U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Aircraft Landing Performance and Runway Excursion Mitigation

Date: 8/28/23 **AC No:** 91-79B
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This advisory circular (AC) provides ways for pilots and airplane operators to identify, understand, and manage the risks associated with the landing phase of flight. It also provides information that both certificated and noncertificated operators may use to develop personal or standard operating procedures (SOP) to mitigate a runway excursion. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

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CHAPTER 1. INTRODUCTION

1.1 Purpose of This Advisory Circular (AC). This AC provides ways to identify, understand, and manage the risks associated with the landing phase of flight. It describes braking action reports and the Runway Condition Assessment Matrix (RCAM), discusses the hazards associated with runway overruns and excursions, reviews the requirements for predeparture flight planning, and provides procedures for completing a time of arrival (TOA) landing distance assessment. It also provides operators with information they may use to develop standard operating procedures (SOP), training programs, policies, and briefing guides in order to mitigate landing risks. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

1.2 Audience. This AC is intended for pilots, check airmen, dispatch examiners, flightcrews, airplane operators, certificate holders, program managers, training providers, pilot examiners, and other support personnel.

1.3 Where You Can Find This AC. You can find this AC on the Federal Aviation Administration's (FAA) website at https://www.faa.gov/regulations_policies/advisory_circulars/ and the Dynamic Regulatory System (DRS) at https://drs.faa.gov.

1.4 What This AC Cancels. AC 91-79A, Mitigating the Risks of a Runway Overrun Upon Landing, dated September 17, 2014, is canceled. Safety Alert for Operators (SAFO) 19001, Landing Performance Assessments at Time of Arrival, dated March 11, 2019, and SAFO 19003, Turbojet Braking Performance on Wet Runways, dated July 2, 2019, are canceled.

1.5 Background. Heavy snow was falling on a frigid day in December 2005 when a Boeing 737 ran off the runway at Chicago's Midway Airport. Although the aircraft touched down normally, thrust reverser activation was delayed. On a wet runway, this would have resulted in approximately a 180-foot (ft) increase in stopping distance. Although the braking action was reported as "good" by previous aircraft, National Transportation Safety Board (NTSB) analysis had in fact shown it to be poor. As a result, the stopping distance for the accident aircraft was increased by approximately 2000 ft, and the aircraft ran through the airport fence onto Central Avenue, and struck two cars. A dozen people were injured and a child inside one of the cars was killed.

1.5.1 In response to that accident, it was determined that there were no standardized means to observe and predict landing performance on runways whose condition were worse than wet, and the FAA convened the Takeoff and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee (ARC). Because regulations do not include dispatch requirements for landing on runways other than wet or dry, exposure to the risks associated with other runway conditions during TOA had not been formally addressed. The FAA adopted several committee recommendations and implemented them on October 1, 2016.

1.5.2 TALPA standardized runway condition reporting and set the conditions within a matrix that compared airport observations, engineering-based landing performance calculation methods, vehicle observations, and runway friction measuring ranges. The matrix was called the "Runway Condition Assessment Matrix (RCAM)." This guidance is now set out in three separate ACs for airports (AC 150/5200-30, Airport Field Condition Assessments and Winter Operations Safety), aircraft certification (AC 25-32, Landing Performance Data for Time-of-Arrival Landing Performance Assessments), and aircraft operators (this AC).

1.5.3 TALPA recommendations served as the basis for the International Civil Aviation Organization (ICAO) standards. Known collectively as the Global Reporting Format (GRF), this series of publications became applicable in 2021. A complete list of publications can be found on the ICAO website at https://www.icao.int/publications/Pages/default.aspx. International operators should be familiar with the ICAO GRF to ensure proper understanding of terms, procedures, and policies.

1.5.4 The RCAM forms the basis of the FAA's TALPA initiative as well as the ICAO GRF. While the levels of predicted aircraft wheel brake performance were set in these documents, there was no guidance for how actual aircraft performance could be used to provide standard reports. In 2017, the Society of Aircraft Performance and Operations Engineers (SAPOE) convened a special task group to address this issue. The result was published as two ASTM standards (ASTM E3188, Standard Terminology for Aircraft Braking Performance, and E3266, Standard Guide for Friction-Limited Aircraft Braking Measurements and Reporting) that set formalized definitions and minimum standards for braking action reports derived directly from aircraft data. These documents described how braking action reports should be structured, the intended precision of the reported braking action, and how accuracy should be applied to the RCAM scale.

1.5.5 According to FAA and NTSB information, runway overruns during the landing phase of flight account for approximately ten incidents or accidents every year with varying degrees of severity, including fatalities. As a result, the NTSB recommended that a means be developed for aircraft to have the capability to record and report braking performance. This was later published in Safety Recommendations A-16-23 and A-16-24 after another runway excursion in 2015. This AC revision incorporates guidance on this capability.

1.6 **Content of This AC.** This guidance incorporates the recommendations from the TALPA ARC and the material from SAFOs 19001 and 19003, and references guidance from ASTM E3188 and E3266.

1.6.1 Braking Action and Braking Action Reports. To effectively manage landing risk, it is critical that the effect of wheel braking is understood, as it plays a vital role in both dispatch and TOA landing distance assessments. While these risks are commonly associated with transport category aircraft and operations, this AC provides the knowledge, skills, and techniques that may be used by other aircraft with similar designs.

1.6.2 Runway Overrun Hazards. In addition to wheel braking, proper airmanship based on a foundation of knowledge regarding other overrun risk factors is essential. These risks, which are generic to all aircraft, are discussed as well as their consequences.

1.6.3 Predeparture Flight Planning. This AC provides a brief introduction to the regulations and recommended practices concerning preflight runway requirements for large transport aircraft.

1.6.4 Time of Arrival (TOA) Landing Distance Assessments. Upon arriving at the destination airport, prior to top of descent, the flightcrew obtains the runway's reported condition and assesses if the aircraft can safely land with reference to the wet contaminated runway landing data if available in the pilot's operating handbook (POH)/Airplane Flight Manual (AFM).

1.6.5 Aircraft Braking Action Report (ABAR). Appendix A provides detailed background information on ABAR systems and their use.

1.7 Related Documents (current editions).

1.7.1 ASTM International Standards.

- E3188, Standard Terminology for Aircraft Braking Performance.
- E3266, Standard Guide for Friction-Limited Aircraft Braking Measurements and Reporting.

1.7.2 Advisory Circulars (AC).

- AC 23-8, Flight Test Guide for Certification of Part 23 Airplanes.
- AC 25-7, Flight Test Guide for Certification of Transport Category Airplanes.
- AC 25-31, Takeoff Performance Data for Operations on Contaminated Runways.
- AC 25-32, Landing Performance Data for Time-of-Arrival Landing Performance Assessments.
- AC 60-22, Aeronautical Decision Making.
- AC 120-71, Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers.
- AC 121.195-1, Operational Landing Distances for Wet Runways; Transport Category Airplanes.

1.7.3 FAA Handbooks.

- FAA-H-8083-3, Airplane Flying Handbook.
- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge.

1.7.4 Safety Alerts for Operators (SAFO). SAFO 10005, Go-Around Callout and Immediate Response.

1.7.5 Additional References.

- Approach and Landing Accident Reduction (ALAR)/Runway Excursion Risk Reduction (RERR) Toolkits.
- Flight Safety Foundation (FSF) ALAR Tool Kit.
- FSF's Reducing the Risk of Runway Excursions Report.
- Safety Targeted Awareness Report (STAR) 007, Overruns on Landing, from the European Regions Airline Association (ERA) Air Safety Work Group.
- Flight Test Harmonization Working Group (FTHWG) Topic 32, Codification of Part 25 Takeoff and Landing Performance Assessment (TALPA) (Recommendation Report, July 20, 2022).

1.8 Definitions. The following definitions are used in this AC:

1.8.1 Advisory Data. Aircraft performance data that applies standard engineering factors to certified data to produce nonmandatory guidance for runway conditions other than wet or dry.

1.8.2 Aircraft Braking Action Report (ABAR). A braking action report generated by an automated system designed to provide a standardized indication of the aircraft's braking performance.

1.8.3 Approved Data. Aircraft performance data that is approved for use by the FAA.

1.8.4 Autobrakes. An automated aircraft control system that normally allows the pilot to select a targeted deceleration rate for the landing rollout.

1.8.5 Braking Action. The method for describing the maximum capability of a vehicle's braking system on a wet or contaminated surface that references a standardized scale (the RCAM).

1.8.6 Certified Data. Aircraft performance data that is required to be provided by regulation and is derived from flight testing. This data is provided by the manufacturer as AFM landing distance."

1.8.7 Factored Landing Distance. The AFM landing distance adjusted by the applicable Title 14 of the Code of Federal Regulations (14 CFR) preflight factors.

1.8.8 Friction-Limited Braking. A condition of aircraft braking performance where the amount of deceleration force that can be applied by the aircraft brakes is limited by the friction level of the runway surface. For aircraft so equipped, any increase in command to the brake system will be limited by the anti-skid system.

1.8.9 Global Reporting Format (GRF). The format used by ICAO to denote standard runway condition reporting and aircraft braking performance. This format is based on and largely similar to current FAA guidance.

1.8.10 Operational Landing Distance. A calculation of landing distance based on actual landing weight, aircraft configuration, runway and meteorological conditions, including braking action reports that are used by the flightcrew to make an assessment at the TOA. This calculation normally references advisory data supplied by the manufacturer and may include recommended air distances and safety margins and is used in the TOA assessment.

1.8.11 Operator. For the purpose of this AC, any air operator, foreign air operator, or private operator.

1.8.12 Pilot Braking Action Report (PBAR). A braking action report based on observations from the pilot. In some countries, PBARs may be referred to as a Pilot Report (PIREP) or an Air Report (AIREP).

1.8.13 Porous Friction Course (PFC). A thin layer of porous asphalt that allows water to drain vertically away from the surface of the runway.

