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International Regulations Redefine V1

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Flight Safety Foundation (FSF) is an international membership organization dedicated to the continuous improvement of flight safety. Nonprofit and independent, FSF was launched in 1945 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 690 member organizations in 77 countries.

International Regulations Redefine V1

Recent revisions of the U.S. Federal Aviation Regulations and the European Joint Aviation Requirements redefine V1 as the maximum airspeed at which a flight crew must take the first action to safely reject a takeoff. Other revisions change the method of compensating for the time required by pilots to take action to reject a takeoff; require accelerate-stop data based on airplanes with fully worn brakes; and require wet-runway takeoff-performance data in airplane flight manuals.

FSF Editorial Staff

In February 1998, the U.S. Federal Aviation Administration (FAA) adopted new regulations that redefine V_1 and revise some of the takeoff-performance certification standards for transport-category airplanes.

FAA said that the changes to the U.S. Federal Aviation Regulations (FARs) are similar to changes to European Joint Aviation Requirements (JARs) that will be published soon by the Joint Aviation Authorities (JAA), which represents 29 European countries.

FAA said that previous definitions of V_1 might have caused confusion because they did not make clear that V_1 is the maximum speed at which the flight crew must take the first action to reject a takeoff.[1] The U.S. National Transportation Safety Board (NTSB) said, in a 1990 study, that late initiation of rejected takeoffs (RTOs) was the leading cause of runway-overrun accidents.[2]

FARs Part 1 now provides the following definitions of V_1:

- "V_1 means the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance; [and,]
- "V_1 also means the minimum speed in the takeoff, following a failure of the critical engine at V_{EF}, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance."

Part 1 defines critical engine as "the engine whose failure would most adversely affect the performance or handling qualities of an aircraft." Part 1 defines V_{EF} as "the speed at which the critical engine is assumed to fail during takeoff."

The new FARs Part 25 transport-category-airplane certification standards also include the following:

- A different method for adjusting accelerate-stop distances to compensate for time used by pilots in taking action to reject a takeoff (the new method results in shorter accelerate-stop distances than a method that was adopted by FAA in 1978);
- Methods for compensating for the effects of worn brakes in accelerate-stop performance; and,
- Methods for developing accelerate-stop and accelerate-go performance data for wet runways.

FAA said that the new certification standards regarding pilot reaction time will reduce the runway length needed for takeoff by an average of 150 feet (46 meters); the worn-brakes requirement will add an average of 150 feet; and the wet-runway requirement will add an average of 220 feet (67 meters).

"These estimates are average effects that can vary considerably, depending on the airplane type and the specific takeoff conditions," said FAA. "For example, airplanes equipped with carbon brakes or certain heavy-steel brakes usually will be unaffected by the worn-brake requirements because these brakes provide the same stopping capability in the worn condition as [in] the new condition."

The new U.S. regulations are not retroactive. The changes to Part 25 have not been made retroactive through changes to the general operating regulations in Part 91, the air-carrier operating regulations in Part 121, and the on-demand and commuter-airline operating regulations in Part 135.

The JARs 25 wet-runway takeoff-performance standards will be made retroactive through changes to the JARs operating regulations.

The new Part 25 standards apply only to airplanes for which type-certification application was made after the standards became effective on March 20, 1998. The new standards will not be required for certification of derivatives of airplanes that already have received FAA type certification.

FAA said that some pilots and the airworthiness authorities in Canada and the Netherlands have expressed opposition to FAA's unwillingness to make the new standards retroactive. "JAA strongly supports the [new standards], but also believes that these requirements should be imposed retroactively," said FAA. "The association representing European [aircraft] manufacturers supports applying the [new] standards to new derivatives of existing approved designs as well as to completely new airplane designs."

FAA said, "Considering the safety benefits and available economic-impact information, FAA could not support a recommendation to make the standards … retroactive to either airplanes currently in use or future production airplanes of designs that have already been type certificated. This conclusion was reached after a review of the estimated costs and the potential benefits that would result from applying the [new] standards retroactively."

Another difference between the new U.S. takeoff-performance standards and the pending revisions to the European standards is that FAA has deferred action on revising Part 25 to compensate for the distance used in aligning an airplane for takeoff on the runway. The JARs 25 standards will compensate for runway-alignment distance.

