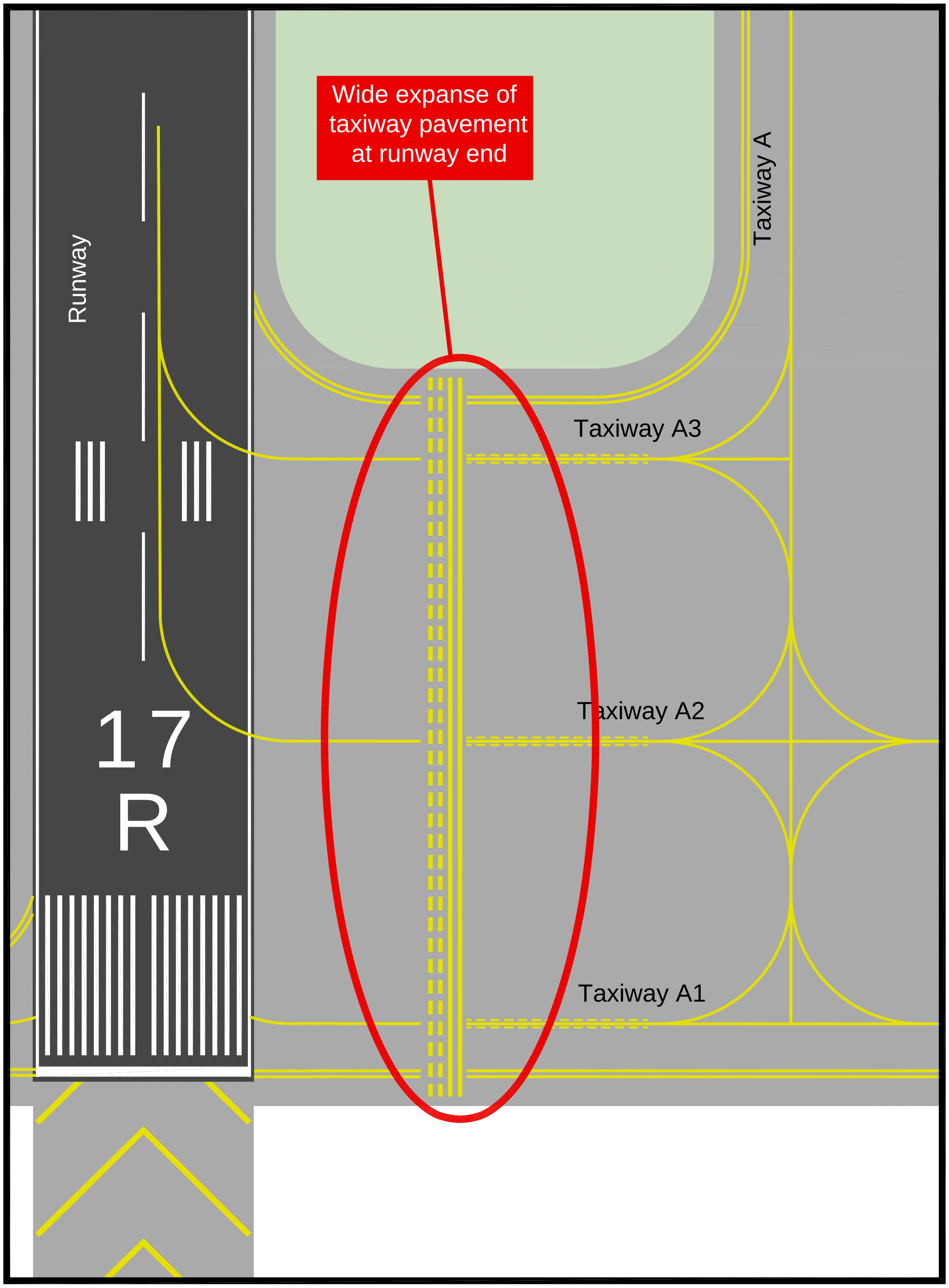
Each airport has specific factors affecting the risk associated with sub-standard geometric configurations. Various mitigating measures or corrective actions may be necessary to minimize risk when “elevated risk” configurations exist at an airport. This is particularly important for high-risk “hot spots” and locations identified under the Runway Incursion Mitigation (RIM) program (https://www.faa.gov/airports/special_programs/rim/). The FAA expects federally obligated airports to develop a plan to address existing areas with unacceptable risk to safety. The FAA further expects such airports to take corrective action as soon as practical.

J.5.4 Wide Expanse of Pavement at Runway-Taxiway Interface.

Wide pavement areas result in placement of airfield signs far from a pilot’s view thus reducing the conspicuity of critical visual cues (signs, markings, lighting). This

7988 increases the risk for pilot loss of situational awareness. See Figure J-13. The
7989 diminished visual cues, particularly under low visibility conditions, increases the
7990 probability of a runway incursion.

7991 **Figure J-13. Extra-Wide Pavement Area at Runway Entrance**



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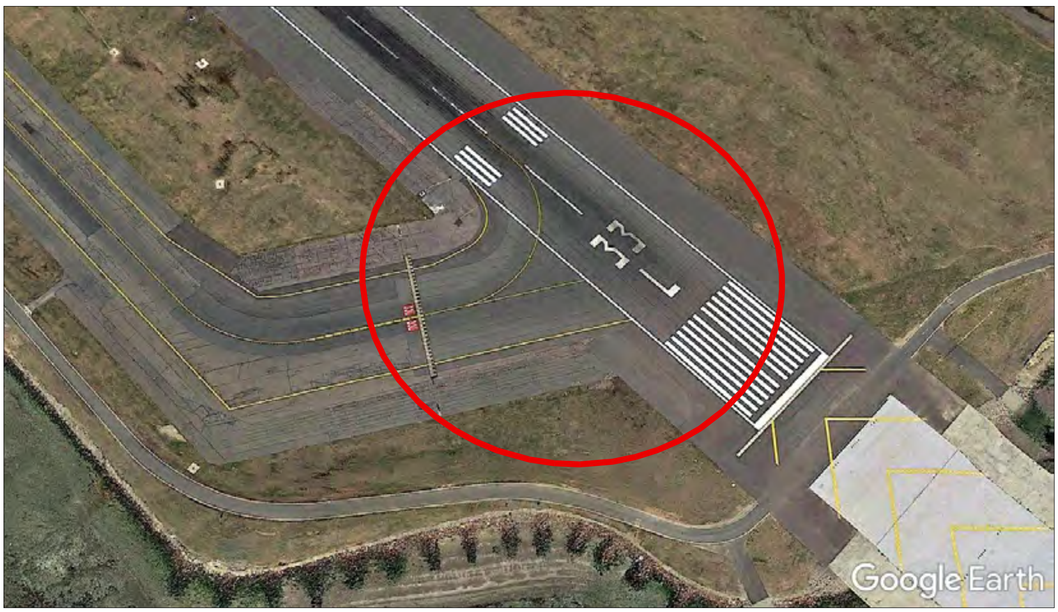
J.5.5 Entrance Taxiway Intersecting Runway at Other Than a Right Angle.

Entrance taxiways intersecting a runway at other than a right angle increase the risk of a runway incursion. The acute angle reduces a pilot's field of view in one direction making it difficult for a pilot to detect an aircraft operating on the runway. This configuration also increases the width of the entrance pavement reducing the pilot's ability to maintain situational awareness. The RIM program has demonstrated taxiway configurations that intersect runways at angle other than 90-degrees increases the probability of runway incursions. Refer to paragraph 4.9 for standards addressing entrance taxiways. See Figure J-14 and Figure J-15.

Figure J-14. Entrance Taxiway Intersecting Runway End at an Acute Angle



Note: A pilot at the holding position has an enhanced viewing range of the approach area but a diminished range of view down the runway.

Figure J-15. Entrance Taxiway Intersecting Runway End at an Obtuse Angle

Note: A pilot at the holding position has an enhanced viewing range of the runway but a diminished range of view in the approach area.

J.5.6 Complex Runway-Taxiway and Taxiway-Taxiway Intersections.

Complex intersections increase the possibility of pilot error due to loss of situational awareness. Complex intersections can preclude standard installation of signs, marking and lighting that provide key visual cues for navigation.

J.5.6.1 Complex Intersections Exceeding The “Three-Path Concept”.

1. Excessive options at complex intersections create potential for loss of situational awareness that increase the risk of runway incursions and wrong surface takeoffs.
2. Complex intersections often produce wide expanses of pavement, which place lighting, marking and signage in non-standard or unexpected locations.
3. Refer to paragraph 4.3.3 for taxiway intersection design based on the “three-path concept”.
4. See Figure J-16 and Figure J-17 for examples of complex taxiway intersections.

Figure J-16. Complex Taxiway Intersection not Meeting the "Three-Path Concept"