1.8.14 Reliable Pilot Braking Action Report (PBAR). A PBAR whose precision and accuracy can be justified and can therefore be reasonably used to create a time of landing performance assessment for the aircraft receiving the report. The following should be considered when determining if the braking action report is reliable:

1. Similar types of aircraft (e.g., transport category jet aircraft with fully modulating anti-skid systems).
2. Time since braking action report was given (e.g., stable conditions with cold temperature and no active precipitation will likely be reliable for a longer time than reports provided during an active precipitation event with temperatures near 0 ºC).
3. Pilot education and training in the principles of braking action and braking action reporting.

1.8.15 Runway Condition Code (RwyCC). A number from 0 to 6 that represents the slipperiness of a designated portion of a runway (i.e., a specific one-third of the runway); a rating of 0 indicates extremely slippery and a rating of 6 indicates a dry runway. (See Table 3-2, Pilot/Operator Runway Condition Assessment Matrix (RCAM).)

1.8.16 Takeoff and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee (ARC). The FAA body formed to reduce the risk of runway overruns by developing a series of guidance materials for runway conditions and aircraft performance. These procedures have since formed the basis of the ICAO GRF.

1.8.17 Time of Arrival (TOA) Assessment. Upon arriving at the destination airport, prior to top of descent, the flightcrew obtains the runway's reported condition, assesses if the aircraft can safely land, with reference to the wet contaminated runway landing data if available in the POH/AFM.

1.8.18 Torque-Limited Braking. A condition of aircraft ground deceleration performance where the amount of deceleration force that can be generated by the aircraft brakes is limited by the maximum torque capability of the wheel brakes.

1.8.19 Unfactored Airplane Flight Manual (AFM) Landing Distance. The landing distance provided by the AFM without any factors applied.

Note: For some operations, these landing distances may be determined in a way that represents the maximum performance capability of the airplane, which may not be representative of normal operations. (See Chapter 2, Predeparture Flight Planning.)

1.8.20 Wheel Braking Coefficient. The ratio of the deceleration force from the braked wheels/tires relative to the sum of the vertical (normal) forces acting on the braked wheels/tires. The wheel braking coefficient is the result of the combination of all functioning braked wheels.

1.9 Training Considerations. We recommend operators include the information in this AC in their SOPs for operations of aircraft in their pilot training programs.

1.10 AC Feedback Form. For your convenience, the AC Feedback Form is the last page of this AC. Note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this AC on the Feedback Form.

CHAPTER 2. PREDEPARTURE FLIGHT PLANNING

2.1 Background.

2.1.1 Dispatch Requirements. Large transport category airplanes are subject to specific regulations with the intent of ensuring that a flight does not begin that cannot be safely concluded. Title 14 CFR parts 91 subpart K (part 91K), 121, and 135 operators must not plan to arrive at either the destination or the alternate airport at a weight that would require them to use more runway than is available (and 14 CFR part 125, § 125.49(a) requires part 125 operators to only use an airport if it is adequate for the proposed operation). These predeparture planning procedures are also recommended, although not required, for part 91 operators.

Note: During a discussion of predeparture flight planning requirements, it is important to keep in mind that the regulations specify flight-planning requirements, not landing requirements. In other words, upon arrival, all (100 percent) of the runway available may be used for landing.

2.1.2 Title 14 CFR Compliance. It is not the intent of this AC to provide all the predeparture landing distance regulatory requirements. However, pilots must be knowledgeable of the regulations applicable to their type of operation, so they can both comply with such regulations and fully understand regulatory shortcomings. Parts 91K, 121, and 135 require operators of large transport category airplanes to comply with certain landing distance requirements at the time of takeoff. These requirements are sometimes referred to as "dispatch requirements." The requirements limit the allowable takeoff weight to that which would allow the airplane to land within a specified percentage of the Landing Distance Available (LDA) on: (1) the most favorable runway at the destination airport under still air conditions; and (2) the most suitable runway in the expected wind conditions. Part 91, § 91.1037(e); part 121, § 121.195(e); and part 135, § 135.385(d) further require an additional 15 percent be added to the landing distance required when the runway is wet or slippery, unless a shorter distance can be shown using operational landing techniques on wet runways.

2.1.2.1 **Sections 91.1037(b), 121.195(b), and 135.385(b).** Regulations require that during preflight planning, the flightcrew may not depart on the flight unless it has been determined that the aircraft will be able to perform a full stop landing within 60 percent of the effective length of the runway. To determine the landing distance required, multiply the AFM approved landing distance by 1.667 or divide the AFM approved landing distance by 0.60. This factor assumes a dry runway condition at TOA.

Example: AFM approved landing distance = 3000 ft (3000' x 1.667 = 5000' or 3000' ÷ 0.60 = 5000'.) In this example, to comply with the 60 percent rule, the runway LDA at the planned destination would need to be at least 5000 ft long.

2.1.2.2 **Sections 91.1037(e), 121.195(e), and 135.385(d).** If weather reports or forecasts indicate that the runways at the destination airport may be wet or slippery, unless a shorter distance can be shown using operational landing techniques, that the aircraft may not depart unless the operator can show that the effective runway length at the destination airport is at least 115 percent of the runway length required for a dry runway (as calculated above).

Example: If it was determined that the runway at the planned destination would need to be 5000 ft to comply with the 60 percent rule in dry conditions (as in the first example, above), then in forecast wet conditions, the runway LDA would need to be at least 5750 ft long (5000' x 1.15 = 5750').

Note 1: The additional 15 percent increase required by the regulations above is based only on the previously calculated distances used for a dry runway. Caution: The increase is not based on demonstrated wet runway stopping performance; therefore, wet runway factored landing distance may not provide enough runway for the aircraft to stop.

Note 2: There exists a common misconception that grooved runways or runways covered in PFC are considered dry for predeparture-planning calculations. Pilots and dispatchers must remember that the 15 percent increase is still required if the runway will be wet on landing, even if it is grooved or PFC.

2.1.2.3 **Sections 91.1037(c), (d), (e), and 135.385(f).** Parts 91 and 135 operators that are authorized via operations specifications (OpSpecs) or management specifications (MSpecs) to use a Destination Airport Analysis program (such as a part 135 eligible-on-demand operator) may depart on a flight if preflight planning indicates that the aircraft will be able to perform a full stop landing within 80 percent of the effective runway length available. To determine the landing distance required, multiply the AFM approved landing distance by 1.25 or divide the AFM approved landing distance by 0.80. This factor assumes a dry runway condition at TOA.

Example: AFM approved landing distance = 3000 ft. (3000' x 1.25 = 3750' or 3000' ÷ 0.80 = 3750'.) In this example, to comply with the 80 percent rule, the appropriately authorized operator would need to confirm that the runway LDA at the planned destination is at least 3750 ft long.

Note: The 80 percent factored distance in most cases will not provide a safe landing margin if the runway is either wet or contaminated. Operators must exercise extreme caution when preflight planning if the destination airport runway is either wet or contaminated.

2.1.3 Overview. Table 2-1 below provides an overview of predeparture landing distance requirements.

Table 2-1. Regulatory Planned Dispatch Destination Airport Requirements

Regulation	Type of Airplane	Runway Condition	Percentage of Effective Runway Length
§ 121.195(b) § 135.375(a) § 135.385(b) § 91.1037(b)	Large turbine/Large reciprocating engine powered	Dry	60%
§ 121.195(c) § 135.385(c)	Turboprop, Large turbine engine powered (excluding turbojet)	Dry	70%
§ 121.195(d) § 135.385(d) § 91.1037(d)	Turbojet without an approved AFM wet runway landing technique	Wet/Slippery	115% of § 121.195(b) or § 135.385(b), or § 91.1037(d) AFM factored dry landing distance
§ 135.385(f) § 91.1037(c)(2)	Large turbine powered, eligible on demand	OpSpecs/MSpecs Authorized	80%
§ 121.197 § 135.387(a) § 91.1037(b)	Large turbine engine powered, alternate airport	Dry	Turbojet airplanes: 60% Turbo-propeller: 70%
§ 121.197 § 135.387(a) § 135.375(b)	Large turboprop/Large reciprocating engine, alternate airport	Dry	70%
§ 135.387(b) § 91.1037(d)	Large turbine powered, eligible on demand, alternate airport	OpSpecs/MSpecs Authorized	80%

2.1.4 Part 91 Recommendations. Preflight planning requirements for part 91 operators are governed by §§ 91.103 and 91.605. (Section 91.1037 is only applicable to part 91K operators.) Although not required by regulation, we recommend that part 91 operators and pilots calculate predeparture landing distance performance requirements based on the guidance contained in their AFM.

2.2 **AFM Landing Distance Data.** Operators and pilots should flight plan using the best available information concerning expected destination runway conditions. The regulatory requirements referenced in this chapter are intended to represent a minimum level of compliance. Compliance with preflight planning regulations is accomplished by using approved data from the AFM.

2.2.1 It is important for pilots and operators to keep in mind that AFM landing performance data is determined during certification flight tests using analysis criteria that are not representative of everyday operational practices. Landing distances determined in compliance with 14 CFR part 25 and published in the AFM do not reflect normal operational landing distances. The goal of determining landing distances during certification tests is to demonstrate the shortest landing distances for a given airplane weight with a test pilot at the controls. Flight test and data analysis techniques employed by some airplane manufacturers for determining landing distances can result in the use of high touchdown sink rates (as high as 480 ft per minute) and approach angles of negative 3.5 degrees to minimize the airborne portion of the landing distance. Maximum manual braking, initiated as soon as possible after landing, is used to minimize the braking portion of the landing distance. Therefore, the landing distances determined under part 25, § 25.125 and published in the AFM may be shorter than and not reflect normal operational landing distances.

2.2.2 With respect to landing performance data for wet or contaminated runways, the landing distances provided in the AFM may not represent performance that is operationally achievable. This is because the wet or contaminated runway data is usually the result of applying an algorithm to the dry, smooth, hard surface runway data, not on demonstrated aircraft ability. In other words, wet and contaminated runway data also may not represent performance that you should expect to achieve in normal operations. The fact that the short distances achieved during flight testing are not usually repeatable during normal operations, along with many other variables affecting landing distance, is taken into consideration in the preflight landing performance calculations by requiring a significant safety margin in excess of the unfactored AFM landing distance that would be required under those conditions.