"Due to the controversial nature of the issues of retroactivity and runway-alignment distance, FAA has decided to: (1) proceed with the proposed rules without requiring retroactive application of these standards or adding a new requirement concerning runway-alignment distance, and (2) recommend that the issues of retroactive application of these standards and runway-alignment distance be added to the FAA/JAA harmonization work program," said FAA. "The harmonization work program is the formal method developed by FAA and JAA to harmonize relations and policies."

Although the new Part 25 takeoff-performance standards are not retroactive, some manufacturers have complied voluntarily with the new standards during certification of derivatives of airplanes that were type certificated under the previous standards, said Donald K. Stimson, acting manager of the Flightcrew Interface Branch of the FAA Transport Airplane Directorate.

Stimson said that examples of airplanes that have been certificated to standards equivalent to those in the revised Part 25 include the Airbus A319, A321, A330 and A340; and the Boeing 737-600, 737-700 and 737-800.[3]

V1 concept is critical to takeoff planning. The FARs require the flight crew of a transport-category airplane to ensure that the runway intended for use (including any clearway or stopway off the end of the runway) is long enough to allow the takeoff to be safely continued or rejected from a predetermined go/no-go point on the runway. The go/no-go point is where the airplane reaches V_1 while accelerating for takeoff (Figure 1, page 3).

"To assure that the takeoff can be safely continued from the go/no-go point, the length of the runway plus any clearway must be long enough for the airplane to reach a height of 35 feet (10.6 meters) by the end of that distance, even if a total loss of power from the most critical engine occurs just before reaching the V_1 speed," said FAA. "This distance is known as the accelerate-go distance.

"If the pilot finds it necessary to reject the takeoff, the runway plus any stopway must be long enough for the airplane to be accelerated to the V_1 speed and then brought to a complete stop. This distance is known as the accelerate-stop distance."

The accelerate-go distance and the accelerate-stop distance vary according to the airspeed designated as V_1 by the manufacturer for certification flight tests. "A lower V_1 speed, corresponding to an engine failure early in the takeoff roll, increases the accelerate-go distance and decreases the accelerate-stop distance," said FAA. "Conversely, a higher V_1 speed decreases the accelerate-go distance and increases the accelerate-stop distance."

Typically, the manufacturer designates V_1 airspeeds that result in equal accelerate-go distances and accelerate-stop distances. When the accelerate-go distance and the accelerate-stop distance are equal, the distance is called the balanced field length. "In general, the balanced field length represents the minimum runway length that can be used for takeoff," said FAA.

The manufacturer is required to designate V_1 speeds and airplane takeoff configuration, and compile takeoff-performance data for the full range of weight, altitude and temperature conditions in which the airplane is expected to operate. The data must be developed according to runway and