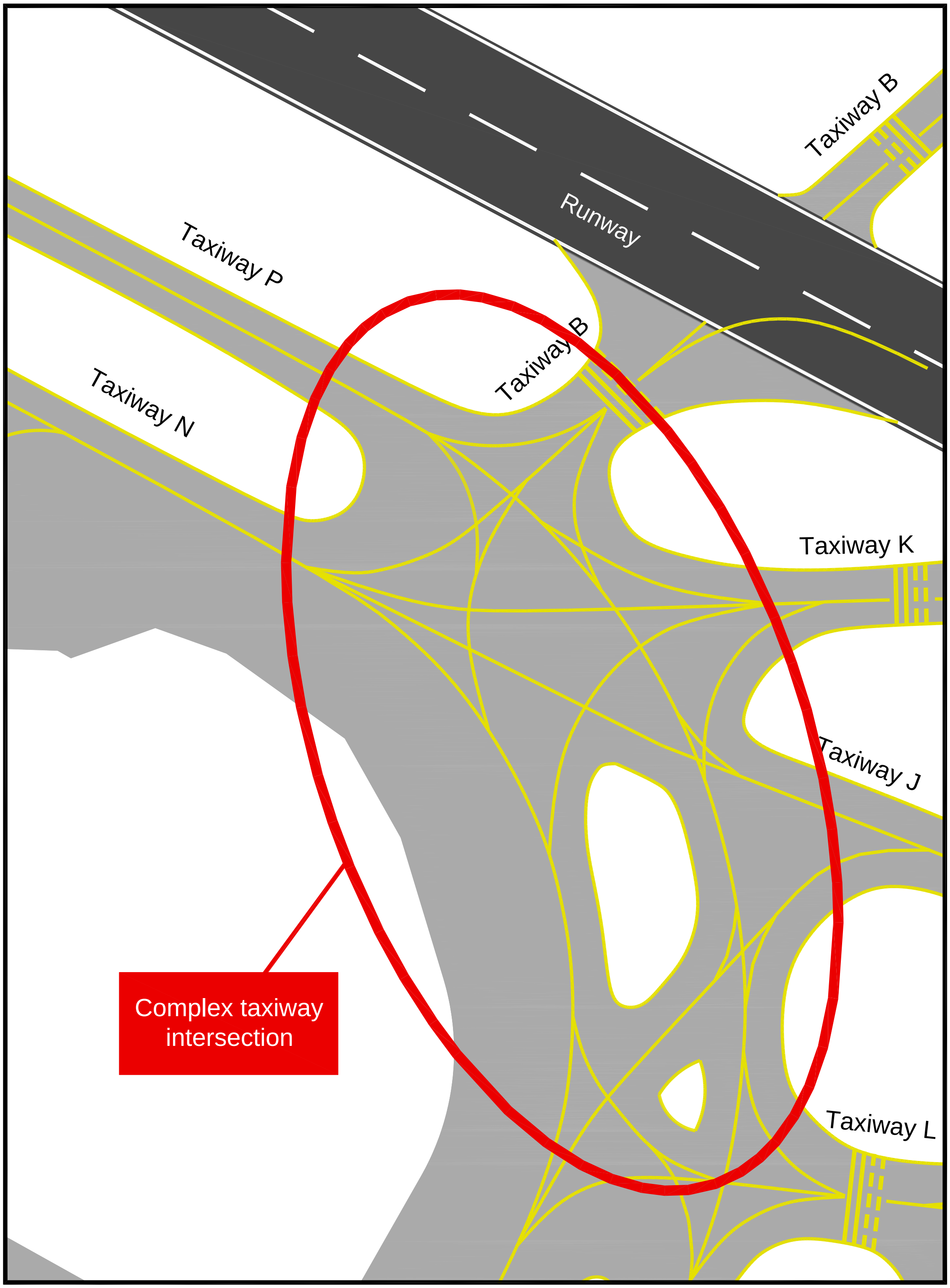
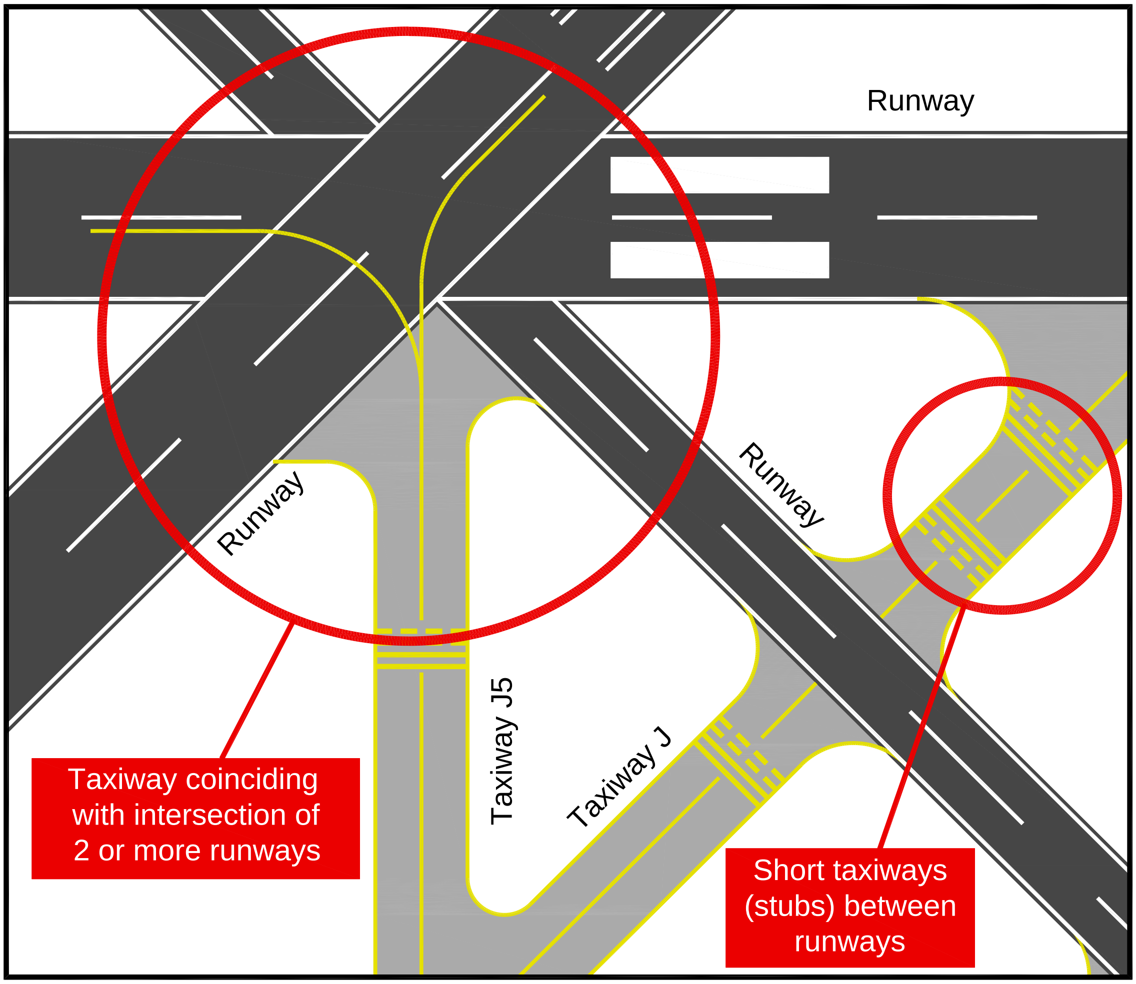


Figure J-17. Aerial Image of Complex Taxiway Intersection Exceeding the "Three-Path" Concept

J.5.6.2 Runway-Taxiway Intersections that Coincide with Two or More Runways.

1. The large expanse of pavement prevents standard placement of signs, marking and lighting.
2. Potential for pilot loss of situational awareness can contribute to a wrong runway takeoff.
3. See Figure J-18.

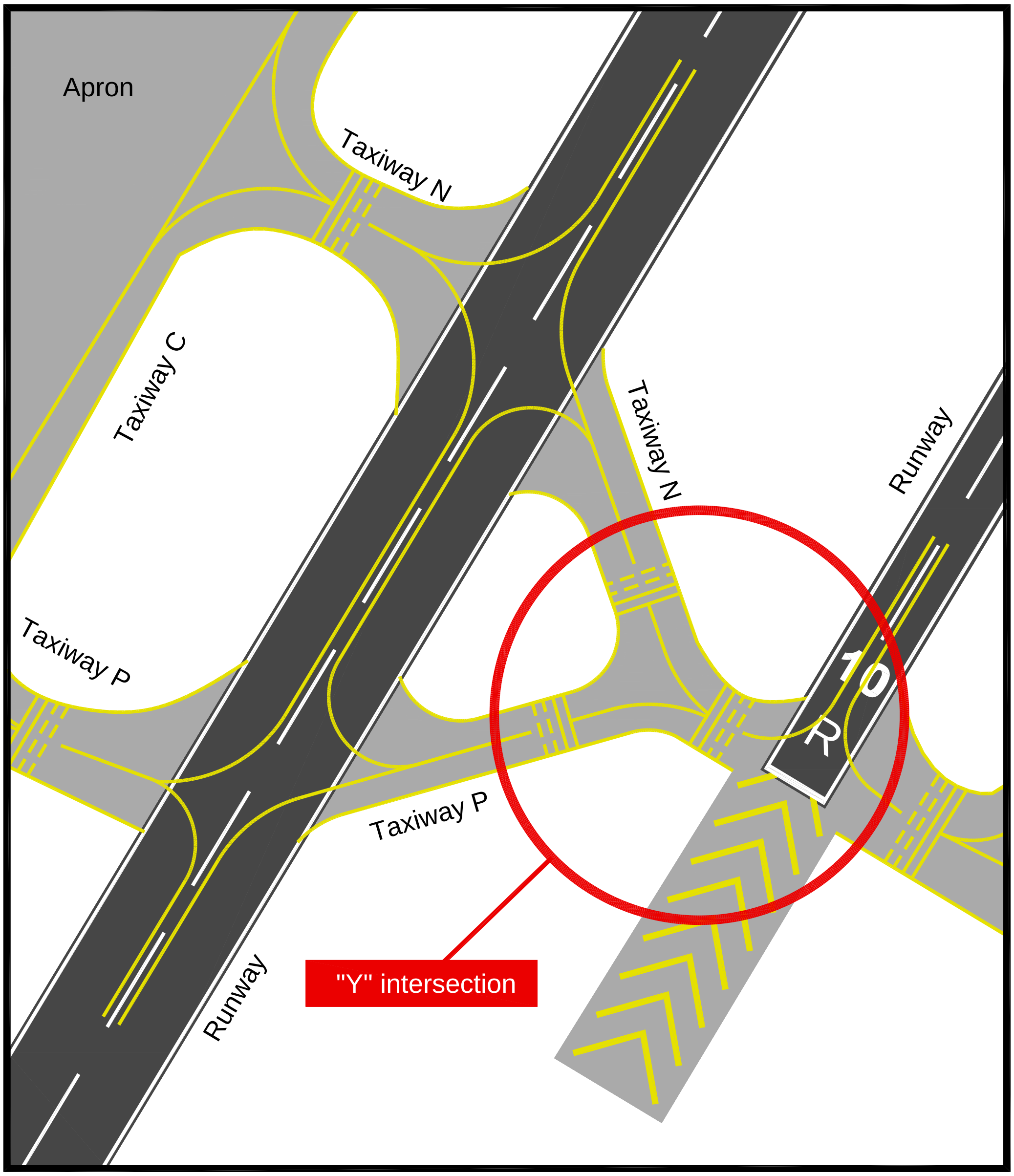
Figure J-18. Taxiway Intersection that Coincides with Multiple Runways



J.5.6.3 Y-Shaped Taxiways.

1. Multiple path choices present opportunities for ground navigation errors that can lead to a runway incursion.
2. Potential for conflict with two aircraft or two vehicles converging to a single taxiway.
3. See Figure J-19.

Figure J-19. Y-Shaped Taxiway Crossing a Runway



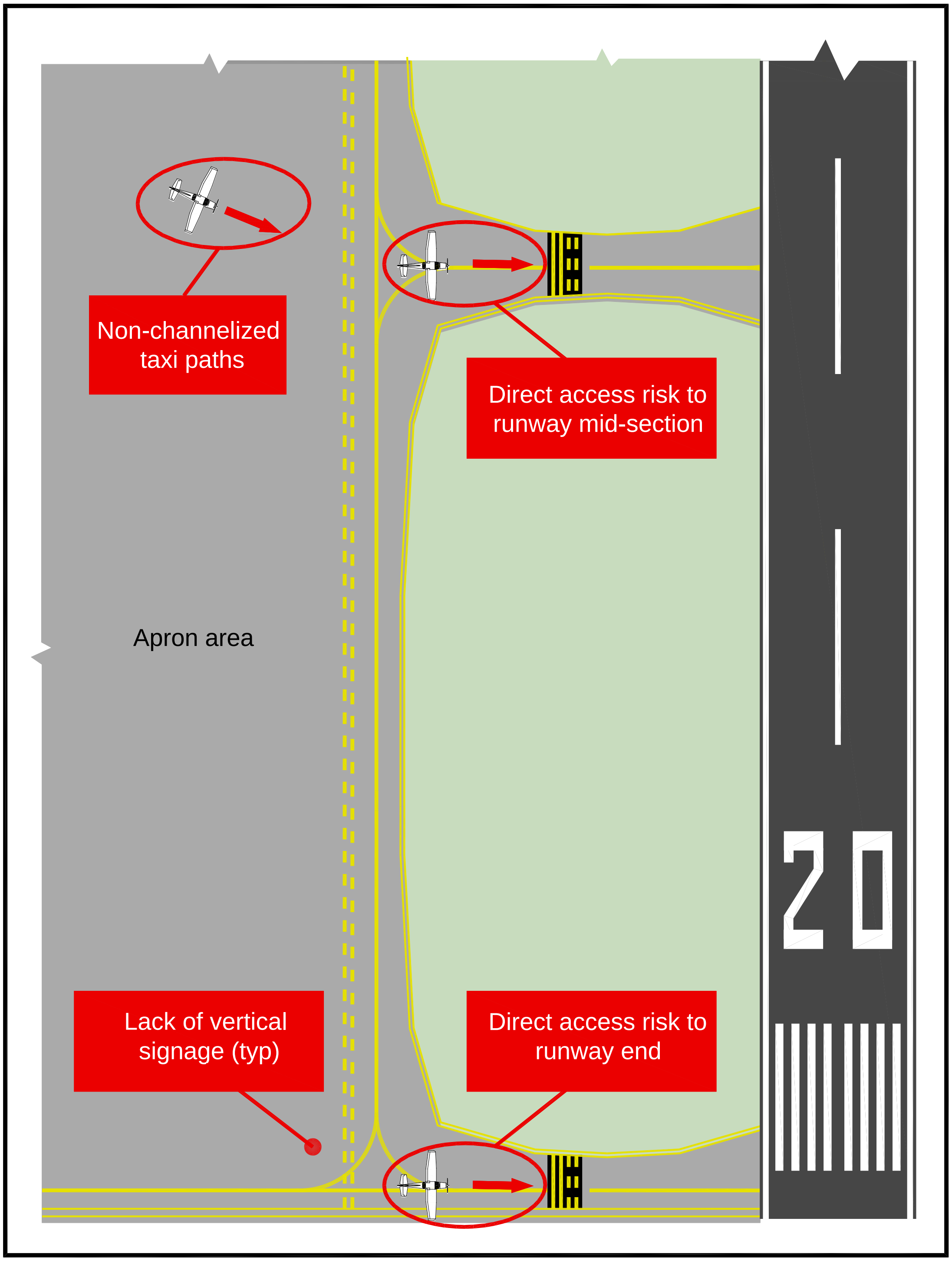
J.5.7 Direct Access from the Apron to a Runway.