2.2.3 To summarize, landing distance information provided by some manufacturers in the AFM, determined in compliance with part 25 during aircraft flight testing is aimed at achieving and recording the shortest landing distance possible and is not representative of everyday operational practices. The distances reported have been demonstrated in flight tests with a test pilot at the controls using techniques not typically used by pilots in normal operations. Both NTSB and FAA data identify the failure of pilots and operators to assess actual required landing distances to account for slippery or contaminated conditions or any other changed condition existing at the time of landing as a significant causal factor in landing overruns. Even when predeparture flight planning requirements have been satisfied, we strongly recommend that pilots perform a TOA landing distance assessment prior to landing.

CHAPTER 3. TIME OF ARRIVAL (TOA) LANDING DISTANCE ASSESSMENT

3.1 Background. A TOA assessment is critical when the landing runway is not the same runway analyzed for dispatch or when runway conditions and/or type and depth of contamination have changed. In addition, current weather, actual airplane weight, and available braking systems to be used should be considered. Once the operational landing distance is determined, an additional safety margin of at least 15 percent should be added to that distance. Except under emergency conditions, flightcrews should not attempt to land on runways that do not meet the TOA assessment criteria and safety margin.

Note: The FAA acknowledges that there are situations when pilots need to know the absolute performance capability of the airplane. These situations include emergencies or abnormal and irregular configurations of the airplane such as engine failure or flight control malfunctions. In these circumstances, the pilot must consider whether it is safer to remain in the air or to land immediately and must know the actual landing performance capability, without an added safety margin, when making these evaluations. This guidance is not intended to curtail such evaluations from being made for these situations.

3.2 General. Per Title 49 of the United States Code (49 U.S.C.) § 44702(b), operators engaged in air transportation have a statutory obligation to operate with the highest possible degree of safety in the public interest. Although current regulations do not require a landing distance assessment be performed at the TOA, operators are required to restrict or suspend operations when conditions are hazardous. Sections 91.3, 91.1011, 121.533, 121.535, 121.537, 125.371, and 135.69 place the responsibility for the safe operation of the flight jointly with the operator, pilot in command (PIC), and dispatcher, as appropriate to the type of operation being conducted.

3.2.1 As explained in Chapter 2, compliance with regulations applicable at the time of dispatch or takeoff does not guarantee that the airplane can land safely within the distance available on the runway used for landing at the TOA, particularly if the runway, runway surface condition, meteorological conditions, airplane configuration, airplane weight, or the intended use of airplane ground deceleration devices is different than that used in the preflight calculation.

3.2.2 Additionally, §§ 121.195(e), 135.375(b), and 135.385(c) and (e) allow use of an alternate airport to meet the requirements if forecast conditions at the destination airport are inadequate. These provisions imply, but do not mandate, that a landing distance assessment is accomplished prior to conducting an approach to determine if it is safe to land at the destination or if it is necessary to divert to an alternate airport.

3.3 Conducting the Assessment. Operators and pilots should use the most adverse reliable braking action report, if available, or the most adverse expected conditions for the runway or portion of the runway that will be used for landing, when making a TOA landing distance assessment. Operators and pilots should consider the following factors in determining the operational landing distance: the age of the report, meteorological conditions present since the report was issued, type of airplane or device used to obtain the report, whether the runway surface was treated since the report, and the methods used for that treatment. Operators should create guidance for flightcrews that enable adequate briefings, articulate pilot flying and pilot monitoring duties, and ensure clear policies and procedures. Pilots who operate their aircraft independently should ensure decision points regarding TOA landing criteria are mapped out prior to the flight.

3.3.1 When to Conduct the Assessment. A TOA landing distance assessment is initially performed when landing weather and field conditions are obtained, usually prior to beginning the descent from cruise altitude (top of descent). The assessment includes a consideration of how much deterioration in field conditions can be tolerated so that a quick decision can be made just prior to landing if new information is obtained that indicates that field conditions are worse than expected (e.g., the preceding aircraft provides a worse-than-expected braking action report).

3.3.2 Source of Data.

3.3.2.1 When available, the operational landing distance data used is advisory data based on the recommendations of AC 25-32. This data may be provided by the manufacturer or developed by a performance data provider.

3.3.2.2 If advisory data for a landing distance assessment at TOA is not available from the manufacturer or from a performance data provider, the Landing Distance Factors (LDF) from Table 3-1, Landing Distance Factors, may be used. To find the landing distance required, multiply the AFM dry, unfactored landing distance by the applicable LDF in Table 3-1 for the runway conditions existing at the TOA. If the AFM landing distances are presented as factored landing distances, then that data must be adjusted to remove the applicable preflight factors that were applied. The LDFs given in Table 3-1 include a 15 percent safety margin; an air distance representative of normal operational practices; a reasonable accounting for temperature; the effect of increased approach speed, reduced wheel braking, and thrust usage (reverse or not); and the additional effect of reduced wheel braking capability on altitude and wind distance adjustment.

3.3.2.3 Currently, there are no plans to provide aircraft manufacturers of normal, utility, aerobatic, and commuter category airplanes (14 CFR part 23 airplanes) with advisory information similar to AC 25-32 (which is applicable to transport category airplanes). In the absence of guidance to manufacturers of part 23 aircraft, operational landing distance data may be based on the recommendations of AC 25-32. In the absence of guidance to part 23 aircraft manufacturers, the manufacturer or data provider should consider the recommendations in AC 25-32 when creating data for a TOA assessment.

3.3.3 Using the LDF Table. As stated above, when manufacturer-produced or third-party provider data is not available, the LDFs from Table 3-1 may be used for the TOA landing distance assessment.

1. To find the landing distance required, multiply the unfactored AFM landing distance by the applicable LDF in Table 3-1 for the runway conditions existing at the TOA.
2. If the AFM landing distances are presented as factored landing distances, first adjust the data to remove the preflight factors that were applied prior to multiplying the distance by the LDF. (See appropriate examples in Chapter 2.)
3. The LDFs given in Table 3-1 include a 15 percent safety margin.

Table 3-1. Landing Distance Factors

The following factors are multipliers to the unfactored AFM demonstrated landing distances:

Runway Condition Code	**6**	**5 Grooved/ PFC**	**5 Smooth**	**4**	**3**	**2**	**1**
Braking Action	Dry	Good	Good	Good to Medium	Medium	Medium to Poor	Poor
Turbojet, No Reverse	1.67	2.3	2.6	2.8	3.2	4.0	5.1
Turbojet, With Reverse	1.67	1.92	2.2	2.3	2.5	2.9	3.4
Turboprop (see Note)	1.67	1.92	2.0	2.2	2.4	2.7	2.9
Reciprocating	1.67	2.3	2.6	2.8	3.2	4.0	5.1

Note: These LDFs apply only to turboprops when the AFM provides for a landing distance credit for the use of ground idle power lever position. Turboprops without this credit should use the “Turbojet, No Reverse” LDFs.

3.4 Runway Condition Considerations. Airport assessments should be based on information that most accurately represents the conditions anticipated. When available for the portion of the runway that will be used for landing, the following are considered:

- RwyCCs,
- Expected runway condition (contaminant type and depth), and
- Braking action reports.

3.4.1 Timeliness. It is important to note the time of the latest RwyCC and any associated reliable braking action reports. Several overruns have occurred when pilots were provided with a runway condition that was no longer reliable given changes in meteorological conditions.

ATTENTION: Pilots are strongly advised to review the weather conditions and compare that to the time of the latest braking action report.

3.4.2 Situational Awareness. Throughout the descent and approach, pilots should remain vigilant for any deterioration in conditions. You should use all available resources to determine what condition you may expect upon landing to include ATC reports, field condition reports, flight visibility, and onboard weather radar.

3.5 Risks Associated With Moderate or Heavy Rain. Several runway excursions and overruns have raised concerns with wet runway stopping performance assumptions. Analysis of the stopping data from these incidents and accidents indicates the braking coefficient in each case was significantly lower than expected for a wet runway than would be predicted by § 25.109 and AC 25-7. These incidents and accidents occurred on both grooved and ungrooved runways. The data indicates that applying a 15 percent safety margin to wet runway advisory data, as recommended (see Figure 5-1, Effects of Compound Factors), may be inadequate in certain wet runway conditions.

3.5.1 Rainfall Amount. In a rainfall event, such as an active thunderstorm, the amount of water or moisture on a runway can change rapidly. The dynamic nature of rainfall can present challenges for the timely and accurate reporting of water or moisture on a runway.

3.5.2 Risk Mitigation. It is recommended that if it is anticipated that more than 1/8 inch of water will be on the runway, the LDF associated with medium to poor braking, or a RwyCC of 2, be used during the TOA assessment. In addition, when planning to land on a smooth runway under conditions of moderate or heavy rain, or when landing on a grooved or PFC runway under heavy rain, pilots should consider that the surface may be contaminated with water at depth greater than 1/8 inch and adjust their landing distance assessment accordingly.

Note: A Special Weather Observation (SPECI) will only be generated if a thunderstorm begins. A SPECI is not generated when rainfall rates simply change. In addition, ATC radar is not optimized for the detection of rainfall and during an active or fast-moving weather event, PIREPs can rapidly become obsolete.

3.6 Risk Associated With Standing Water. When standing water is present, aircraft braking can rapidly degrade as the contact area of the tire is lifted away from the pavement by the effects of hydroplaning. When this occurs, pilots have reported that the aircraft feels like it accelerates. This change in sensation is because braking performance can degrade in a matter of seconds, resulting in up to a 77-percent decrease in braking force. This rapid decrease in friction also affects cornering ability, making lateral drift more difficult to control, if not impossible. Unexpected handling characteristics due to standing water have been shown to lead to pilot confusion and a possible delay in the use of thrust reversers or ground spoilers.

3.6.1 RwyCC Limitations. Note on the RCAM (see Table 3-2, Pilot/Operator Runway Condition Assessment Matrix (RCAM)) that only 1/8 inch of water separates a wet runway (with a RwyCC of 5 and “good” braking action) from a runway contaminated with standing water (and a RwyCC of 2 and "medium to poor" braking action). This dramatic difference is due to the possibility of dynamic hydroplaning that may occur any time water depth exceeds 1/8 inch.