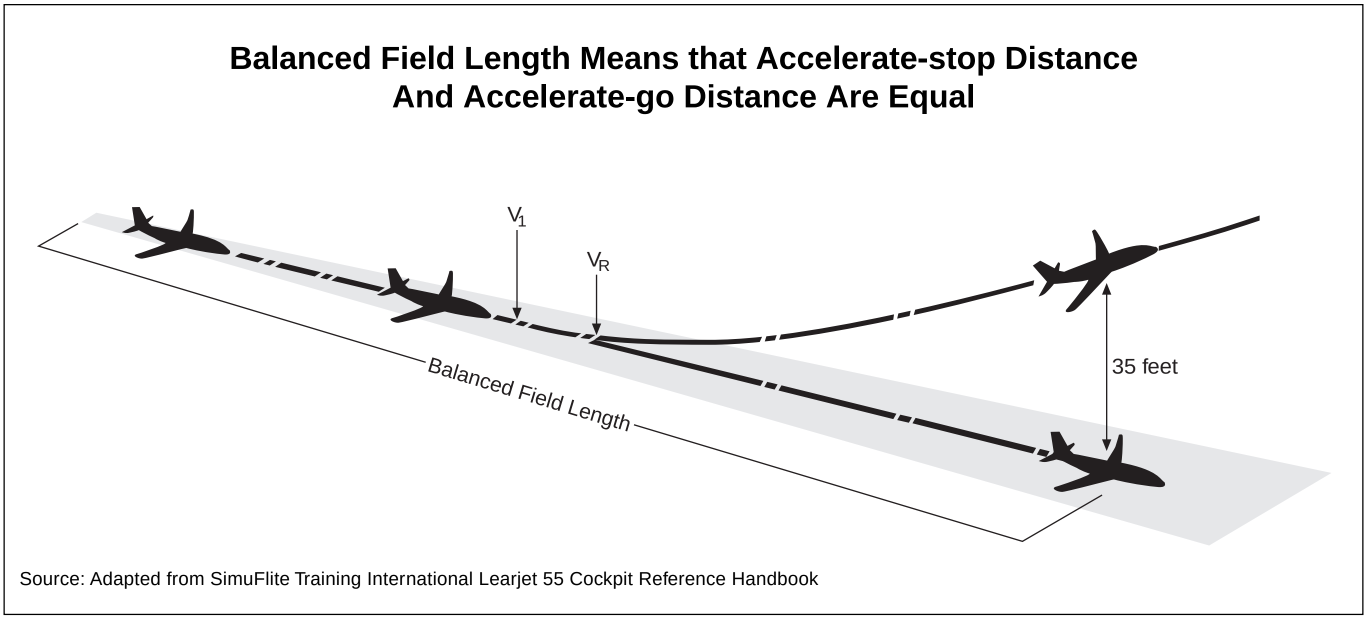


Figure 1

wind factors specified in Part 25. The data then are published in the airplane flight manual (AFM).

The flight crew is required to use a V_1 speed from the AFM that results in accelerate-go and accelerate-stop distances, or a balanced field length, appropriate for the airplane's takeoff weight, the airplane's takeoff configuration, the runway length, the runway gradient, the surface wind conditions, the air temperature, and the runway (airport) elevation.

Based on the takeoff-performance data in the AFM, the flight crew or airline dispatch personnel may have to make adjustments such as reducing fuel, passenger and/or cargo loads to reduce the airplane's gross weight; selecting a more suitable runway; or rescheduling the departure for a time of day when the air temperature will be more favorable for a safe takeoff.

After the appropriate calculations and adjustments are made by the flight crew or airline dispatch personnel, the selected V_1 speed theoretically establishes a go/no-go point from which the takeoff either can be safely completed, even if the airplane loses power from the critical engine just before reaching V_1, or rejected and the airplane can be brought safely to a halt on the remaining runway and/or stopway.

Inconsistent terminology has caused confusion about the V1 concept. An important assumption in the V_1 concept today is that the *decision* to continue the takeoff or reject the takeoff is made *before* reaching V_1. The accelerate-stop performance data in AFMs are based on the pilot flying *taking the first action* to reject the takeoff *at* V_1.

[For airplane-certification purposes, the actions required to reject a takeoff include applying the wheel brakes, reducing thrust, and deploying the speed brakes or spoilers. The manufacturer establishes the order in which these actions are taken.]

Previous definitions of V_1 did not state clearly that V_1 is the maximum speed at which the pilot flying must take the first action to reject the takeoff. "[There is] a great deal of misunderstanding and disagreement regarding the definition and use of the V_1 speed," said FAA. "In general, inconsistent terminology used over the years in reference to V_1 has probably contributed to this confusion."

Before 1978, Part 1 defined V_1 as the critical-engine failure speed. In 1978, the definition of V_1 was changed to takeoff decision speed, and V_{EF} was established as the critical-engine failure speed. V_1 also is referred to as the engine failure recognition speed in the FAA *Flight Test Guide for Certification of Transport Category Airplanes* (Advisory Circular 25-7). FAA currently is revising the circular.

FAA's 1998 redefinition of V_1 responded to a 1990 recommendation by NTSB based on a study of accidents that occurred during high-speed rejected takeoffs.[2]

In its report on the study, NTSB said, "Runway overruns following high-speed [RTOs] have resulted and continue to result in airplane incidents and accidents. Although most RTOs are initiated at low speeds (below 100 knots) and are executed without incident, the potential for an accident or an incident following a high-speed (at or above 100 knots) RTO remains high." (Table 1, pages 4–5, shows RTO accidents and incidents in 1997.)