Taxiways leading directly from an apron to a runway, as shown in Figure J-20, can create the false expectation of a parallel taxiway prior to the runway. This results in pilot confusion that could lead to a runway incursion. Taxiway geometries forcing the pilot to make turns promotes situational awareness and minimizes the risk of runway incursions. Refer to Figure 4-2 for standard taxiway configurations between the apron and a runway.

1. Taxiways from the terminal area with a straight path to the middle third of a runway present a risk of taxiing aircraft entering a high-energy area of a runway during an operation.

2. Taxiways from an apron area or holding bay leading directly to a runway end present a risk of a taxiing aircraft entering the runway during an operation.

Figure J-20. Apron-Taxiway Configuration – Elevated Risk

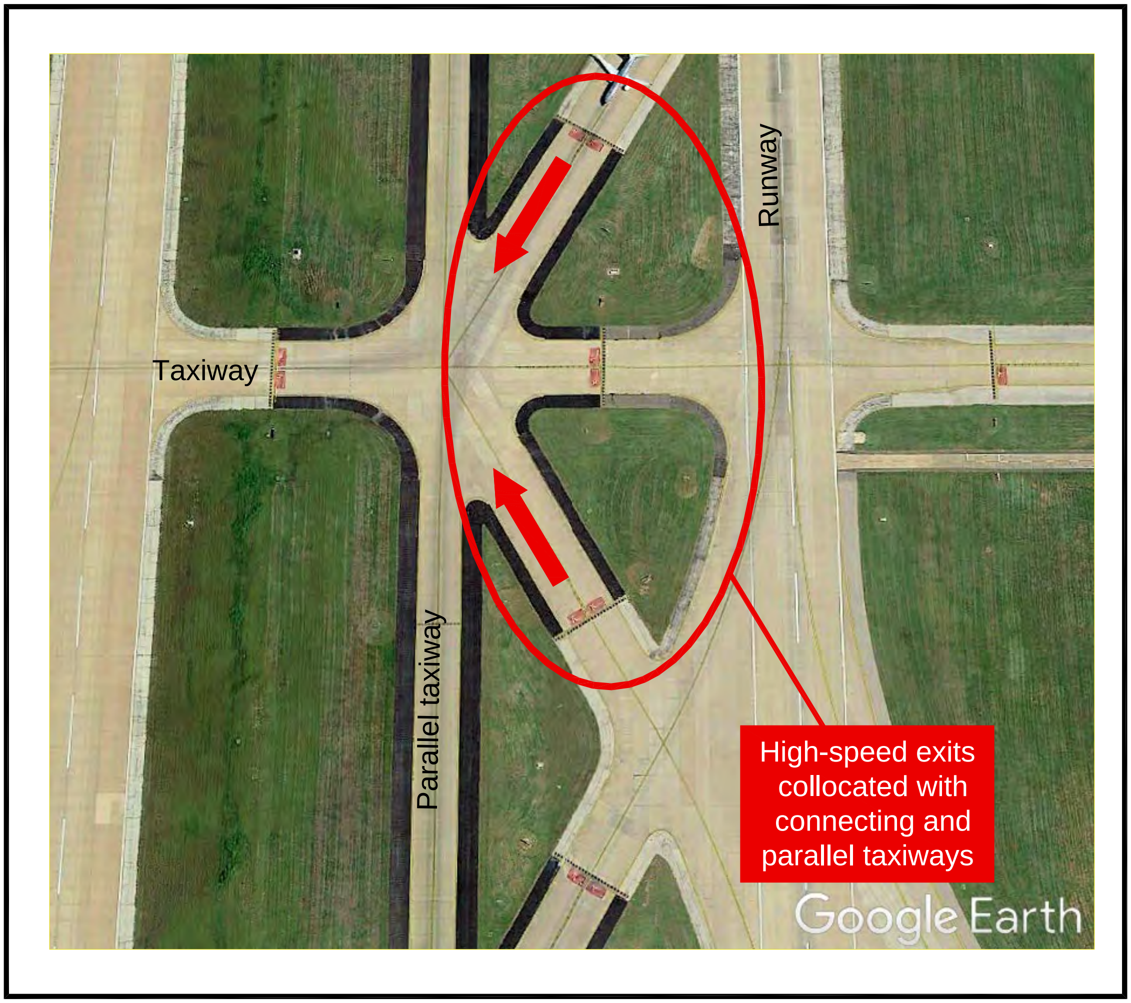


J.5.8 High-Speed Exit Crossing a Connecting Taxiway.

This configuration, as depicted in Figure J-21 and Figure J-22, results in a wide expanse of pavement creating non-standard marking, signing and lighting.

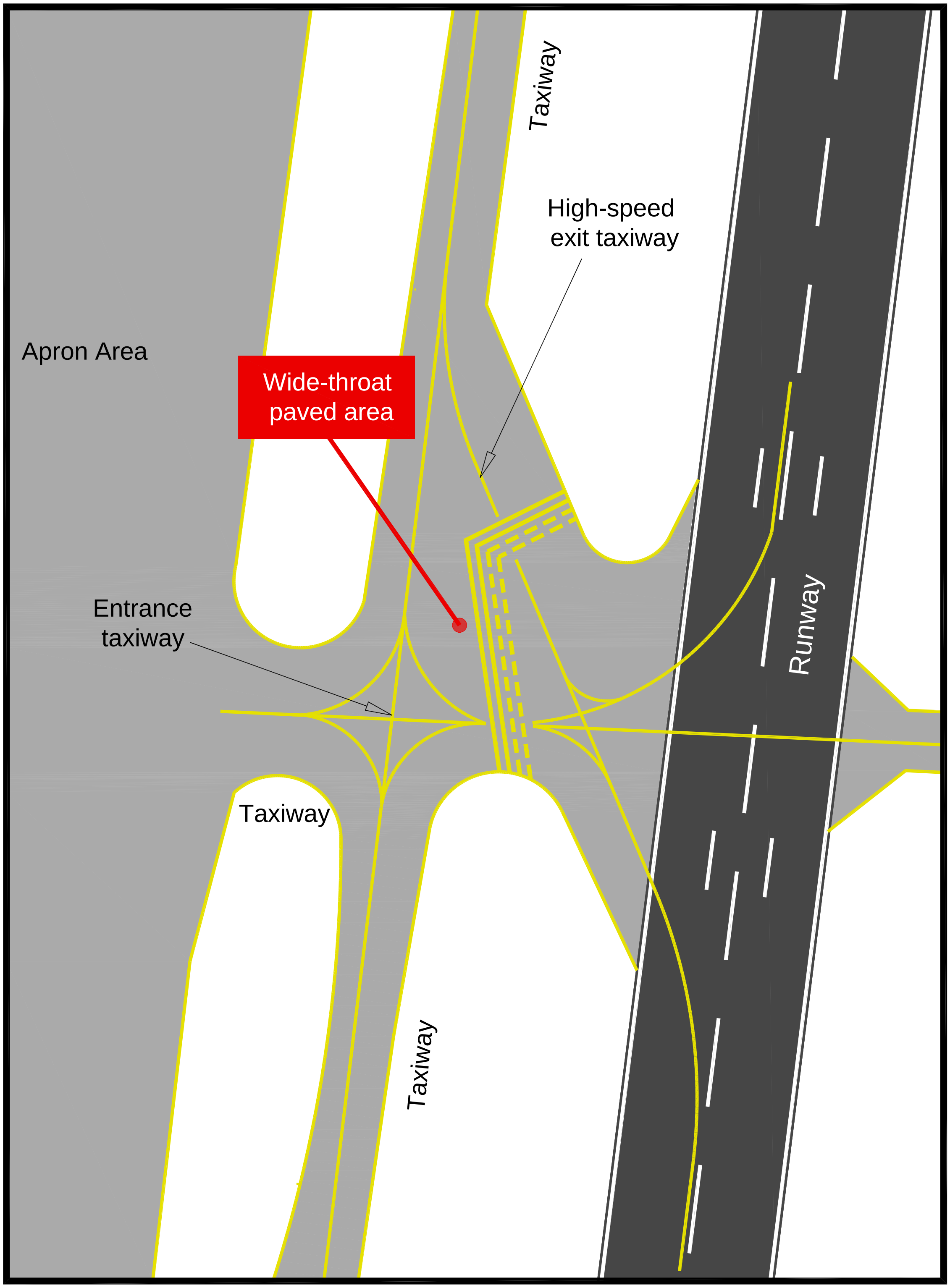
1. The lack of visual cues can lead to pilot confusion, increasing risks to safety.
2. High-speed taxiways collocated with another taxiway increase the risk of a pilot using the exit taxiway as a runway entrance or crossing point thus providing a limited range of view when entering a runway. See paragraph 4.8.5 for additional information.

Figure J-21. Aerial Image of High-speed Exit Collocated with Connecting Taxiways



Note: High-speed exit leading directly across a connecting taxiway.

8074 **Figure J-22. High-Speed Exit Collocated with Connecting Taxiway**



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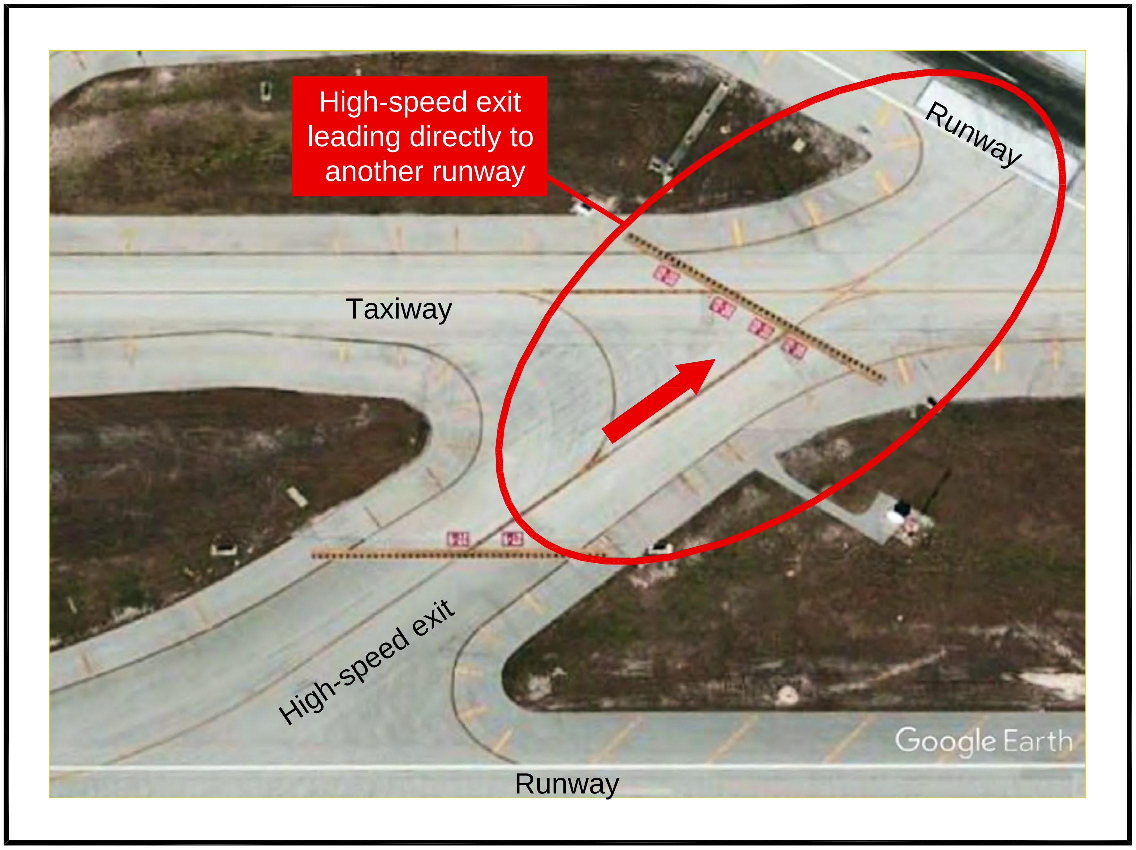
J.5.9 High-Speed Exits Leading Directly into or Across Another Runway.