3.6.2 Operations at Foreign (Non-U.S.) Airports.

3.6.2.1 Pilots should be aware that the design and maintenance standards referenced in this AC might not be met in other countries. Standards for design, construction, and maintenance of runways are based on ICAO Annex 14, Aerodromes, standards; however, they may lack oversight in implementation of those standards.

3.6.2.2 Outside of the United States, there is often less usage of grooving or PFC overlay which, when present, will normally aid in drainage, mitigate the risk of hydroplaning during active precipitation, and improve braking action. Unless the pilot is knowledgeable of an international airport's runway maintenance program, and sure that the runway has improved drainage capabilities with grooved or PFC surfaces, they should consider basing their TOA assessment on the recommendations in paragraph 3.6.1.

3.7 Aircraft Performance Considerations. In addition to runway surface conditions, the following considerations may also impact operational landing distance calculations:

- Runway slope,
- Airport pressure altitude,
- Wind,
- Temperature,
- Airplane weight and configuration,
- Approach speed at threshold,
- Adjustment to landing distance (such as autoland), and
- Planned use of airplane ground deceleration devices.

Note: Risk of overrun linked to a runway being more slippery than expected is amplified in tailwind conditions (increased ground speed at touchdown and potential floating aircraft). This potential situation needs particular attention.

3.8 Autobrake and Manual Brake Usage. When autobrakes are a part of the aircraft's landing configuration, the landing distance assessment is not intended to force a higher than necessary autobrake selection. Autobrakes normally target a deceleration rate and may not require the employment of the full braking capabilities of the aircraft. Conversely, landing calculations using manual brakes assume that the full capability of the aircraft's wheel brake system is employed during the rollout phase.

3.8.1 Safety Margin. To accommodate for real-world operational variations, the manual wheel braking landing distance used for a TOA assessment should include a safety margin of at least 15 percent. For operations when the runway is dry, or when the runway is wet, grooved, or PFC, if the manual braking distance provides a 15 percent safety margin, then the braking technique may include a combination of autobrakes and manual brakes even if the selected autobrake landing data does not provide a 15 percent safety margin. The operator will need to ensure that proper procedures and crew training are in place when the selected autobrake landing data does not provide a 15 percent safety margin.

3.8.2 Contaminated Runways. For contaminated runways, the minimum 15 percent safety margin should always be based on either autobraking or manual braking to be used (i.e., should correspond to the selected level of autobrake, if used).

3.9 Touchdown Point. The touchdown point used in the landing distance assessment reflects the assumed air distance. Operational landing data usually includes an allowance for 1,500 ft or 7 seconds of air distance from the threshold to touchdown. An air distance as short as 1,000 ft may be used provided an operator's landing assessment procedures include enhancements to minimize the risk of overruns or undershoots, including:

1. Training in touchdown control and short field landing techniques.
2. Identification of required touchdown point and training to assure go-around procedures are initiated if unable to achieve a suitable touchdown point.
3. Approach guidance and runway markings on the specific runway are consistent with a shorter air distance.
4. Operational data provided to the crew for the specific runway, conditions, and aircraft-landing configuration without the need for interpolation.
5. The flight techniques assumed in the creation of the performance data used for shorter air distances are appropriately trained and documented. For example, the assumed speed bleed-off used in the performance data needs to be consistent with the trained flight techniques for flaring the aircraft.

3.10 Crosswind Considerations. During operations when standing water may be present, operators should be aware of the effect of crosswind landing on a contaminated runway, given most aircraft only provide demonstrated crosswind and not a maximum crosswind limit. Tire cornering limitations can reduce wheel braking capability. As a result, crosswind limits can become a dominant factor in TOA landing distance assessments. Pilots should always be vigilant of these limits, especially when braking action is less than good.

3.11 Assessment Based on Preflight (Dispatch) Criteria. When the runway is dry, the assessment may be as simple as confirming that the runway meets the criteria used for dispatch. To use an assessment based on preflight (dispatch) criteria, pilots need to:

1. Ensure that the runway used for landing is the same runway that was assessed during preflight or for dispatch;
2. Confirm that the wind velocity and other factors that could affect landing distance are the same as those considered during preflight or the dispatch assessment; and
3. When applicable, consider the possibility of a late runway change such as a side step to a parallel runway.

3.12 Risk Management Considerations. Landing on a contaminated runway can involve multiple hazards, including cognitive bias, changing weather conditions, and high task loading. Because these hazards occur at a time with pressing time constraints, they can create an environment where errors are likely to occur. Managing such risks requires mitigation in the form of organizational policies, effective training, and well-designed procedures.

3.12.1 Policy Considerations. The overall strategy for managing risk should involve structured briefings during times of low task loading to address contingencies should new information be received. Once in the terminal area, the pilots should focus on the execution of the briefed plan, not analysis of the risk. While flightcrews always need a decision space for unexpected events, primary decision points concerning acceptable risk should be clearly communicated by the operator.

3.12.2 Flightcrew Training Considerations. Ensure that briefings are complete, checklists are run correctly, and that plan continuation bias does not drive actions counter to established rules and SOPs. This should be the primary goals of the pilot monitoring.

3.12.3 Procedure Considerations. Decisions regarding TOA landing distance assessments should be made using the best available information considering timeliness, reliability, and data precision. SOPs should require that when runway conditions are likely to change, crews brief the worst braking levels acceptable and the indications that would accompany them. This briefing needs to take place prior to descent. Once the descent begins, pilots actively monitor conditions and when faced with a pre-briefed scenario, respond with the previously briefed set of actions.

3.13 Technical Considerations for Understanding Landing Performance and the RCAM. Much like how aircrews must have a technical knowledge of their aircraft's systems and not just checklists and procedures, a basic engineering background on wheel braking and runway friction can serve to greatly enhance the guidance in this AC. As an aid for good decision making, a knowledge of runway friction and training on the RCAM is provided.

3.13.1 Runway Friction. The ability of a runway to act as an agent for an aircraft to transfer its weight into wheel braking force during landing is a function of the runway surface friction characteristics and the wheel braking system of the aircraft.

3.13.1.1 Runway Friction Properties Runway pavement is a function of the large-scale and small-scale properties of the pavement, known as macro and micro texture. Airports construct and aircraft are certified for runways whose pavement properties can be shown to support a minimum amount of friction when measured with a testing device. These tests are typically done in dry conditions with devices that have self-wetting capabilities.

3.13.1.2 **Wet Runways.** When there is a possibility that the runway surface is lubricated with water to a degree large enough to affect wheel braking performance, the runway is reported as "wet" and classified in the RCAM with the number 5. Airports are required to accomplish routine friction testing. Should such a test result in a value below a specified threshold, the runway is listed with a Notice to Air Missions (NOTAM) of "Slippery when Wet." Runway friction is also affected by any substance that is found on top of the pavement. When this occurs, the runway is said to be "contaminated."

3.13.1.3 **Water Removal.** Runways are normally constructed with a built-in crown so that water will drain towards each side. To aid in this drainage, pavement can be designed with lateral grooves or with a special pavement property known as PFC overlay. Grooved runways increase the rate of water drainage through the polished channels in the grooves while PFC surfaces allow water to drain through the surface. The primary purpose of each is to facilitate the dynamic drainage of water below the aircraft tire as it rolls over the surface. However, these runway improvements do not affect the basic lubricating properties water has on the texture of the pavement itself.

3.13.2 Types of Contamination. Any substance that rests on the surface of a pavement can have three distinct properties. These are:

3.13.2.1 **Solid Contaminant.** The substance represents a non-movable surface that has its own friction properties. These properties can exhibit a wide range of friction, with relatively high friction available when hot sand is bonded to very cold ice to very poor friction. While solid contaminant is mostly encountered as frozen water, it can occur as a result of rubber buildup or in rare occasions, growths such as lichen.

3.13.2.2 **Loose Contaminant.** A condition whereby a substance compresses directly under a rolling tire but has a depth to a degree that the tire must also displace it as well.

3.13.2.3 **Deformable Contaminant.** A condition whereby a substance resting above the surface of the pavement acts to deform away from underneath the tire as it rolls. Deformable contaminant can be extremely hazardous as it can lift the tire away from the surface and result in hydroplaning.

3.13.3 Takeoff Performance. During takeoff, aircraft performance may be limited with consideration of loose contaminant imparting additional drag due to the combination of displacement by the aircraft's tires and impingement of the contaminant spray on the aircraft structures. AC 25-31 details the guidance recommended under these conditions when determining takeoff performance data.

Note 1: AFM guidance may contain additional limitations for contamination type and depth due to possible damage to the airframe from the impingement of the contamination.

Note 2: During landing, it is possible that loose contaminant can aid in deceleration. However, it is recommended that credit not be taken for this effect.

Note 3: Loose contamination that affects aircraft acceleration has been referred to by some operators as "clutter." It is recommended that terminology used by operators be harmonized with the guidance in ASTM E3188, as well as this AC, AC 25-32, and AC 150/5200-30.

3.13.4 Landing Performance. Landing performance is most affected by the degree mechanical wheel braking can impart a decelerating force to the aircraft. This effect is classified using a standardized engineering scale that represents the maximum force available from an aircraft's wheel braking system. A model was created by the TALPA ARC to create a reasonably conservative relationship between this engineering scale and a set of standardized descriptions of wet and contaminated conditions known as the RCAM.

3.13.5 RCAM. The RCAM serves three core functions. First, it provides standardized means of reporting information from aircraft and airports so that a TOA landing performance assessment can be made. Second, it is a means of classifying information so that aircrews can build a shared mental model of the expected degree of risk during landing. Third, it is a means for airports and aircraft manufacturers to develop standardized models for calculating performance. It is important to understand that the RCAM is at its core, a model for risk management.

3.13.5.1 **Models vs Theories.** Models are designed to provide an effective path for communication. Theories are designed to provide an explanation for all data involved in a process. The RCAM was designed to provide a reasonably conservative model for runway conditions and engineering-based wheel braking performance values. The RCAM is an industry best practice. However, there may be instances where the model may not apply values conservative enough for TOA landing assessments. The use of braking action reports along with the knowledge and skills outlined in this AC are designed to assist in mitigating these instances.