NTSB provided the following examples from 45 RTO runway-overrun accidents that occurred worldwide from 1962

(continued page 6)

Table 1
Transport-category Airplane Accidents and Incidents During Rejected Takeoffs, 1997

Date	Location	Aircraft Type	Operator	Aircraft Damage	Injuries	Description
Jan. 10	Jeddah, Saudi Arabia	Airbus A300-B4-200	Air Afrique	substantial	none	The airplane ran off the end of the runway during the rejected takeoff. The landing gear and engines were damaged.
Jan. 10	Bangor, Maine, U.S.	Beech 1900D	Mesa Airlines	substantial	2 minor	The captain commanded an abort because the stall warning horn sounded during rotation and lift-off. The first officer, the pilot flying, rejected the takeoff and landed the airplane. The nose landing gear collapsed when the airplane struck a snowbank on the runway. The U.S. National Transportation Safety Board said that the stall warning was false.
Jan. 19	Aspen, Colorado, U.S.	Learjet 36A	NA	none	none	The nose-gear steering system malfunctioned during the takeoff roll. The airplane exited the runway onto snow-covered terrain during the rejected takeoff. The steering failure was caused by a hydraulic leak.
Feb. 19	Denver, Colorado, U.S.	Boeing 737-291	United Airlines	none	none	A tire on the right main landing gear burst during the takeoff roll. A brake fire occurred during the rejected takeoff. The occupants evacuated the airplane on the runway.
Feb. 22	Austin, Texas, U.S.	Beech Super King Air 300	NA	minor	none	The airplane yawed during the takeoff and then veered off the runway during the rejected takeoff. The nose landing gear collapsed, and the propellers were bent.
March 9	Albuquerque, New Mexico, U.S.	Boeing 737-522	United Airlines	none	none	The flight crew rejected the takeoff because a thrust-reverser indicator light illuminated. Investigation disclosed an open battery fuse.
March 10	Abu Dhabi, United Arab Emirates	Airbus A320	Gulf Air	substantial	1 serious; 3 minor	The takeoff was rejected close to V_1 when directional control was not maintained in a strong crosswind. The airplane veered off the runway and struck an embankment. The nose landing gear was forced into the cockpit on impact and seriously injured the captain.
March 11	Portland, Oregon, U.S.	McDonnell Douglas DC-8-71F	American International	none	none	The elevator did not respond to flight-control input when the pilot flying attempted to rotate the airplane for takeoff. The flight crew rejected the takeoff and taxied the airplane back to the ramp.
March 15	Kansas City, Missouri, U.S.	Boeing 727-223	American Airlines	none	none	The nose landing gear began to vibrate during the takeoff roll. The flight crew rejected the takeoff and returned to the gate. Investigation disclosed that both tires on the nose landing gear were worn.
April 1	Tshikapa, Zaire	Convair 580	Compagnie Africaine d'Aviation	destroyed	none	The pilot heard an unusual noise and perceived that the airplane was not accelerating normally during takeoff. The pilot believed that an engine problem had occurred and rejected the takeoff. The airplane ran off the end of the 3,300-foot (1,000-meter) runway and struck an embankment. The runway has a substantial slope. Although takeoffs normally are conducted down-slope, the takeoff in the accident airplane was conducted up-slope.
April 4	Griffin, Georgia, U.S.	Douglas C-54A	Customair	destroyed	2 fatal	The airplane was taking off at 0016 for a positioning flight to pick up cargo in Americus, Georgia. The no. 1 engine failed when the airplane was about three-quarters of the way down the 3,700-foot (1,121-meter) runway. Tire skid marks indicated that braking was begun about 800 feet (242 meters) from the end of the runway. The airplane struck a building about 1,500 feet (455 meters) from the end of the runway. The pilots were killed.
April 4	Las Vegas, Nevada, U.S.	McDonnell Douglas DC-9-82	Continental Airlines	minor	none	A loud bang occurred on takeoff, and the airplane began to veer right. The tires on the left-main landing gear ruptured during the rejected takeoff.
April 11	Banjarmasin, Indonesia	Boeing 737-200	Sempati Air	substantial	none	The crew rejected the takeoff from Banjarmasin Airport at about 80 knots when they heard loud bangs being emitted by an engine. The airplane veered off the runway because of a suspected failure of the brakes on the right main landing gear. The landing gear and the no. 1 engine were damaged when the airplane struck a ditch.
May 16	Cleveland, Ohio, U.S.	Boeing 737	US Airways	none	none	The first officer's airspeed indicator failed during the takeoff. The flight crew rejected the takeoff and taxied back to the gate.
May 18	Kansas City, Missouri, U.S.	Beech 1900D	Air Midwest	none	none	The flight crew rejected the takeoff because of a low engine-torque indication. Investigation disclosed that the torque indicator had malfunctioned.
June 5	Kansas City, Missouri, U.S.	Boeing 727-232	Delta Air Lines	none	none	The flight crew rejected the takeoff after a compressor stall occurred in the no. 1 engine. Investigation disclosed that the compressor stall was caused by an accumulation of moisture and ice in the engine drains.