Aircraft exiting from a high-speed exit may not have sufficient distance to decelerate and stop prior to encountering an adjacent runway hold line. See Figure J-23. This configuration increases the probability of a runway incursion.

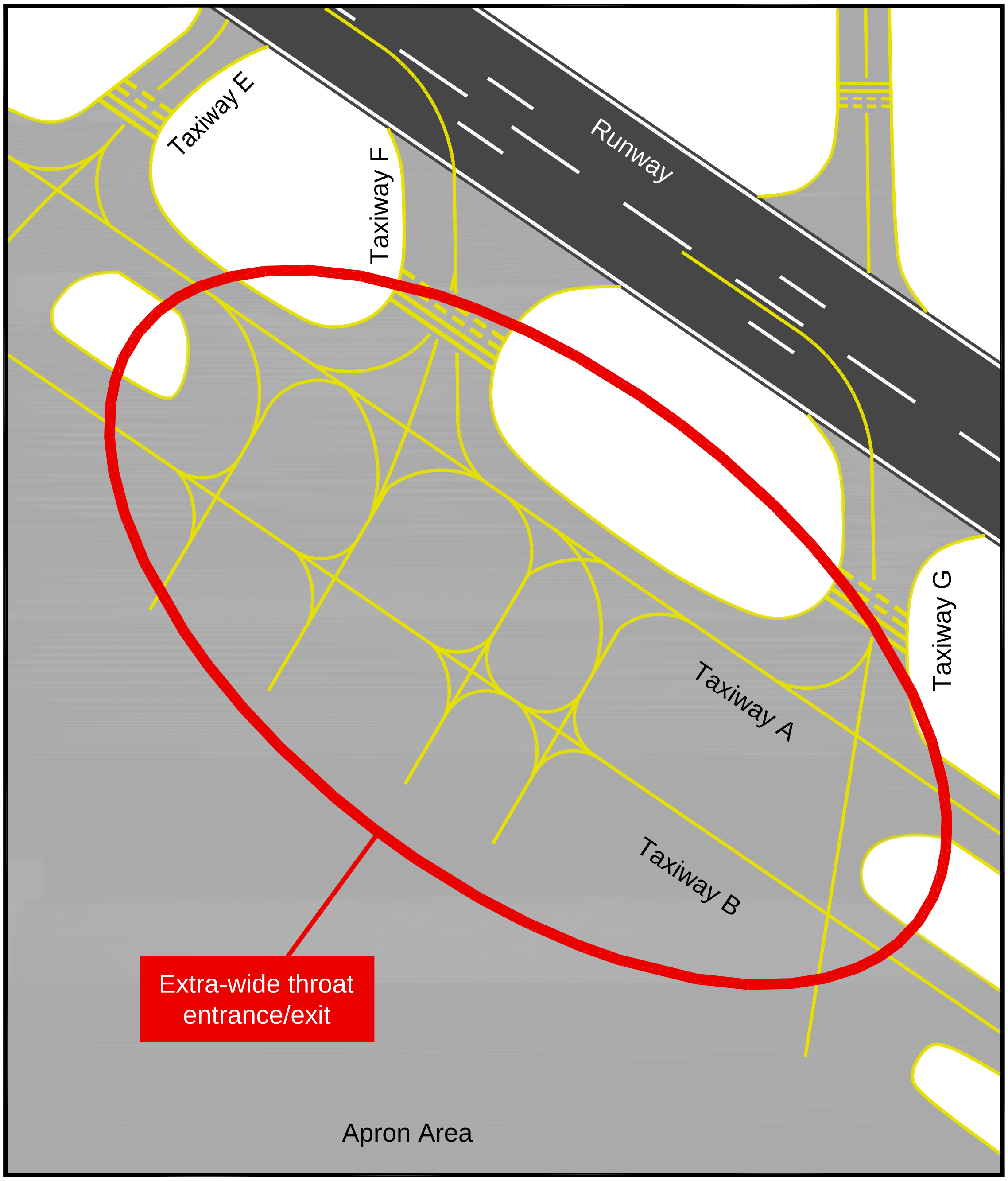
Figure J-23. Aerial Image of High-speed Exit Leading to Another Runway



J.5.10 Wide Expanse of Pavement at Apron-Taxiway Interface.

Parallel taxiways that are contiguous with apron pavement create a wide expanse of pavement void of critical visual cues such as elevated signs (i.e. taxiway location and direction signs). See Figure J-24. This lack of visual cues can contribute to pilot loss of situational awareness. Additionally, the lack of surface markings induces non-channelized taxiing, which increases the risk of wingtip conflicts.

Figure J-24. Parallel Taxiway Adjacent to Apron Pavement



J.5.11 Short (Stub) Taxiway Connection to a Runway.

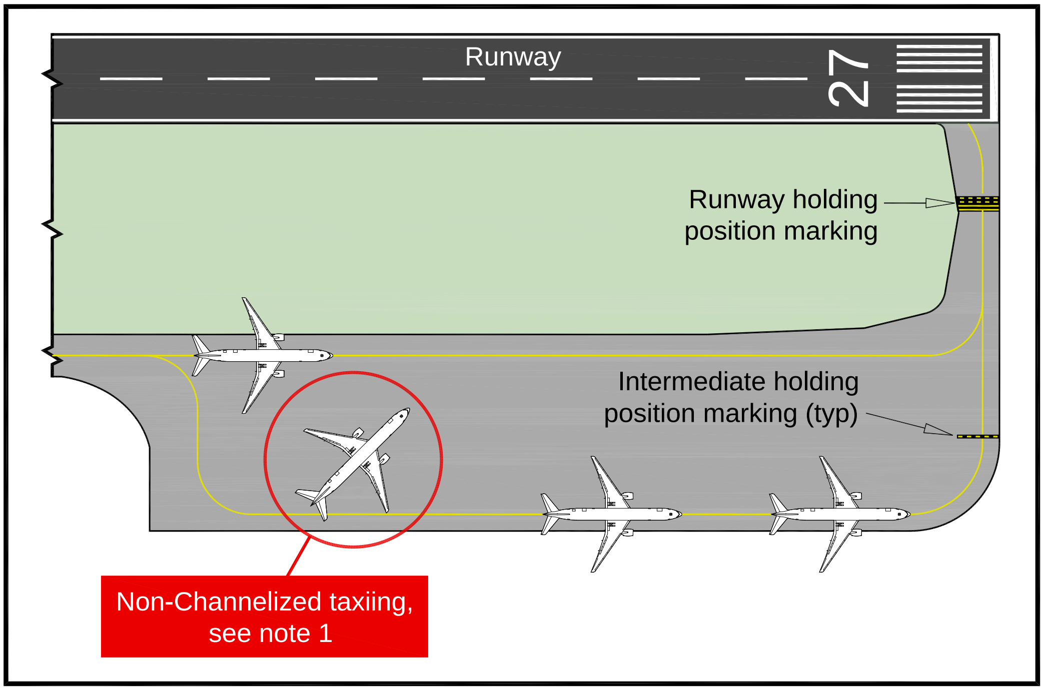
Short (stub) taxiway configurations between runways result in aircraft encountering a runway holding position almost immediately upon entry onto the taxiway segment. Pilots not familiar with the location may fail to hold short thus resulting in a runway incursion. Taxiway stubs also create challenges of holding an aircraft or vehicle without adversely affecting one of the runways. See Figure J-19 and Figure J-25.

Figure J-25. Aerial Image of Short (Stub) Taxiway Connection to a Runway

J.5.12 Wide Expanse of Holding Bay Pavement.

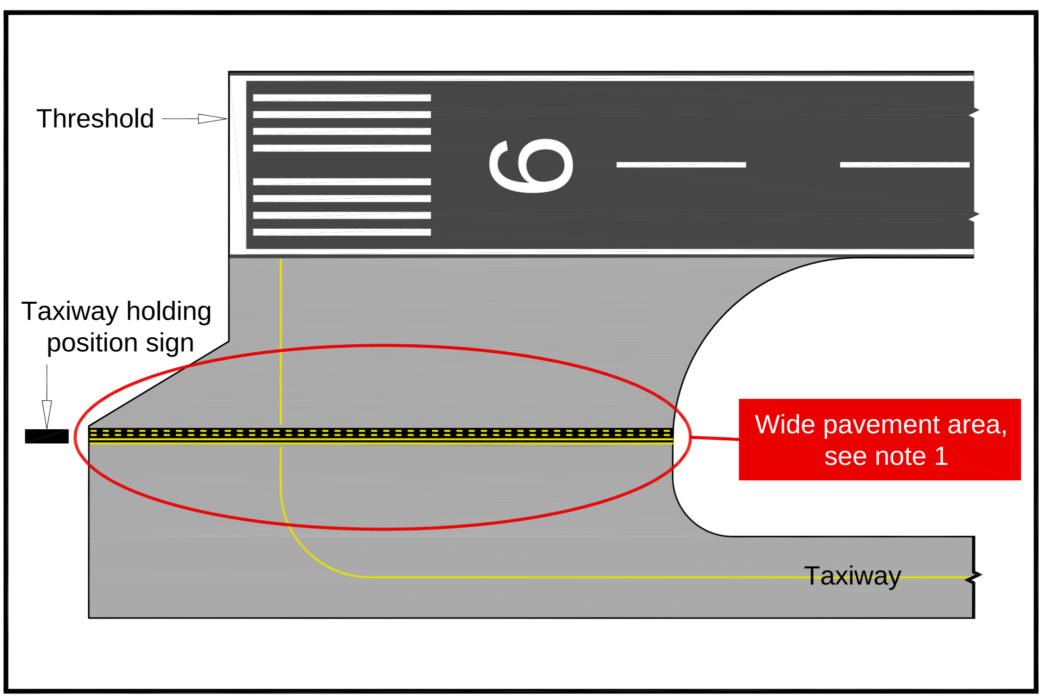
The wide pavement area of holding bays limit the proper placement of signs, lighting and surface marking. See Figure J-26 and Figure J-27. The diminished visual cues increase the risk of pilot loss of situational awareness. Certain wide holding bay configurations encourage non-channelized taxiing involving judgmental steering, in particular when pavement markings are insufficient. This situation does not ensure proper wingtip clearance during maneuvering of aircraft into and out of the holding bay. Refer to paragraph 4.9 for holding bay design standards.

Figure J-26. Poor Holding Bay – Moderate Risk Configuration



Note 1: Non-channelized taxiing does not provide assurance of standard wing-tip clearance availability.

Figure J-27. Poor Holding Bay – Elevated Risk Configuration

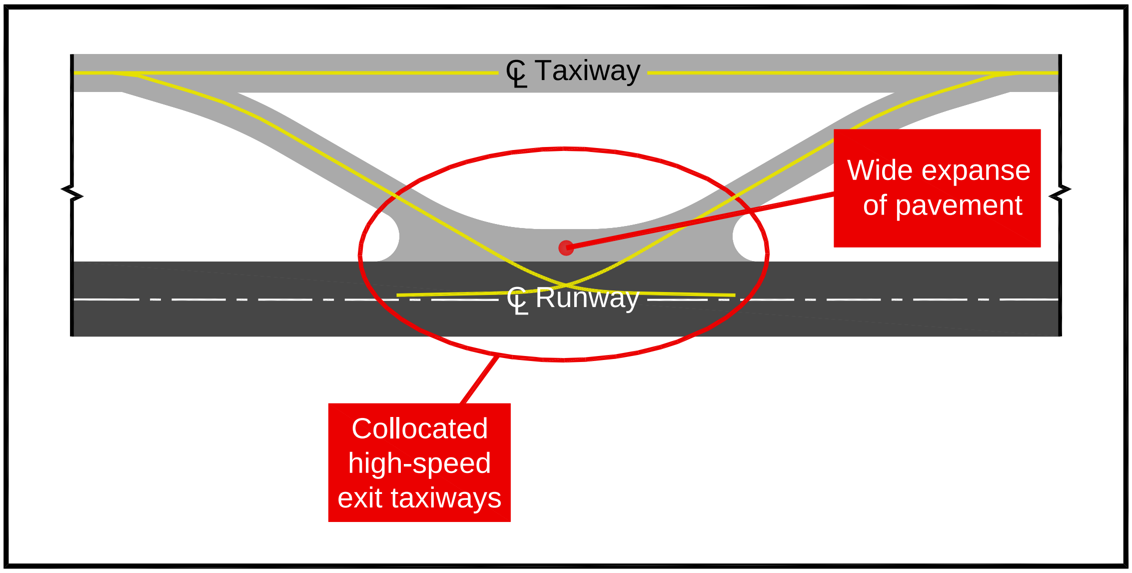


Note 1: The wide distance of the holding bay places the vertical signs outside of the pilot's normal viewing range.