3.13.5.2 **Standardized Reporting.** TOA assessments should be conducted as the result of an airport observation and/or aircraft observations. Dry conditions are not normally reported, unless they occur in conjunction with other parts of the runway that are other than dry. Observations from airports are given with numerals (e.g., 5, 3, 2, etc.) while observations from aircraft are given with words (e.g., Good, Medium, etc.).

3.13.5.3 **Aircraft Braking Performance Levels.** The RCAM is divided into six categories, each representing a range of maximum wheel braking ability. Operator guidance should contain landing performance data for each category that represents the lowest inclusive value of wheel braking for that category. TOA landing assessments normally use only one category. However, multiple reports may be provided for each runway as described below.

3.13.5.4 **Reporting Runway Sections.** RwyCCs are provided for each third of the runway. This was primarily done to provide flightcrews with situational awareness. Airports are tasked with maintaining consistent runway conditions throughout their entire length. However, weather and operational conditions may result in variations. Operators should establish policies regarding how TOA landing assessments are made when varying RwyCCs are reported.

3.13.5.5 **Building a Mental Model of Risk.** The ability to discriminate airport observations, aircraft observations, and cockpit observations (e.g., radar, visual cues, etc.) allows the flightcrew to build a shared mental picture of what the most likely condition a flightcrew can expect at the TOA. In general terms, with conditions constant and timely reporting, braking action reports may offer a higher degree of confidence than RwyCCs. Similarly, onboard radar may offer a timelier picture of expected conditions than either braking action reports or RwyCCs. Flightcrew training and operational guidance is key to effectively mitigating this risk.

3.13.5.6 **Standardized Performance Metrics.** There are three RCAMs published that provide performance metrics for stakeholders. The RCAM in this AC is intended to be used by flightcrews and aircraft operators. AC 150-5200/30 contains an RCAM for airport operators that includes guidance for runway friction measurements. AC 25-32 contains an RCAM with engineering values used to calculate landing distances referencing certification standards. This guidance for airports and manufacturers ensures that the information in the RCAM depicted here represents the best available information for operators and flightcrews.

Note: Runway friction measurements utilized by airports do not have the appropriate degree of precision and accuracy to be used for TOA landing assessments and are purposely omitted from this AC.

3.13.5.7 **Control/Braking Assessment Criteria.** Table 3-2 lists the basic metrics for how vehicle control can be related to braking assessments. This information is generic throughout all RCAM types and can be applied to any vehicle used to observe wheel braking. Guidance for reliable aircraft braking action reports is covered in Chapter 4 and should be used by all operators reporting aircraft observations, either by pilots or aircraft reporting systems.

Table 3-2. Pilot/Operator Runway Condition Assessment Matrix (RCAM)

Assessment Criteria		Control/Braking Assessment Criteria	
Runway Condition Description	**RwyCC**	**Deceleration or Directional Control Observation**	**Reported Braking Action**
• Dry	6	---	---
• Frost • Wet (includes damp and 1/8 inch depth or less of water) ***1/8 Inch (3 mm) Depth or Less of:*** • Slush • Dry Snow • Wet Snow	5	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	Good
-15 ºC and Colder Outside Air Temperature: • Compacted Snow	4	Braking deceleration OR directional control is between Good and Medium.	Good to Medium
• Slippery When Wet (wet runway) • Dry Snow or Wet Snow (any depth) over Compacted Snow ***Greater Than 1/8 Inch (3 mm) Depth of:*** • Dry Snow • Wet Snow ***Warmer Than -15 ºC Outside Air Temperature:*** • Compacted Snow	3	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	Medium
Greater Than 1/8 Inch (3 mm) Depth of: • Water • Slush	2	Braking deceleration OR directional control is between Medium and Poor.	Medium to Poor
• Ice	1	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	Poor
• Wet Ice • Slush over Ice • Water over Compacted Snow • Dry Snow or Wet Snow over Ice	0	Braking deceleration is minimal to nonexistent for the wheel braking effort applied OR directional control is uncertain.	Nil

Note 1: The unshaded portion of the RCAM ("Assessment Criteria" columns) is used by airport operators conducting a runway condition assessment.
Note 2: The shaded portion of the RCAM ("Control/Braking Assessment Criteria" columns) is for pilots making braking action reports.
Note 3: Runway condition codes (RwyCC), one for each third of the landing surface (e.g., 4/3/3), represent the runway condition description as reported by the airport operator.

CHAPTER 4. BRAKING ACTION REPORTS

4.1 General. Standardizing braking action reports by using braking action codes in the RCAM, which provides the latest PIREPs, ensures that pilots are provided objective, useful information so they can accurately assess the runway condition prior to landing. A runway is assumed to be dry unless reported otherwise (usually through the Automatic Terminal Information Service (ATIS), NOTAM, or PIREP). Runway conditions other than dry are described as being either wet or contaminated. Since aircraft braking ability varies greatly due to wet or contaminated runway conditions, it is important to report any reduction in braking ability to air traffic control (ATC).

4.2 Understanding Aircraft Deceleration. The "stopping performance" of a landing aircraft is a combination of aerodynamic and mechanical braking forces. The relative impact of these forces changes during the landing rollout. Aerodynamic forces are dominant immediately after touchdown when the aircraft is at higher speeds. As the aircraft decelerates, mechanical forces play a more important role.

4.3 Classifying Wheel Braking Action. Braking action describes the degree to which the weight on the braked wheels can be transferred into a decelerating force by the aircraft's brakes. This system is comprised of the tire, wheel brakes, and anti-skid system (if available). Usually, as brakes are applied, the wheel speed decreases below the free rolling speed and a wheel slip is created. The friction created by this wheel slip imparts a decelerating force to the aircraft. Anti-skid systems modulate the wheel braking to ensure a targeted wheel slip value is not exceeded. On a dry runway, the ability of the wheel brakes to impart a decelerating force is normally limited to the ability of the braking system to absorb heat and is said to be "torque limited." As the runway friction decreases, this slip ratio will be achieved at successively lower forces applied to the wheel brakes and the force imparted by the brakes will be limited by the anti-skid. In this case, the brakes are said to be "friction limited." The relationship between the decelerating force from the braked wheels and the vertical force acting on them is known as the wheel braking coefficient. As the runway becomes more slippery, the wheel braking coefficient decreases. The standardized scale used in the RCAM is based on wheel braking performance and has three distinct characteristics:

1. The scale only represents values when the aircraft's braking system is performing at its maximum capability (i.e., the point of friction-limited deceleration is reached due to the slipperiness of the runway);
2. Each division of the scale represents a range of values with the defining value for that division being the lowest wheel braking coefficient value for that range; and
3. The scale assumes the braking coefficient value (reported braking action) is valid for the entire length of the landing roll, unless otherwise specified. (See paragraph 4.10 below.)

4.4 Braking Action Reports. Braking action is an observation of the aircraft's performance when the maximum capability of the wheel brakes is being applied. The report provides time-critical and operationally relevant information to pilots when a runway may be more slippery than previously reported. In addition to pilots, braking action reports can be used by airport operators to confirm or downgrade a RwyCC in an updated Field Condition Report (FICON) NOTAM.

4.4.1 Braking Action. "Braking action" is the term used to describe the maximum capability of a vehicle's braking system on a wet or contaminated surface with reference to the standardized scale in the RCAM under the column labeled "Control/Braking Assessment Criteria." A braking action report may also convey the observation by the flightcrew that the reported wheel braking performance that is likely to be experienced during the landing rollout. Braking action is classified according to the primary source of information used to generate the report:

1. Pilot Braking Action Report (PBAR): A braking action report resulting from the observations of a pilot of the aircraft's autobraking system's ability to prevent skidding or locking up of the wheels which causes the aircraft to skid (refer to https://www.youtube.com/watch?v=Q8PBHLJfztw).
2. Aircraft Braking Action Report (ABAR): A report given describing a level of braking action using data from the aircraft.

4.4.2 Reliable PBAR. To determine if a braking action report is reliable, consider the type of aircraft making the report and the timeliness of the report. A report recently made by an aircraft similar to the one you are flying is more likely to provide information you can use to accurately predict your aircraft's braking performance.

4.5 "Braking Action Advisories Are in Effect." If runway braking action is reported as less than good, or if weather conditions are conducive to deteriorating braking action, ATIS will include the statement, "Braking action advisories are in effect." When this happens, ATC is required to provide each arriving and departing aircraft with the most recent braking action report for the runway in use. As a pilot, when braking action advisories are in effect, it is your responsibility to ensure that you have the most recent braking action report from ATC. You should also be prepared to provide ATC with a report after landing describing the runway conditions you observed and your aircraft's braking ability.

4.5.1 Braking Action Degraded. When stopping an aircraft, the pilot expects the deceleration of the aircraft to be proportional to the amount of braking applied. When the actual deceleration is less than expected, braking action is degraded. Usually, as brakes are applied, the wheels slow and the friction between the tires and the runway surface causes the aircraft to decelerate. If contaminants such as water, snow, slush, or ice are present on the runway, even if the wheels start to slow down as brakes are applied, the tires may slip along the surface of the runway due to the lack of friction caused by the presence of the contaminant(s). If you notice a deterioration of braking action which is worse than reported, you should report it to ATC to alert other pilots to the condition.

4.5.2 RCAM. The RCAM is the tool that enables airport operators and aircraft pilots to accurately communicate runway conditions. The RCAM ties runway contaminant types and depths to aircraft performance. Pilots need to be familiar with the RCAM in order to make objective braking action reports that are useable to other pilots.

4.6 How to Use the RCAM.

4.6.1 Format. The RCAM braking action codes and definitions are shown in Table 3-2, Pilot/Operator Runway Condition Assessment Matrix (RCAM). Note that the left side of the table, labeled "Assessment Criteria," is for use by airport operators that conduct and report the runway condition of paved runways. Airport operators report RwyCCs as numbers (e.g., 5, 3, 2, etc.). RwyCCs are not reported by pilots. Pilots should use the right side of the table, labeled "Control/Braking Assessment Criteria," to make braking action reports and should use words such as "good," "medium," or "poor." Dry conditions are not normally reported unless other parts of the runway are wet or contaminated.