Table 1
Transport-category Airplane Accidents and Incidents During Rejected Takeoffs, 1997 *(continued)*

Date	Location	Aircraft Type	Operator	Aircraft Damage	Injuries
June 25	Bogota, Colombia	Boeing 727-100	NA	NA	NA
The airplane ran off the end of the runway during the rejected takeoff.					
July 3	Rio de Janeiro, Brazil	Cessna Citation I	Riana Taxi Aereo	destroyed	none
The airplane was taking off at 1000 from Santos Dumont Airport for an air-taxi flight to Sao Jose dos Campos, Brazil. The pilot flying had difficulty rotating the airplane and rejected the takeoff. The airplane ran off the end of the runway and slid into Guanabara Bay.					
July 17	Birmingham, Alabama, U.S.	Boeing 737-200	United Airlines	none	none
A popping noise occurred on takeoff and the airplane began to swerve right. Birds had been ingested in the no. 2 engine. The tires overheated and deflated during the rejected takeoff.					
July 20	Dalian, China	McDonnell Douglas MD-82	China Northern Airlines	substantial	none
The pilot said that the autothrottle system disengaged and he elected to reject the takeoff near V_1. The pilot then saw that the airplane would run off the end of the wet, 10,890-foot (3,300-meter) runway, so he turned left toward a taxiway. The airplane skidded sideways off the end of the runway, collapsing the landing gear, and came to rest on its fuselage 561 feet (170 meters) from the end of the runway.					
Aug. 3	Douala, Cameroon	Boeing 737-200C	Air Afrique	destroyed	none
The flight crew rejected the takeoff after hearing a loud bang at about 110 knots. The noise was suspected to have been caused by fragments of tread shed by a tire. The airplane came to a stop 429 feet (130 meters) off the end of the 9,405-foot (2,850-meter) runway. The airplane was destroyed by a postaccident fire.					
Aug. 21	Minneapolis, Minnesota, U.S.	Airbus A320-211	Northwest Airlines	none	none
The flight crew rejected the takeoff when the no. 2 engine failed. Preliminary investigation disclosed metal in the engine's tail pipe.					
Sept. 6	Najran, Saudi Arabia	Boeing 737-200	Saudi Arabian Airlines	destroyed	none
The captain rejected the takeoff below V_1 because of indications of an engine problem. The no. 2 engine remained at high power and did not respond to power-lever movement. The airplane ran off the side of the runway into soft sand and ground-looped. The landing gear collapsed, and the airplane burned.					
Oct. 7	Cleveland, Ohio, U.S.	Boeing 757-224	Continental Airlines	none	none
The flight crew rejected the takeoff when they discovered that the airplane was on the wrong runway.					
Oct. 19	Cleveland, Ohio, U.S.	Boeing 737-300	Continental Airlines	none	none
The flight crew rejected the takeoff when another aircraft entered the active runway without clearance.					
Oct. 24	Portland, Maine, U.S.	Learjet 24B	Air Ambulance Care Flight	minor	none
The tires on the right-main landing gear burst during the takeoff roll. The airplane veered off the runway during the rejected takeoff.					
Nov. 21	Syracuse, New York, U.S.	McDonnell Douglas DC-9-15F	Kitty Hawk Aircargo	substantial	none
The flight crew rejected the takeoff when the anchors securing empty cargo pallets broke. The cargo pallets struck and substantially damaged the aft bulkhead and engine spars.					
Nov. 29	Island Lake, Manitoba, Canada	Beech 1900D	Ministic Air	minor	none
The flight crew rejected the takeoff when the stall-warning system activated on rotation. The airplane ran off the end of the 4,000-foot (1,212-meter) runway and struck a snowbank.					
Dec. 1	El Paso, Texas, U.S.	Swearingen SA-227	Servicios Aereos Litoral	minor	none
The flight crew rejected the takeoff when the tires on the left-main landing gear burst. Debris from the burst tires damaged the left engine, the left propeller and the fuselage skin.					
Dec. 1	Kansas City, Missouri, U.S.	Boeing 737-201	NA	none	none
The flight crew rejected the takeoff because of a high oil-pressure indication in the no. 1 engine. Investigation disclosed that the oil-pressure relief valve was jammed.					
Dec. 17	Johannesburg, South Africa	Ilyushin Il-18	Ramaer	destroyed	none
The pilot rejected the takeoff because the airplane would not rotate at V_R. The airplane ran off the end of the 14,580-foot (4,418-meter) runway, and the left main landing gear collapsed.					