J.5.13 Collocated High-speed Exit Taxiways.

Collocated high-speed exit taxiways create a wide, expansive pavement area at the runway-taxiway interface that precludes proper placement of lighting and signage. See Figure J-28. Refer to paragraph 4.8.5 for high-speed taxiway exit design standards.

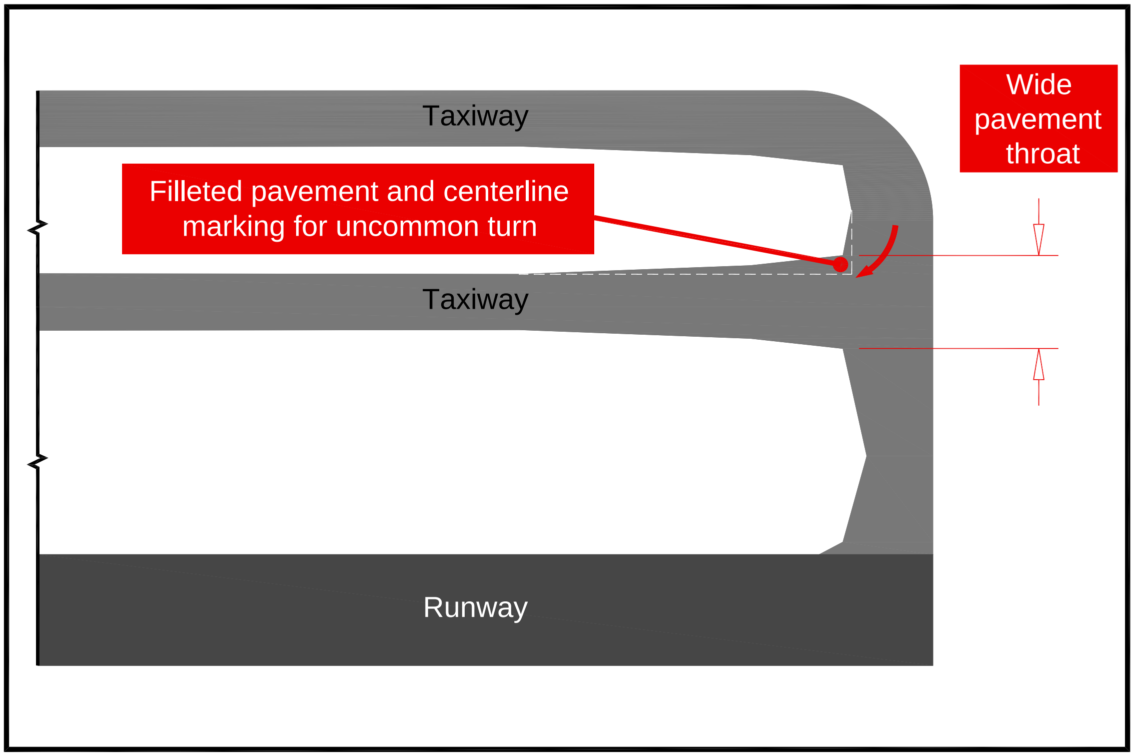
Figure J-28. Collocated High-Speed Runway Exit Taxiways



J.5.14 Fillet Pavement between Parallel Taxiways.

Turning movements from an outer parallel taxiway to an inner parallel taxiway at the runway end are uncommon. Providing fillet pavement for this uncommon turn creates a wide pavement throat a pilot may misconstrue as the runway. This loss of situational awareness can lead to a wrong surface departure event. See Figure J-29.

Figure J-29. Taxiway Fillet Pavement for Uncommon Turn



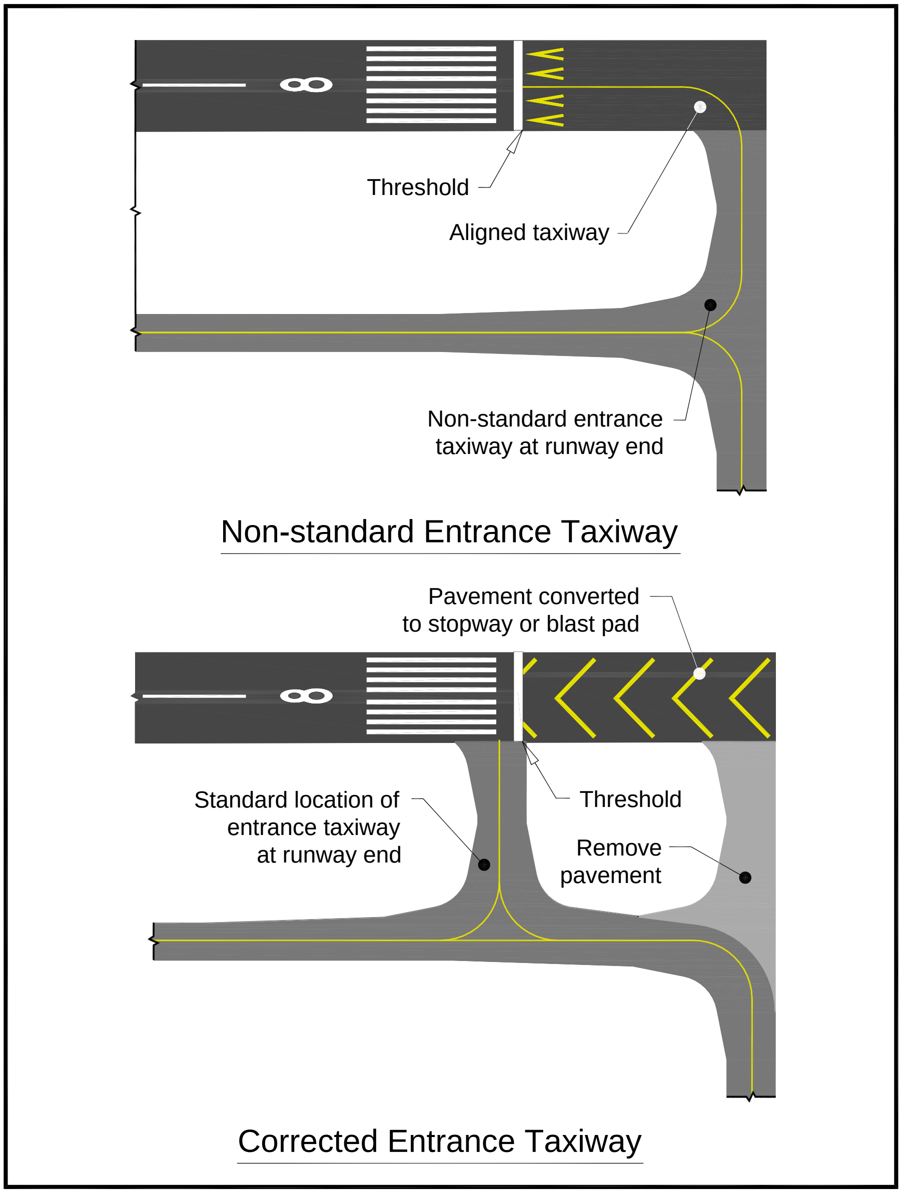
J.5.15 Aligned Taxiways.

An aligned taxiway is one whose centerline coincides with a runway centerline. See Figure J-30. Aligned taxiways represent an elevated hazard risk due to the potential for taxiing aircraft to take a position in direct line with departing or landing aircraft. Aligned taxiways also can contribute to a pilot's loss of situational awareness.

J.5.15.1 **Standards.**

For locations with existing aligned taxiways, the FAA expects the airport to have a plan on file to correct the non-standard aligned taxiway as soon as practical (i.e. next reconstruction project). Mitigation of aligned taxiways commonly involves converting the aligned taxiway pavement into a blast pad and constructing a new entrance taxiway at the standard location, as shown in Figure J-30.

Figure J-30. Aligned Taxiway and Corrected Design



J.5.16 Taxiway Connections to V-shaped Runways.

Crossing-taxiways (or connecting taxiways) located between runways that converge (e.g. V-shaped runways) can increase runway incursion risks when the taxiway length between runways is short. See Figure J-31 and Figure J-32. The associated risks include:

1. Hold lines in close proximity to each other similar to the risk associated with a short-stub taxiway per paragraph J.5.11.
2. Taxiways that intersect runways at other than 90 degrees thus providing that pilot a diminished range of view to a portion of the runway. Aligned taxiway to reach runway end.

Figure J-31. Taxiway Connections to V-shaped Runways

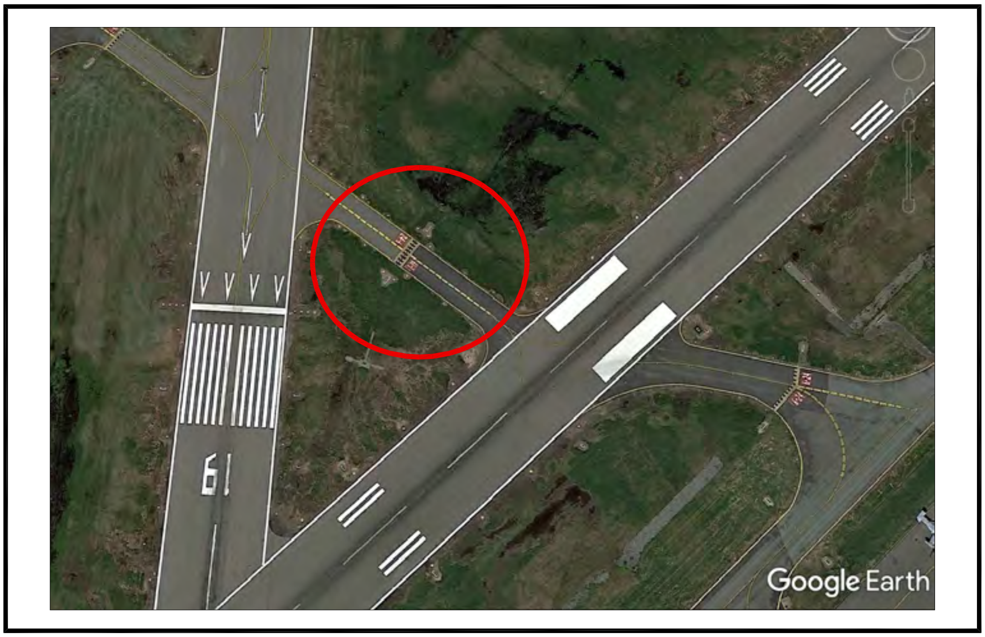
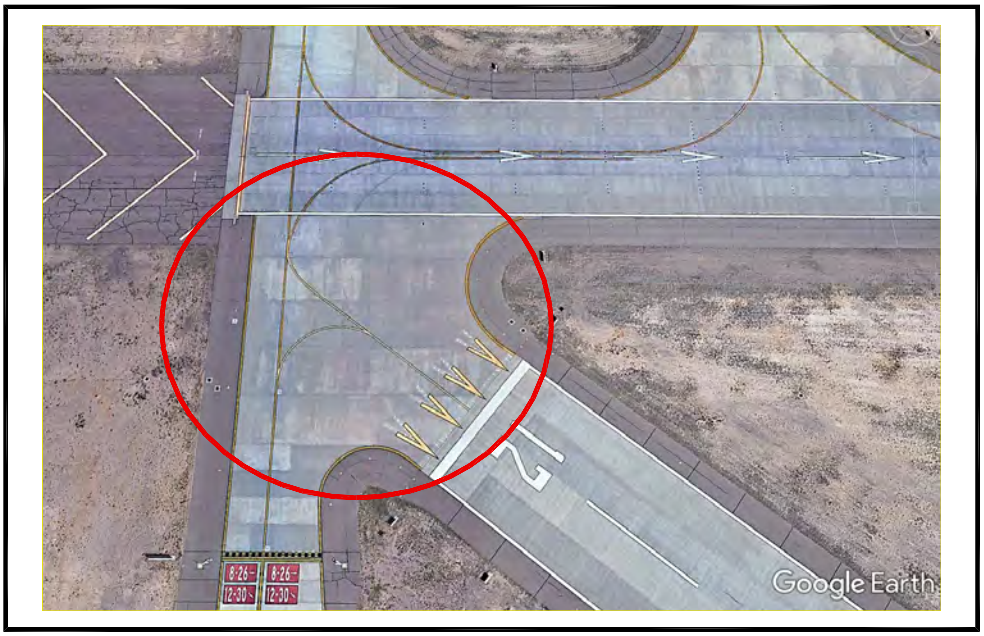