4.6.2 Aircraft Braking Performance Levels. The matrix is divided into six categories, each representing a range of maximum wheel braking ability. Operator guidance should contain landing performance data for each category that represents the lowest inclusive value of wheel braking for that category. Multiple reports may be provided for each runway, as described below.

4.6.2.1 **Reporting Runway Sections.** RwyCCs are provided for each third of the runway. This is primarily done to provide pilots with situational awareness. Airport operators are tasked with maintaining consistent runway conditions throughout their entire length; however, weather and operational conditions may result in variations.

4.6.2.2 **Control/Braking Assessment Criteria.** The RCAM lists the basic metrics for how vehicle control can be related to braking assessments. This information can be applied to any vehicle used to observe wheel braking.

4.7 **Criteria for Making Observations.** Braking action reports should be based solely on the wheel braking component of the aircraft's deceleration. Pilots need to understand that stopping results do not necessarily correlate to braking action. The effects of aerodynamic forces, while beneficial to stopping performance, should not be considered when making a braking action report. For turbojets, the effect of reverse thrust should not be considered. Likewise, for propeller driven airplanes, the effect of reverse pitch should not be considered.

4.7.1 Considerations. To make an accurate assessment of the airplane's braking performance, whether the braking action report is based on pilot's observations (PBAR) or aircraft data (ABAR), the following questions need to be considered:

1. What was the level of braking performance in relation to the scale in the RCAM? For aircraft with little or no direct instrumentation on wheel braking forces, pilots should determine the level of braking through observation. (See paragraph 4.9 below.) For

aircraft with ABAR systems installed, the system may automatically identify if braking is friction limited and will determine the RCAM level of braking.

2. Was it possible to detect wheel braking during the aircraft's deceleration on the runway? Confirm that wheel braking can be readily distinguished by applying brakes to the point where a change in deceleration can be identified. This change in deceleration should be easily discernable during manual braking by noting the effect of increasing brake application on deceleration. It may also be discernable while using autobrakes if the aircraft manufacturer or operator has developed appropriate procedures for this purpose.
3. Was the runway condition such that the observed braking action could reasonably be expected throughout the entire landing rollout? If you determine that runway conditions are not consistent throughout the entire runway, that information should be indicated in the braking action report.
4. Did the aircraft's braking system reach the point where it was friction limited? Identify when friction-limited braking occurs by observing the point where an increase in brake activation yields no increase in deceleration.

Note 1: In case of landing in non-normal conditions, ABAR/PBAR may not be applicable, since the aircraft may not have its normal braking capability.

Note 2: The primary focus during landing is a safe stop and lateral control.

4.8 Recommended Method for Classifying Pilot Observations. The following information is applicable to PBARs based on the observations made by a pilot without any reference to aircraft data. It utilizes industry best practices to provide observational references for the braking levels listed.

4.8.1 Terminology. Given that autobrake use is an SOP in most large jets, the criteria that can be observed when applying brakes manually, to maximize the usefulness of PBARs, should be the use of the terms "good," "medium," "poor," and "nil." (See Figure 4-1, An Illustration of Good, Medium, and Poor Braking, below.) These terms allow a pilot with little or no flight deck instrumentation on braking to report significant ranges of deceleration performance. The criteria for these reporting terms are described below:

4.8.1.1 **Good.** Describes the level of braking typically seen on a wet runway when aggressive braking can still be achieved, and directional control is not significantly compromised. For this level of deceleration performance, the initiation of friction-limited braking may not be required as aggressive braking can be reasonably inferred.

4.8.1.2 **Medium.** Describes the level of braking typically seen on snow-covered runways. Wheel braking forces can still be differentiated, and their effectiveness controlled, but at a noticeably reduced level. Friction-limited braking is readily identified as the point where brake pedal commands cease to increase deceleration or when anti-skid braking becomes active. Directional control is noticeably reduced.

4.8.1.3 **Poor.** Describes the level of braking typically seen on ice-covered runways or when hydroplaning during heavy rain. Braking and directional control is minimal and an increase in brake application fails to produce any increase in deceleration. Poor braking is considered a hazardous condition, as small errors in aircraft configuration and technique can result in excessive deviations in landing performance.

4.8.1.4 **Nil.** Braking deceleration is minimal to non-existent or directional control is uncertain. A report of nil braking action on a runway requires the closure of that runway for safety reasons. Although closing the runway may be an inconvenience to other pilots, pilots that experience nil braking action should be encouraged to make such reports.

Note: During landing, if you do not observe an indication of friction-limited wheel braking (where an increase of force on the brake pedals does fails to produce an increase of deceleration), the appropriate response to a braking action query is "braking action nil." (See paragraph 4.8.1.4 above.)

4.8.2 Example. With proper training, the criteria listed above can be readily observed by pilots. Consider an airplane that weighs 120,000 lbs. During landing, 100,000 lbs. of that weight will be supported by the main landing gear, which is equipped with wheel brakes, and the remaining 20,000 lbs. will be supported by the nose landing gear, which does not have wheel brakes. In this condition, an accurate mapping of the observed forces could be described in terms of braking action in the following manner:

1. Good: A 120,000 lbs. airplane could experience a wheel braking force on the order of 30,000 lbs. or approximately 0.3 Gs.
2. Medium: A 120,000 lbs. airplane would only experience a braking force on the order of 16,000 lbs., approximately a 47 percent decrease from GOOD braking.
3. Poor: A 120,000 lbs. airplane would experience a wheel braking force on the order of 7,000 lbs.; this is approximately a 57 percent decrease from MEDIUM and approximately 77 percent from GOOD.

Figure 4-1. An Expectation of Good, Medium, and Poor Braking

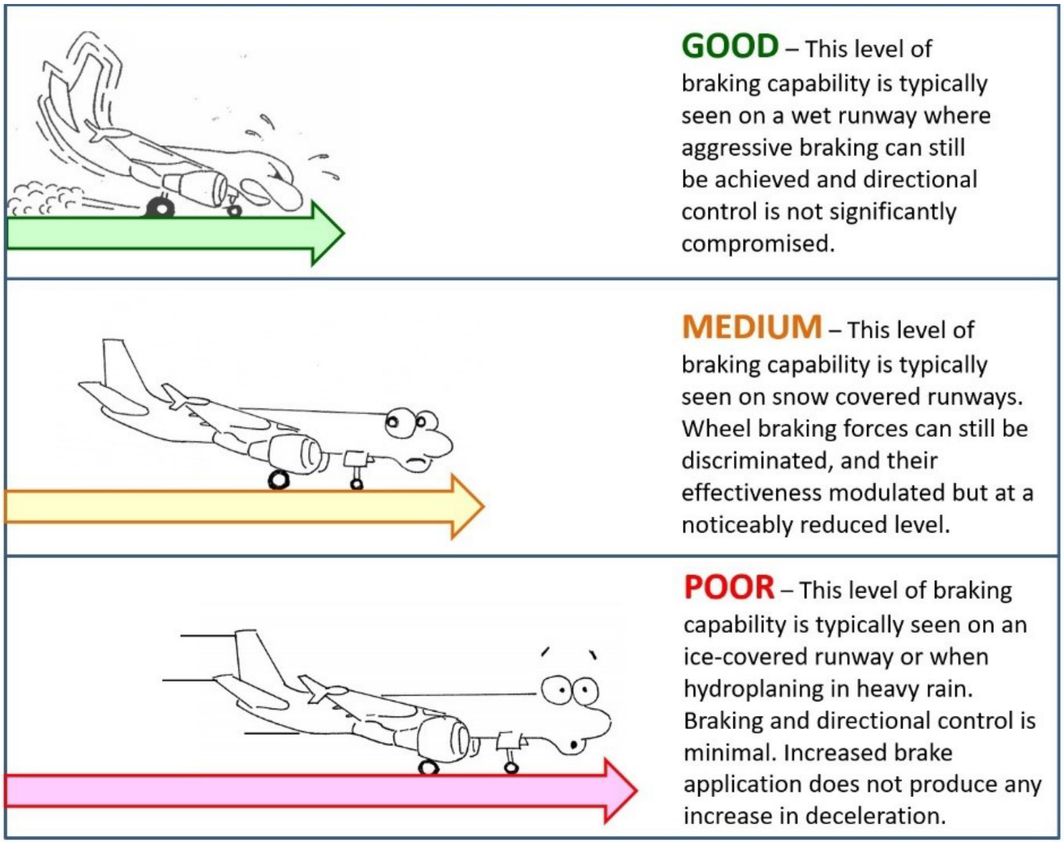


Figure courtesy of Robert Kostecka

4.8.3 Usage. It is recommended that pilots refrain from making reports using the phrases "good to medium" and "medium to poor" unless they have been specifically trained on how to recognize those conditions. In the absence of that training, we encourage pilots to be conservative and report the lowest braking action level observed.

4.9 Pilot or Pilots Reporting Conventions. Both PBAR and ABAR are normally considered valid for the entire runway. Braking action reports may be reported with reference to the applicable third of the runway, although this is not a requirement. Airport operators may also report runway surface conditions by runway thirds.

4.9.1 Examples. The following examples illustrate:

1. Braking action reports applicable to the full runway length:
   - PBAR: "Tower, flight XXX experienced POOR braking."
   - ABAR: "Ground, flight XXX would like to report an ABAR of MEDIUM."

2. Braking action reports applicable to a specific portion of the runway:
   - PBAR: "Tower, flight XXX experienced POOR braking due to standing water at the intersection of runways 33 and 10."
   - ABAR: "Ground, flight XXX would like to report an ABAR of MEDIUM on the last third of the runway just before the turnoff at Juliet."