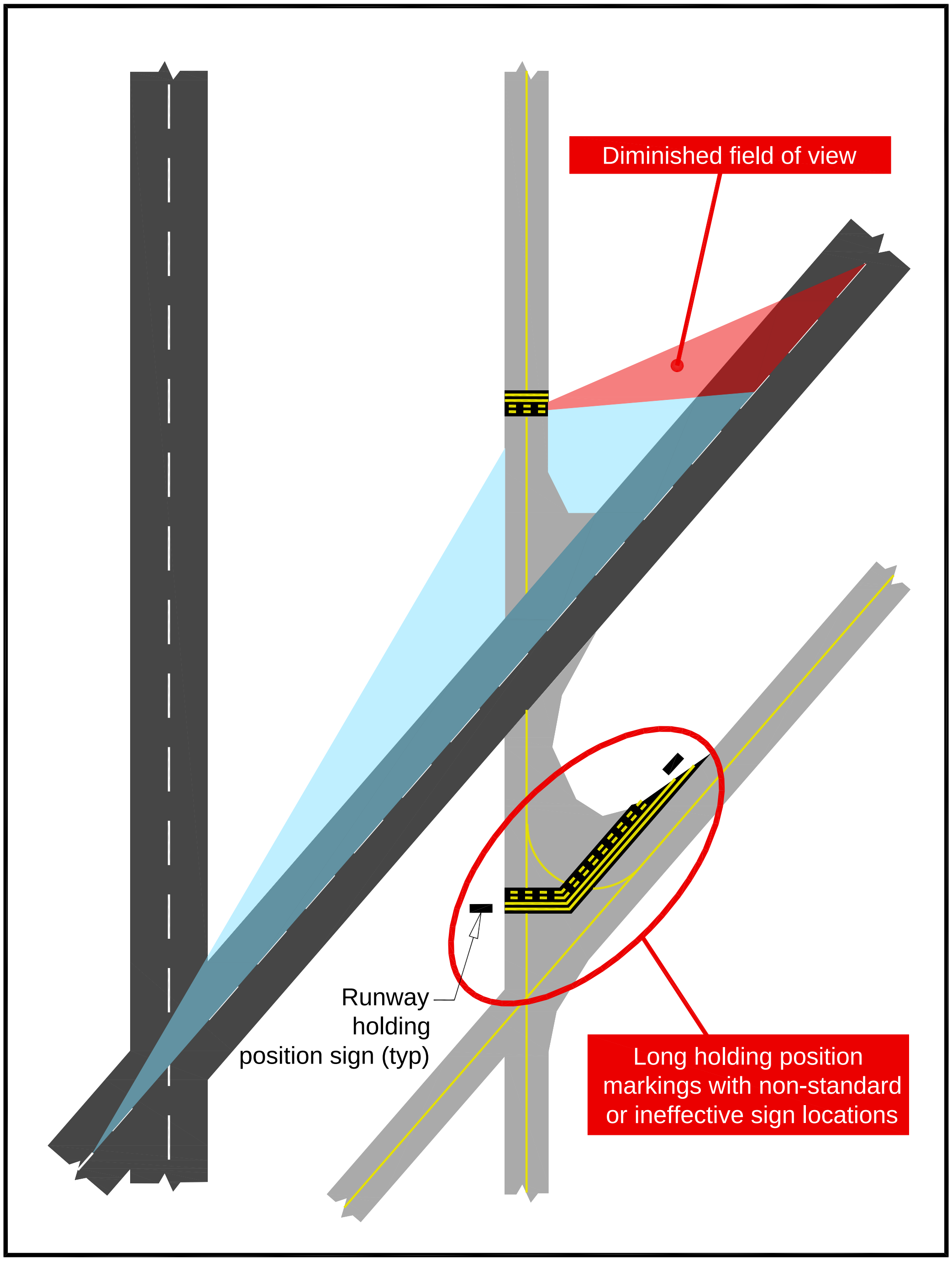
Figure J-32. Taxiways to Converging, Non-Intersecting Runways



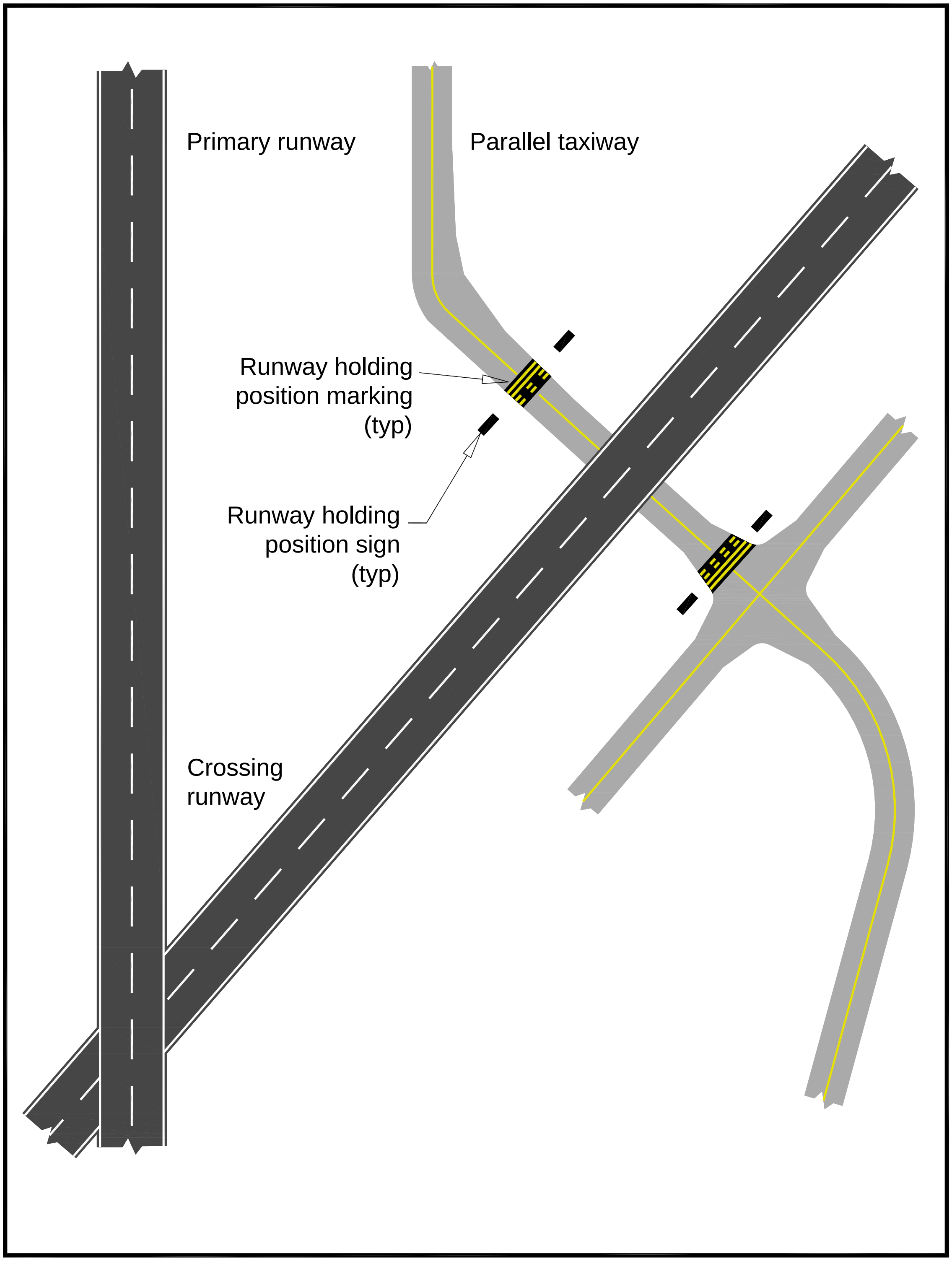
J.5.17 Parallel Taxiways/Runway Intersection.

The intersection of a parallel taxiway with a crossing runway may induce runway incursion risks if the intersection angle is less than 75 degrees. Additionally, the pavement fillets for acute angle intersection can create non-standard conditions for pavement marking and signage. It is not necessary for a parallel taxiway to be equidistant to the runway it serves for the entire length of the taxiway. When intersecting a crossing runway, adjust the alignment of the parallel taxiway to establish a 90-degree angle, plus or minus 15 degrees, with the runway centerline. See Figure J-33.

Figure J-33. Parallel Taxiway/Runway Intersection – Elevated Risk



8166 **Figure J-34. Parallel Taxiway/Runway Intersection – Optimum Configuration**



8167

APPENDIX K. APPROACH AND DEPARTURE REFERENCE CODES

K.1 General Overview.

The Approach and Departure Reference Codes (APRC and DPRC) are specifically for runway to taxiway separations. The APRC and DPRC are not design standards. They identify aircraft operations on a runway and its associated taxiway with no operating restrictions. These codes may help Air Traffic Control and the Airport Operator determine the capabilities of their airfield based on existing runway to parallel taxiway separation. Airports often serve aircraft exceeding their airport's or specific runway's design standards. A runway's pavement strength or a taxiway fillet radius are other examples used to assess operational conditions.

K.1.1 Runway-to-Taxiway Separation.

Plan and design the runway-to-taxiway separations per paragraph 3.20 for new infrastructure. A parallel taxiway increases capacity and improves safety by eliminating the need for aircraft to use the runway for taxiing. The landing and takeoff flight path profiles and physical characteristics of an aircraft determine this separation. Adhering to the separation standard prevents any part of a taxiing airplane (located on a centerline) from penetrating the RSA or the OFZ. This separation depends on the ADG of the larger aircraft. For example, if the parallel taxiway serves ADG IV aircraft and the runway serves ADG III; ADG IV standards control the separation distance.

K.2 Approach Reference Code (APRC).

Based on existing runway to taxiway separation, the APRC is a three-component code describing a combination of aircraft and visibility scenarios that will allow concurrent operations on the runways and taxiways without generating ATC operational restrictions.

1. The codes in Table K-1 mimic the RDC (see paragraph 1.6.4), using the APRC convention AAC/ADG/RVR (example: B/II/4000).
2. Within the limits of the APRC, airplanes up to the listed AAC and ADG and operating down to the visibility minimums noted per runway-to-taxiway separation, taxiing on the parallel taxiway may be conducted without operational mitigation.

Table K-1. Approach Reference Code (APRC)

Visibility Minimums	Runway to Taxiway Separation (ft)										
	≥ 150	≥ 200	≥ 225	≥ 240	≥ 250	≥ 300	≥ 350	≥ 400	≥ 450	≥500	≥550
Not lower than 3/4 mile (4000 RVR)	B/I(S)/ 4000	B/I(S)/ 4000	B/I/ 4000	B/II/ 4000	B/II/ 4000	B/III/ 4000 D/II/ 4000	B/III/ 4000 D/II/ 4000	D/IV/ 4000 D/V/ 4000 [1]	D/IV/ 4000 D/V/ 4000 [2]	D/V/ 4000 [3] D/VI/ 4000	D/IV/ 4000
Lower than 3/4 mile but not lower than 1/2 mile (2400 RVR)	N/A	B/I(S)/ 2400	B/I(S)/ 2400	B/I(S)/ 2400	B/I/ 2400	B/II/ 2400	B/III/ 2400	D/IV/ 2400 D/V/ 2400 [1]	D/IV/ 2400 D/V/ 2400 [2]	D/V/ 2400 [3] D/VI/ 2400	D/IV/ 2400
Lower than 1/2 mile but not lower than 1/4 mile (1600 RVR)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	D/IV/ 1600	D/IV/ 1600	D/V/ 1600	D/VI/ 1600
Lower than 1/4 mile (1200 RVR)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	D/IV/ 1200	D/IV/ 1200	D/V/ 1200	D/VI/ 1200

Note 1: Airport elevation at or below 1,345 ft.
Note 2: Airport elevation between 1,345 ft and 6,560 ft.
Note 3: Airport elevation above 6,560 ft.

General Notes:

- (S) denotes small aircraft
- Entries for Approach Category D also apply to Approach Category E. However, there are no Approach Category E aircraft currently in the civil fleet.
- For ADG-VI aircraft with tail heights of less than 66 feet (20 m), ADG-V separation standards apply.

K.2.1 APRC Example.

XYZ airport currently has a runway to taxiway separation of 350-feet. The RDC for this runway is C/II/2400, and in accordance with the online Runway Design Standards Matrix Tool requires a 400-foot separation. Using Table K-1, the APRC in this example is B/III/4000 and D/II/4000 at visibility minimums at not lower than ¾ mile (4000 RVR), and B/III/2400 at visibility minimums at lower than ¾ mile, but not lower than ½ mile (2400 RVR). This means that the following aircraft may land and taxi on the parallel taxiway without an operational restriction:

K.2.1.1 **Visibility minimum at not lower than ¾ mile (4000 RVR).**

1. Within Approach Categories A & B, Airplane Design Groups I(S), I, II, & III.

2. Within Approach Categories C & D, Airplane Design Groups I & II.

K.2.1.2 Visibility minimum at lower than ¾ mile, but not lower than ½ mile (2400 RVR).

1. Within Approach Categories A and B, Airplane Design Groups I(S), I, II, & III.
2. The Airport Operator (sponsor) and the ATC manager may implement operational restrictions of aircraft on the parallel taxiway to maximize the runway's capability.
3. Coordinate these procedures with Airport's Division and document in a Letter of Agreement between the Airport Operator and Air Traffic. Below is an example of operational restrictions implemented by the ATC Manager in reference to the previous example.

K.2.1.3 Visibility minimum not lower than ¾ mile (4000 RVR).

1. The parallel taxiway is to remain clear of ADG IV or larger aircraft when any aircraft is on final approach and within two miles of the runway threshold.
2. No aircraft will be on final approach and within two miles of the runway threshold when the parallel taxiway is occupied by an ADG IV aircraft or larger.

K.2.1.4 Visibility minimum lower than ¾ mile, but not lower than ½ mile (2400 RVR).

1. The parallel taxiway is to remain clear of ADG III or larger aircraft when any aircraft is on final approach and within two miles of the runway threshold.
2. No aircraft will be on final approach and within two miles of the runway threshold when an ADG III or larger aircraft occupy the parallel taxiway.

K.3 Departure Reference Code (DPRC).

Based on existing runway to taxiway separation, the DPRC is a two-component code (AAC and ADG) describing the type of aircraft that can depart a runway while any aircraft is on the parallel taxiway. Table K-2 summarizes the minimum runway to taxiway separation for each DPRC. Within a DPRC, airplanes up to the AAC and ADG may conduct unrestricted operations.

Table K-2. Departure Reference Code (DPRC)

Runway to Taxiway Separation (ft)					
≥ 150	**≥ 225**	**≥ 240**	**≥ 300**	**≥ 400**	**≥ 500**
B/I(S)	B/I	B/II	B/III D/II	D/IV D/V	D/VI [1]

Note 1: Refer to Figure K-1. ADG-VI airplanes may depart with aircraft on the parallel taxiway where the runway to taxiway separation is as little as 400-feet under these two scenarios:

a. No ADG-VI aircraft is occupying the parallel taxiway beyond 1,500 feet of the point of the start of takeoff roll.

b. No aircraft, regardless of size, is occupying the parallel taxiway beyond 1,500 feet of the point of the start of takeoff roll when there is snow, ice, or slush contamination on the runway.

General Notes:

- (S) denotes small aircraft
- Entries for Approach Category D also apply to Approach Category E. However, there are no Approach Category E aircraft currently in the civil fleet.

K.3.1 DPRC Example.

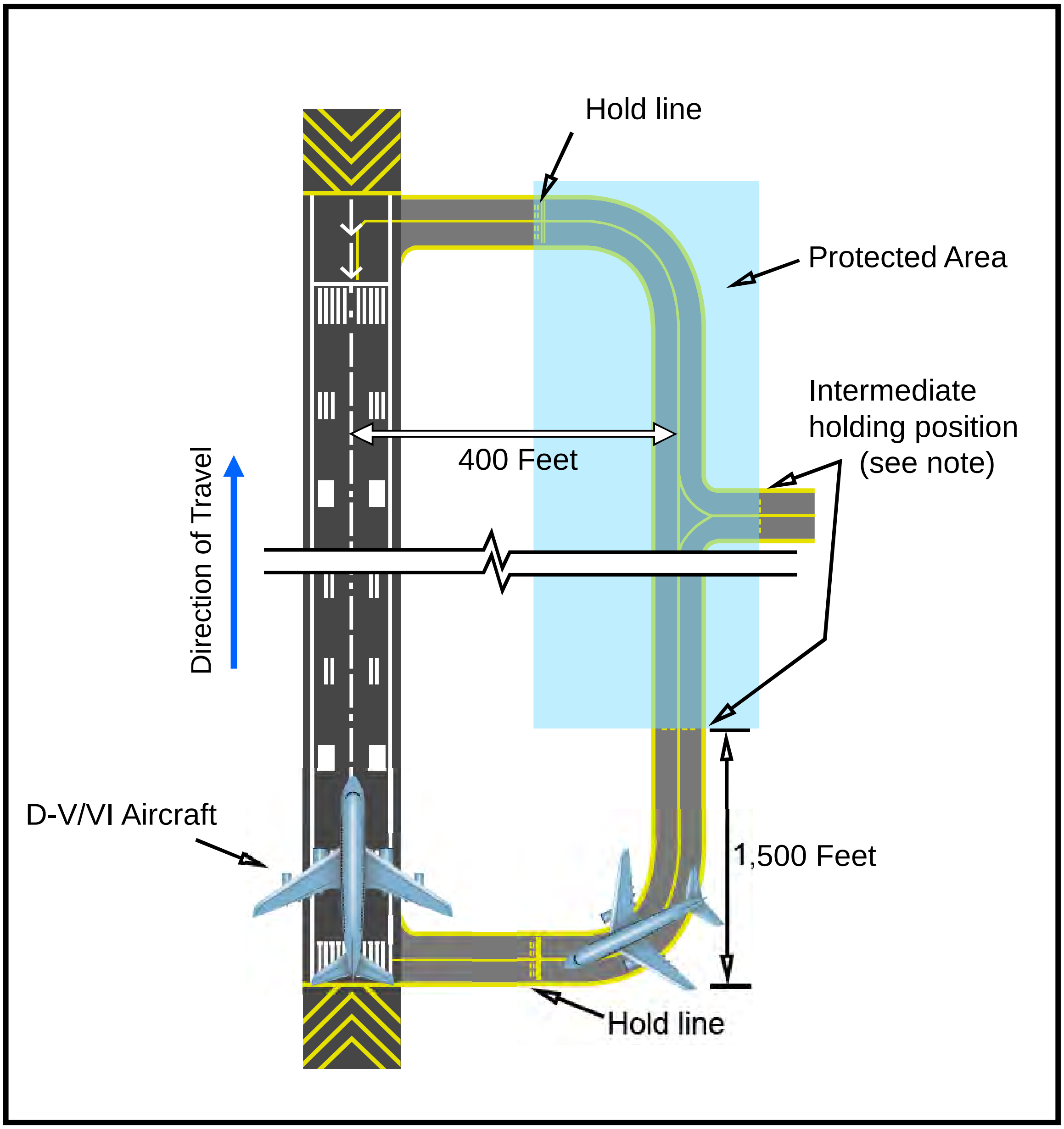
XYZ airport currently has a runway to taxiway separation of 240-feet. The DPRC, in this example, is B/II. The following aircraft may depart with any aircraft on the parallel taxiway without operational mitigation:

- Within Approach Categories A & B, Airplane Design Groups I(S), I, & II.

The ATC Manager may implement the following operational restrictions for the parallel taxiway:

- Remain clear of aircraft ADG III or larger when aircraft larger than B/II is departing the runway.

8272 **Figure K-1. ADG V-VI Departures**



8273
8274 **Note:** Refer to AC 150/5340-1 for Intermediate holding position marking.

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APPENDIX L. DIFFERENCES IN AIRPORT DESIGN STANDARDS AND RELATIONSHIP OF AIRCRAFT CHARACTERISTICS TO DESIGN COMPONENTS

L.1 Table L-1 depicts the differences in design standards associated with an increase in the AAC and ADG. Table L-2 depicts the differences in design standards associated with a decrease in visibility minimums. Table L-3 relates aircraft characteristics to various design components.

Table L-1. Differences in Design Standards with Upgrade in Aircraft Approach Category (AAC) and Airplane Design Group (ADG)

AAC/ ADC upgrade	Differences in Airport Design Standards	Reference
A-I* to B-I*	No change in airport design standards.	
B-I* to C-I	Increase in crosswind component.	Refer to paragraph B.3 and Table B-1.
	Increase in runway separation standards.	Refer to interactive online Runway Design Standards Matrix Tool and Table 4-7.
	Increase in RPZ dimensions.	Refer to online Runway Design Standards Matrix Tool and paragraph 3.12.1.
	Increase in OFZ dimensions.	Refer to paragraph 3.10.
	Increase in runway design standards.	Refer to online Runway Design Standards Matrix Tool.
	Increase in surface gradient standards.	Refer to paragraph 3.15, Figure 4-29, paragraph 4.14, and paragraph 5.9.
	Increase in threshold siting standards.	Refer to paragraph 3.4.
A-I to B-I	No change in airport design standards.	
B-I to C-1	Increase in crosswind component.	Refer to paragraph B.3 and Table B-1.
	Increase in runway separation standards.	Refer to online Runway Design Standards Matrix Tool and Table 4-7.
	Increase in RPZ dimensions.	Refer to online Runway Design Standards Matrix Tool and paragraph 3.12.1.
	Increase in runway design standards.	Refer to online Runway Design Standards Matrix Tool.

AAC/ ADC upgrade	**Differences in Airport Design Standards**	**Reference**
	Increase in surface gradient standards.	Refer to paragraph 3.15, Figure 4-29, paragraph 4.14, and paragraph 5.9.
A-II to B-II	No change in airport design standards.	
B-II to C-II	Increase in crosswind component.	Refer to paragraph B.3 and Table B-1.
	Increase in runway separation standards.	Refer to online Runway Design Standards Matrix Tool and Table 4-7.
	Increase in RPZ dimensions.	Refer to online Runway Design Standards Matrix Tool and paragraph 3.12.1.
	Increase in runway design standards.	Refer to online Runway Design Standards Matrix Tool.
	Increase in surface gradient standards.	Refer to paragraph 3.15, Figure 4-29, paragraph 4.14, and paragraph 5.9.
A-III to B-III	No change in airport standards.	
B-III to C-III	Increase in runway separation standards.	Refer to online Runway Design Standards Matrix Tool and Table 4-7.
	Increase in RPZ dimensions.	Refer to online Runway Design Standards Matrix Tool and paragraph 3.12.1.
	Increase in runway design standards.	Refer to online Runway Design Standards Matrix Tool.
	Increase in surface gradient standards.	Refer to paragraph 3.15, Figure 4-29, paragraph 4.14, and paragraph 5.9.
A-IV to B-IV	No change in airport design standards.	
B-IV to C-IV	Increase in RPZ dimensions.	Refer to online Runway Design Standards Matrix Tool and paragraph 3.12.1.
	Increase in surface gradient standards.	Refer to paragraph 3.15, Figure 4-29, paragraph 4.14, and paragraph 5.9.
C-I to D-I	Increase in runway design standards.	Refer to online Runway Design Standards Matrix Tool.
C-II to D-II	Increase in runway design standards.	Refer to online Runway Design Standards Matrix Tool.