4.10 Comparison of Braking Action Reports: PBAR vs ABAR.

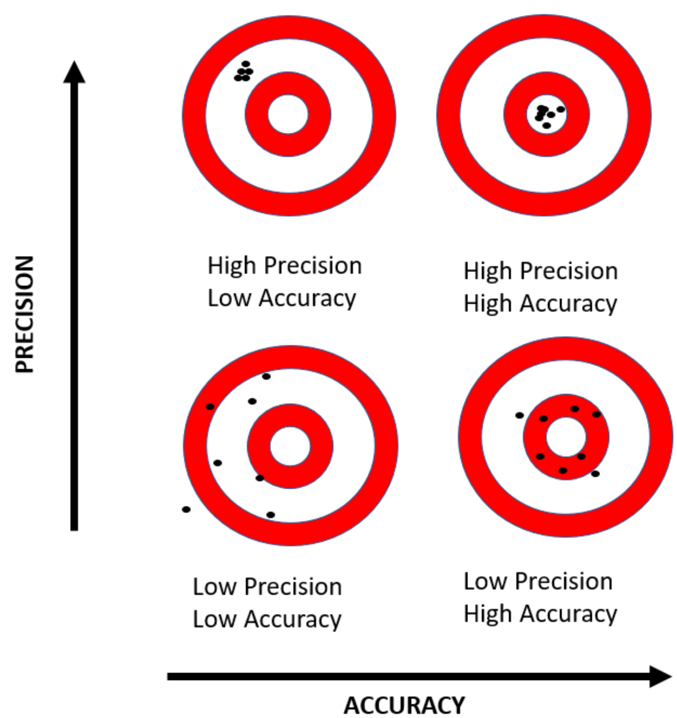
4.10.1 Accuracy and Precision. Braking action reports are of the greatest value when accuracy and precision are maximized.

4.10.1.1 A clear understanding of accuracy and precision is important when comparing the relative advantages and limitations of braking action reports which are based on pilot observations (PBARs) and reports automatically generated by systems using aircraft data (ABARs).

4.10.1.2 With respect to braking action reports, accuracy refers to the degree to which the braking action report correctly correlates to the braking levels in the RCAM. Precision refers to the ability of a braking action report to consistently represent a given value for a given observation.

4.10.1.3 The concepts of precision and accuracy are illustrated in Figure 4-2. Accuracy is represented by how close we are to the bullseye; precision is represented by the closeness of the grouping.

Figure 4-2. Precision and Accuracy



4.10.2 Limitations and Advantages of Braking Action Reporting Methods. Figure 4-3 illustrates how precision and accuracy are affected when braking action reports are made under the described conditions.

Figure 4-3. Comparison of Various Braking Action Reports

 Five Braking Categories Minimum Training	**Braking Action Report** • With little or no guidance and training, current braking action reports can be subject to large variations in accuracy and precision.
 Three Braking Categories Expanded Training	**Pilot Braking Action Report (PBAR)** • With effective training on the elements of braking action and their reporting, the precision of standardized observations and the accuracy of their mapping can be significantly increased. • Harmonizes engineering analysis methods with the braking levels that can be discerned by the pilot.
 ABAR System	**Aircraft Braking Action Report (ABAR)** • ABAR systems provide the highest level of accuracy and precision. • ABAR systems most effectively serve as the basis for continuous improvement in the safety assurance process.

4.10.3 Validate. By providing timely information relevant to all aircraft with similar braking systems, PBARs can be used by pilots to make assessments that affirm or counter the RCAM's predicted level of performance and by airport operators to confirm or downgrade a RwyCC. To achieve these purposes, it is important that the guidance in this AC regarding PBARs (i.e., braking action reports that are accurate and precise) be followed.

4.11 **Recommended Action.** Operators should use the information provided in this AC to review and assess the risks associated with operations on wet and contaminated runways and update or modify their procedures, as appropriate, to mitigate these risks. The information should also be included in operations manuals, SOPs, training programs, and any other established means of conveying safety and operational information within the organization.

CHAPTER 5. RUNWAY OVERRUN HAZARDS

5.1 Background. In addition to being able to predict and assess aircraft performance on a runway, pilots need to understand and account for other hazards that can significantly affect the landing distance required.

5.2 Overrun Hazards. The following hazards have been shown to increase the risk of a runway overrun.

5.2.1 Unstabilized Approach. Deviations in airspeed, altitude, descent rate, glideslope, runway aim point, and localizer control place pilots in a position where recovery to the desired flight path is unlikely. It is the pilot's responsibility to inform ATC when compliance with an instruction will result in an unstabilized approach due to speed or descent rate.

5.2.2 Excess Airspeed. It is critical that the pilot be aware of airspeed during the approach. The recommended approach reference landing airspeed (Vref), plus wind and gust additives, should be maintained until 50 ft over the runway threshold. Excessive approach speed may result in extra speed over the runway threshold and landing beyond the intended touchdown point. In addition to using more runway to touchdown, once the aircraft is on the runway, excessive speed will require more runway to stop, which could lead to a runway overrun. As a rule of thumb, on dry or wet runways, a 10 percent increase in final approach speed results in a 20 percent increase in landing distance. For example, published Vref is 120 knots (kt) with a landing distance of 3,000 ft. If the aircraft crosses the runway threshold at 132 kts, the aircraft will require 3,600 ft to stop.

5.2.3 Excessive Height Over the Runway Threshold. The landing distances provided in the AFM are based on the aircraft being at 50 ft over the runway threshold. For every 10 ft above the standard 50 ft TCH, landing distance will increase 200 ft. For example, if the aircraft crosses the threshold at 100 ft, the required landing distance will increase by 1,000 ft. (Refer to FSF ALAR Briefing Note 8.3, Landing Distances.)

5.2.4 Landing Beyond the Intended Touchdown Point. AFM/POH distances are based on a touchdown point determined through flight testing procedures outlined in AC 23-8, AC 25-7, and AC 25-32. If the airplane does not touch down within the air distance included in the AFM/POH landing distance, it may not be possible to achieve the calculated landing distance.

5.2.5 High Airport Elevation. High airport elevation or high-density altitude results in a higher true airspeed, groundspeed, and a corresponding longer landing distance, compared to a lower airport elevation. Pilots should be aware that the performance penalty for high airport elevation can be significant. The AFM/POH usually includes an adjustment for this factor. (Refer to § 25.125(a).)

5.2.6 Airplane Landing Weight. Any item that affects the landing speed or deceleration rate during landing affects the landing distance, so the gross weight of the aircraft has a significant effect on landing distance. In other words, the required landing distance varies in direct proportion to the gross weight. For example, a 10 percent increase in landing weight results in a 5 percent increase in landing speed and a 10 percent increase in landing distance. (Refer to the Pilot's Handbook of Aeronautical Knowledge (PHAK) for more information.)

5.2.7 Downhill Runway Slope. Runway slope has a direct effect on landing distance. A 1-percent downhill slope increases landing distance by 10 percent (factor of 1.1). This effect is usually only accounted for in performance computations if the downhill runway slope exceeds 2 percent. (Refer to FSF ALAR Briefing Note 8.3.)

5.2.8 Delayed Use of Deceleration Devices/Maximum Braking.

5.2.8.1 For those airplanes so equipped, deceleration devices consist of spoilers/speed brakes, thrust reversers, and brakes. Since wheel brakes are much more effective in slowing the airplane once on the ground than air drag during the airborne part of the landing, pilots should prioritize achieving the intended touchdown point. The sooner the airplane touches down and starts braking, the shorter the total distance will be. Delayed braking action by the flightcrew during the landing rollout has been the causal factor in several accidents and serious incidents. Similarly, improper use of speed brakes, wheel brakes, and reverse thrust have been significant factors in a number of runway excursion landing accidents.

5.2.8.2 Prompt and proper operation of all means of deceleration has a major effect on landing distances. For aircraft with automatic ground spoilers/speed brake deployment but with manual arming, it is of paramount importance that these devices are effectively armed before landing. In addition, once on the ground, deployment should be verified. Spoilers/speed brakes greatly decrease lift, dump the weight on the wheels, and make the brakes effective. It should be noted that manual spoilers/speed brakes operated by the pilot involve a delay. A 2-second delay at speeds of 200 ft/second (118 kts) increases the airplane stopping distance by almost 400 ft. Landing distance data in the AFM is typically based on a 1-second delay between successive actions to manually deploy/engage the deceleration devices. A conservative approach is to add 200 ft to the landing distance for every second in excess of 2 seconds to deploy the airplane's deceleration devices.

5.2.9 Effect of a Tailwind on Landing Distance. The effect of a tailwind on landing distance is significant. Given that the airplane will land at a particular airspeed independent of the wind, the principal effect of a tailwind on landing distance is the change in the groundspeed at which the airplane touches down. The effect of a tailwind increases the landing distance by 21 percent for the first 10 kts of tailwind. (Refer to the PHAK for additional general information and the aircraft's AFM/POH data to specifically determine if tailwind-landing data is available for your airplane.)