Note: * These airport design standards pertain to facilities designed for small aircraft.

Table L-2. Differences in Airport Design Standards with Lowering Approach Visibility Minimums

Visibility minimums*	Differences in Airport Design Standards	Reference
Visual to Not lower than 1-mile	No change in airport design standards.	Refer to Table 3-6.
Not lower than 1-mile to Not lower than 3/4-mile	Parallel Taxiway:	Refer to Table 3-6.
	• Increase in RPZ dimensions.	Refer to the Runway Design Standards Matrix Tool.
	• Increase in threshold siting standards.	Refer to paragraph 3.4.
Not lower than 3/4-mile to Not lower than CAT-I	For runways with aircraft approach categories A & B runways:	Refer to design standards in Chapter 3.
	• Increase in runway separation standards.	Refer to the online Runway Design Standards Matrix Tool and Table 4-7.
	• Increase in RPZ dimensions.	Refer to the online Runway Design Standards Matrix Tool.
	• Increase in OFZ dimensions.	Refer to paragraph 3.9.
	• Increase in runway design standards.	Refer to the online Runway Design Standards Matrix Tool.
	• Increase in threshold siting standards.	Refer to paragraph 3.4.
	For runways with aircraft approach categories C, D, & E runways:	Refer to design standards in Chapter 3.
	• Increase in runway separation for runways standards with ADG-I & ADG-II standards.	Refer to the online Runway Design Standards Matrix Tool and Table 4-7.
	• Increase in RPZ dimensions.	Refer to the online Runway Design Standards Matrix Tool.
	• Increase in OFZ dimensions.	Refer to paragraph 3.10.
	• Increase in threshold siting standards.	Refer to paragraph 3.4.
Not lower than CAT-I to Lower than CAT-I	Increase in OFZ dimensions for runways serving large aircraft.	Refer to paragraph 3.10.
	Increase in threshold siting standards.	Refer to paragraph 3.4.

Note: ** In addition to the changes in airport design standards as noted, providing for lower approach visibility minimums may result in an increase in the number of objects identified as obstructions to air navigation in accordance with Part 77. This may result in the need for object removal or marking and lighting. Refer to paragraph 3.6.

Table L-3. Relationship of Aircraft Characteristics to Design Components

Aircraft Characteristics	Design Components
Approach Speed	RSA, ROFA, RPZ, runway width, runway-to-taxiway separation, runway-to-fixed object.
Landing and Takeoff Distance	Runway length
Cockpit to Main Gear Distance (CMG)	Fillet design, apron area, parking layout
Main Gear Width (MGW)	Taxiway width, fillet design
Wingspan / Tail Height	Taxiway and apron OFA, parking configuration, hangar locations, taxiway-to-taxiway separation, runway to taxiway separation

APPENDIX M. ACRONYMS

AAA	Airport Airspace Analysis
AAC	Aircraft Approach Category
AAS-100	FAA Office of Airport Safety and Standards, Airport Engineering Division
AASHTO	American Association of State Highway and Transportation Officials
ABN	Airport Beacon
AC	Advisory Circular
ACI	Airports Council International
ACM	Airport Certification Manual
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
ADG	Airplane Design Group
ADIP	Airport Data and Information Portal
ADO	Airports District Office
ADRM	Airport Development Reference Manual
ADS-B	Automatic Dependent Surveillance - Broadcast
AGL	Above Ground Level
AIM	Aeronautical Information Manual
AIP	Airport Improvement Program
ALP	Airport Layout Plan
ALS	Approach Lighting System
ALSF	Approach Lighting System with Sequenced Flashing Lights
ALSF-1	ALS with Sequenced Flashers I
ALSF-2	ALS with Sequenced Flashers II
AOA	Aircraft Operations Area
APRC	Approach Reference Code
APV	Approach Procedure with Vertical Guidance
ARC	Airport Reference Code
ARFF	Aircraft Rescue and Fire Fighting
ARP	Airport Reference Point
ARSR	Air Route Surveillance Radar

ASDA	Accelerate Stop Distance Available
ASDE	Airport Surface Detection Equipment (Radar)
ASDE-X	Airport Surface Detection Equipment – Model X
ASOS	Automated Surface Observing System
ASR	Airport Surveillance Radar
ASRS	Aviation Safety Reporting System
ASSC	Airport Surface Surveillance Capability
ASTM	American Society for Testing and Materials International
ATC	Air Traffic Control
ATC-F	Air Traffic Control Facilities
ATCT	Airport Traffic Control Tower
ATO	Air Traffic Organization
AWOS	Automated Weather Observing Systems
AWSS	Automated Weather Sensor System
BMP	Best Management Practice
BRL	Building Restriction Line
CAD	Computer Aided Design
CAT	Category
CFR	Code of Federal Regulations
CIE	International Committee of Illumination
CL	Centerline
CWY	Clearway
CMG	Cockpit to Main Gear Distance
CNSW	Communications, Navigation, Surveillance and Weather
CPA	Continuous Power Airport
DER	Departure End of Runway
DME	Distance Measuring Equipment
DPRC	Departure Reference Code
DXF	Drawing eXchange Format
EAT	End-Around Taxiway
EMAS	Engineered Materials Arresting System
EMI	Electromagnetic Interference

FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FBO	Fixed Base Operator
FOD	Foreign Object Debris
FSD	Transportation Security Administration Federal Security Director
GA	General Aviation
GIS	Geographic Information System
GLS	Ground Based Augmentation System (GBAS) Landing System
GNSS	Global Navigation Satellite System
GPA	Glide Path Angle
GPS	Global Positioning System
GS	Glideslope
GSE	Ground Service Equipment
HAA	Height Above Airport
HAT	Height Above Touchdown
HIRL	High Intensity Runway Lights
HSS	Hollow Structural Section
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IA-OFZ	Inner-Approach OFZ
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IES	Illuminating Engineering Society of North America
IFP	Instrument Flight Procedure
IFR	Instrument Flight Rules
IFST	International Flight Service Transmitter
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
ISH/ISD	Integrated Surface Hourly/Integrated Surface Data
IT-OFZ	Inner-Transitional OFZ
IVT	IFP Validation Team
LDA	Landing Distance Available

LDIN	Lead-in Lighting System
LIR	Low Impact Resistant
LIRL	Low Intensity Runway Lights
LLWAS	Low Level Windshear Alert System
LNAV	Lateral Navigation
LOC	Localizer
LOS	Line of Sight
LP	Localizer Performance
LPV	Localizer Performance with Vertical Guidance
MALS	Medium Intensity Approach Lighting System
MALSF	MALS with Sequenced Flashers
MALSR	MALS with Runway Alignment Indicator Lights
MDA	Minimum Descent Altitude
MGW	Main Gear Width
MIRL	Medium Intensity Runway Lights
MM	Middle Marker
MN	Magnetic North
MPH	Miles Per Hour
MSL	Mean Sea Level
NAS	National Airspace System
NAVAID	Navigation Aid
NCDC	National Climatic Data Center
NDB	Non-directional Beacon
NEPA	National Environmental Policy Act
NextGen	Next Generation Air Transportation System
NGS	National Geodetic Survey
NPA	Non-Precision Approach
NPDES	National Pollution Discharge Elimination System
NPI	NAS Planning and Integration
NPIAS	National Plan of Integrated Airport Systems
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen

NVGS	Non-Vertically Guided Survey
NWS	National Weather Service
NXRAD	Next Generation Weather Radar
OCS	Obstacle Clearance Surface
ODALS	Omnidirectional Airport Lighting System
OE/AAA	Obstruction Evaluation/Airport Airspace Analysis
OFA	Object Free Area
OFZ	Obstacle Free Zone
OM	Outer Marker
OSHA	Occupational Safety and Health Administration
PA	Precision Approach
PAPI	Precision Approach Path Indicator
PFC	Passenger Facility Charge
PIR	Precision Instrument Runways
POFZ	Precision Obstacle Free Zone
PRM	Precision Runway Monitor
PSI	Pounds per Square Inch
PVC	Point of Vertical Curve
PVI	Point of Vertical Intersection
PVT	Point of Vertical Tangency
RCO	Remote Communications Outlet
RDC	Runway Design Code
REDIM	Runway Exit Design Interactive Model
REIL	Runway End Identifier Lighting
REL	Runway Entrance Lights
RF	Radio Frequency
RIM	Runway Incursion Mitigation
RNAV	Area Navigation
RNP	Required Navigation Performance
ROFA	Runway Object Free Area
ROFZ	Runway Obstacle Free Zone
RON	Remain Over Night

RPZ	Runway Protection Zone
RSA	Runway Safety Area
RTR	Remote Transmitter/Receiver
RVR	Runway Visual Range
RVZ	Runway Visibility Zone
RW	Runway
RWSL	Runway Status Lights
SALS	Short Approach Lighting System
SALSF	Short Approach Lighting System with Sequenced Flashing Lights
SER	Stop End of the Runway
SIDA	Security Identification Display Area
SMS	Safety Management System
SOIA	Simultaneous Offset Instrument Approaches
SRE	Snow Removal Equipment
SRM	Safety Risk Management
SSALR	Simplified Short Approach Light System with Runway Alignment
SSALS	Simplified Short Approach Light System
SSALF	Simplified Short Approach Light System with Sequenced Flashing Lights
SVG	Scalable Vector Graphics
TACAN	Tactical Air Navigation
TBW	Total Bytes Written
TCH	Threshold Crossing Height
TDG	Taxiway Design Group
TERPS	Terminal Instrument Procedures
TESM	Taxiway Edge Safety Margin
TH	Threshold
THL	Takeoff Hold Lights
TL	Taxilane
TLOFA	Taxilane Object Free Area
TODA	Takeoff Distance Available
TOFA	Taxiway and Taxilane Object Free Area
TORA	Takeoff Run Available

TPP	U.S. Terminal Procedures Publication
TRACON	Terminal Radar Approach Control Facility
TSA	Taxiway/Taxilane Safety Area
TVOR	Terminal Very High Frequency Omnidirectional Range
TW	Taxiway
UAS	Unmanned Aircraft Systems
USC	United States Code
UFC	Unified Facilities Criteria
UHF	Ultra-High Frequency
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
V	Visual
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VGS	Vertically Guided Survey
VGSI	Visual Guidance Slope Indicator
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VORTAC	VHF Omnidirectional Range Collocated Tactical Air
V_{REF}	Reference landing speed
V_{SO}	Stall speed
VSR	Vehicle Service Road
WAAS	Wide Area Augmentation System
WCAM	Weather Camera
WEF	Wind Equipment F-400
WHSV	Wildlife Hazard Site Visit
WME	Wind Measuring Equipment

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APPENDIX N. INDEX

Advisory Circular Feedback

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by (1) mailing this form to Manager, Airport Engineering Division, Federal Aviation Administration ATTN: AAS-100, 800 Independence Avenue SW, Washington DC 20591 or (2) faxing it to the attention of the Office of Airport Safety and Standards at (202) 267-5383.

Subject: AC 150/5300-13B   Date: ______________________

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph ___________ on page _______________.

☐ Recommend paragraph _______________ on page _______________ be changed as follows:

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☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

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____
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☐ Other comments:

____
____
____

☐ I would like to discuss the above. Please contact me at (phone number, email address).

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Submitted by: ______________________________   Date: _______________________________