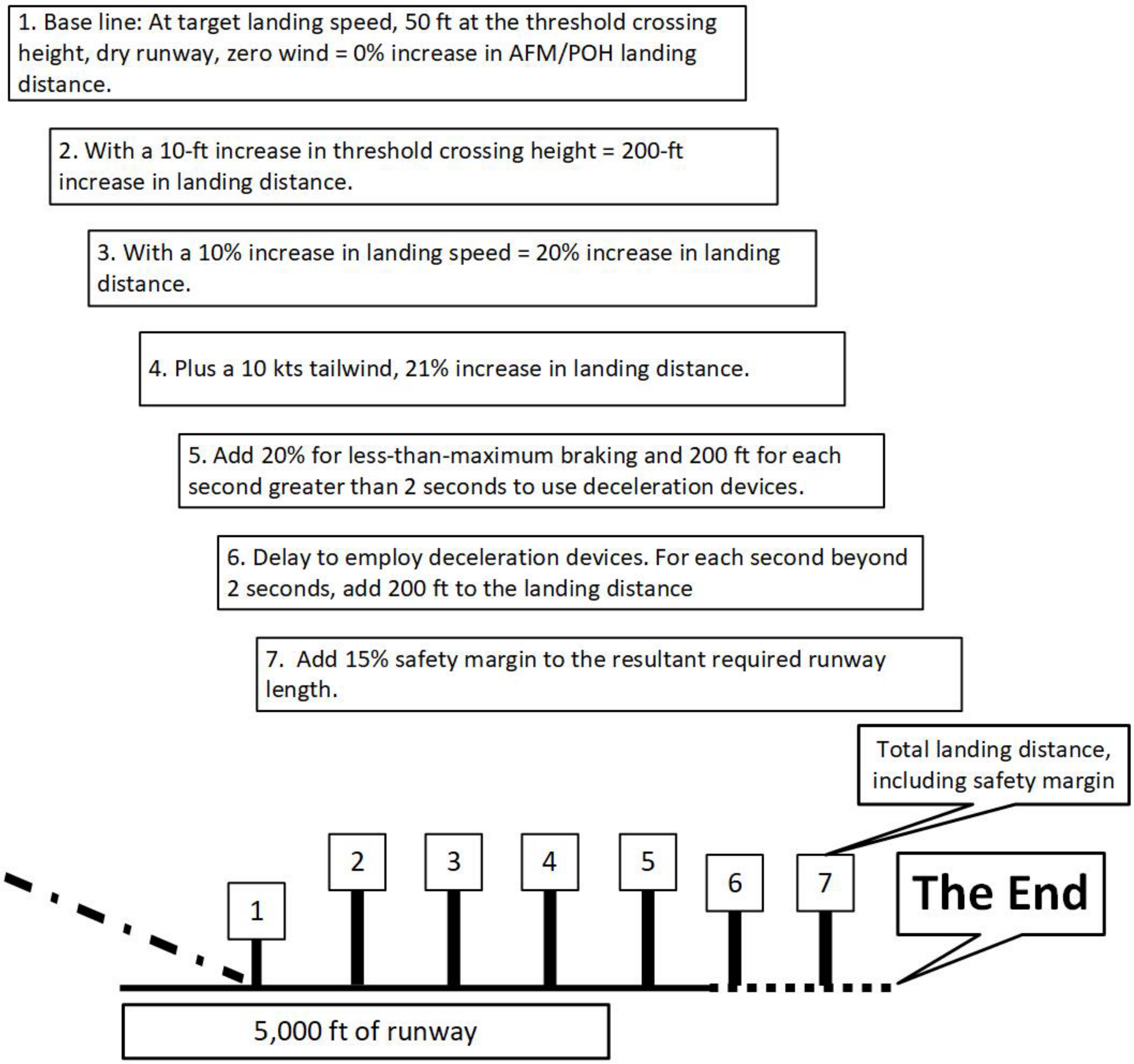
5.2.9.1 Tailwind landings affect all types of airplanes. For transport category airplanes, the effect of tailwind is shown in the AFM landing distance information. For small airplanes, tailwind-landing data may not be provided. The Aircraft Certification Service (AIR) provided the following tailwind performance information for a few small airplanes:

1. Cessna 150 and 152: Note on the landing distance chart, "For operation with tailwinds up to 10 knots, increase distances by 10 percent for each 2 knots."
2. TBM 850: Note under landing distance table to "increase total distances of 30 percent for every 10 knots of tailwind."

5.2.9.2 Tailwind example: Available runway of 5,000 ft, AFM landing distance of 3,000 ft, 50 ft TCH, and at the correct airspeed with a 10 kts tailwind results in an increase in the operational landing distance of 21 percent. This increase equates to an additional 630 ft, which increases the operational landing distance to 3,630 ft.

5.2.10 Cumulative Effect. The LDA can be exceeded when a cumulative effect of the above conditions exists. Pilots need to be aware of this cumulative effect. An example of the compound effects is in Figure 5-1, Effects of Compound Factors, below.

Figure 5-1. Effects of Compound Factors



5.3 Risk Mitigation.

5.3.1 SOPs. Specific SOPs to prevent a runway overrun are a primary risk mitigation tool. Once SOPs are developed, it is imperative that the pilot/flightcrew execute them faithfully to mitigate a runway overrun. At a minimum, the SOPs should contain the factors presented in this AC.

5.3.2 Runway Overrun Mitigation Training Curriculum. An effective training program provides the knowledge and skill to increase the pilot's awareness of the factors that can cause a runway overrun. At a minimum, the operator's training program should include the same elements contained in their SOPs. Also, the go-around maneuver and the reasons to initiate a go-around should be part of the training program. (Refer to SAFO 10005.)

5.3.3 Certificated Air Operator's Flight Checking and Recurrent Training. Checking, testing, and recurrent training that emphasize airplane-landing performance are essential tools to mitigate runway overruns. Pilot examiners, flight and ground instructors, check airmen, and dispatch examiners should specifically stress aeronautical decision-making (ADM), runway overrun risk management, and the elements within this AC as they qualify and train pilots and dispatchers. Instructors and examiners should include runway overrun mitigation strategies during training and checking to ensure the pilot/applicant can apply the principles in a real-world environment.

APPENDIX A. AIRCRAFT BRAKING ACTION REPORT (ABAR) SYSTEMS

A.1 Overview. The information in this appendix is intended for consideration by flight operations management personnel responsible for creating policies and procedures regarding the use of automated systems that generate ABAR. As such, it provides background information for management purposes and is not intended as an operational guide for pilots.

A.2 Design Philosophy. An ABAR system is a report given describing a level of braking action using data from the aircraft. It will reflect to what degree the weight of an aircraft can be transferred to a deceleration force via the wheel brakes when the anti-skid activates during a friction-limited event. An ABAR system can be located either remotely or onboard an aircraft and uses the aircraft's data to produce a standardized indication of wheel braking performance.

A.2.1 ABAR systems are the most accurate and objective means of observing and reporting aircraft braking action. The use of aircraft data to generate an ABAR can mitigate the human errors resulting from inadequate training, inexperience, or cognitive bias that may occur with a Pilot Braking Action Report (PBAR).

A.2.2 The data recorded by the ABAR system during the landing roll is used to:

1. Isolate the mechanical wheel braking forces from all other forces contributing to deceleration, as well as identify when wheel braking is friction limited; and
2. Map those forces in friction-limited conditions to the scale used to make braking action reports.

A.2.3 ABAR systems may come from different vendors and apply to different aircraft. A means of assuring that all systems operate within minimum, industry-based engineering standards, is through demonstrated compliance with ASTM E3266, Standard Guide for Friction-Limited Aircraft Braking Measurements and Reporting. Compliance ensures a minimum degree of confidence in all ABAR systems and facilitates a harmonized communication of wheel braking capability between aircraft with similar performance characteristics. (Refer to Advisory Circular (AC) 25-32, Landing Performance Data for Time-of-Arrival Landing Performance Assessments.)

A.2.4 Aircraft systems may also transmit data that is not visible to the flightcrew. Data not visible to the pilot is not considered part of the ABAR, and may be utilized for other data analysis purposes.

A.3 Aircraft Considerations.

A.3.1 ABAR generating systems are considered applicable to a wide range of aircraft types and manufacturers whose design allows for such an analysis.

A.3.2 ABAR systems installed on aircraft may require appropriate supplemental type certification approval.

A.3.3 ABAR generating systems are designed to be used on aircraft that utilize landing performance data derived in accordance with AC 25-32; International Civil Aviation Organization (ICAO) Doc 10064, Aeroplane Performance Manual; or other equivalent standards.

A.4 Acceptance Criteria for ABAR Systems.

A.4.1 ABAR systems are not required for certification of transport category aircraft and their intended function is not a regulatory requirement.

A.4.2 Operators who utilize ABAR related technology to transmit information with the label "ABAR," should only do so if it can be determined that the system meets its intended function and complies with a minimum engineering standard published for such a system. Entities seeking such a determination for an ABAR producing system should contact their designated FAA representative for guidance.

A.4.3 ASTM E3266 provides a suitable acceptance criterion for operators wishing to transmit information from an ABAR system.

A.5 Confidence of Reports.

A.5.1 ABAR generating systems may rely on aircraft data that is inferred from other sources to calculate the required values. Because these systems may not rely on sensors taking direct measurements of certain values, these systems cannot be calibrated in a manner similar to other flight deck indicators. Therefore, while the ASTM standard sets minimum levels of accuracy and precision for these systems, it should be recognized that there exists a statistical difference between what a system calculates and what a theoretical "real" value could be. For that reason, these systems are described as having a "confidence factor."

A.5.2 ABAR generating system standards require the systems to demonstrate a confidence factor of 95 percent that the system will fall within one level of braking on the Runway Condition Assessment Matrix (RCAM) five level scale (i.e., good, good to medium, medium, medium to poor, and poor.)

A.6 Development of Operational Guidelines. Operators who utilize an ABAR system to provide and/or use such reports should develop operational guidelines and flightcrew training. This should include submitting Pilot Reports (PIREP) based on ABAR information after landing as well as the use of ABAR reports during TOA assessments. ABAR systems whose intended function entails timely recognition from the flightcrew should comply with AC 25.1322-1, Flightcrew Alerting.

Note: Pilots and operators need to understand that an ABAR is a decision support tool rather than a decision-making tool. Pilots should use an ABAR as one piece of information along with the current weather, runway surface conditions, and other factors to make the decision as to whether or not it is safe to land.

A.6.1 The following guidelines are considered acceptable for the operational use of information provided by ABAR systems:

1. When an ABAR confirms the accuracy of the Runway Condition Code (RwyCC) (i.e., both values are the same), the time of arrival (TOA) landing distance assessment should be based on this confirmed value; and
2. When an ABAR and the reported RwyCC disagree (i.e., one value indicates worse runway conditions than the other), the TOA landing distance assessment should be based on the worse (most conservative) report.

Advisory Circular Feedback Form

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 contacting the Air Transportation Division at 9-AFS-200-Correspondence@faa.gov, the General Aviation and Commercial Division at 9-AFS-800-Correspondence@faa.gov, or the Flight Standards Directives Management Officer at 9-AWA-AFB-120-Directives@faa.gov.

Subject: AC 91-79B, Aircraft Landing Performance and Runway Excursion Mitigation

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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☐ Other comments:

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☐ I would like to discuss the above. Please contact me.

Submitted by: ________________________________ Date: ______________________