NA = Not available. V_1 = Takeoff decision speed (as defined in 1997). V_R = Rotation speed.

Sources: Air Data Research, 13438 Bandera Road, Suite 106, Helotes, Texas 78023 U.S.; Airclaims Ltd. Information, Cardinal Point, Newall Road, Heathrow Airport, London TW6 2AS England; Boeing Commercial Airplane Group, P.O. Box 3707, Seattle, Washington 98124 U.S.; Flight International, Quadrant House, The Quadrant, Sutton, Surrey SM2 SAS England; Robert E. Breiling Associates Inc., Suite 4, 6020 N. Federal Highway, Boca Raton, Florida 33487 U.S.; and U.S. National Transportation Safety Board, Public Inquiries Section, 490 L'Enfant Plaza S.W., Washington, D.C. 20594 U.S. This information may not be complete or accurate.

through 1987 (For a discussion of events that have caused some recent RTO incidents, see "Flight Crew Reports Provide Details on Causes and Results of Rejected Takeoffs," page 11):

- In September 1989, the crew of a USAir Boeing 737 initiated an RTO at or slightly higher than V_1 during a takeoff from La Guardia Airport in Flushing, New York, U.S. The airplane was destroyed, and two passengers were killed.

  "The safety board's investigation, which is continuing, has revealed that at least some of the required call-outs were not made during the RTO," said NTSB. [The board later determined that because of a mistrimmed rudder, the airplane drifted to the left during takeoff, and the captain used nose-wheel steering to correct the drift. The RTO was initiated at an airspeed five knots higher than V_1 because of vibration and unusual noise caused by the displaced nose wheel.[4]]

- In June 1989, the captain of a Delta Airlines Lockheed L-1011 initiated an RTO just beyond V_2 after hearing loud noises from the no. 3 engine during takeoff from Frankfurt, Germany.

  "No injuries resulted, but the airplane's brake and wheel assemblies were extensively damaged," said NTSB. "The investigation has revealed that [an engine-inspection-port] plug came loose, causing engine damage and an estimated 20 percent loss of thrust. The [CVR] indicates that the crew was aware that there were no instrument indications of engine failure or engine fire. Contrary to Delta procedures, no call-out was made to indicate the nature of the event, and no call-out was made to indicate that the captain was initiating an RTO."

- In September 1988, the captain of an Eastern Air Lines Boeing 757 initiated an RTO after hearing an unusual sound at or just after V_1 during a takeoff from San Jose, Costa Rica. The airplane was substantially damaged, and seven passengers sustained minor injuries.

  "The captain assumed that the noise resulted from a tire failure and initiated the RTO after rotation had begun," said NTSB. "The cockpit voice recorder [CVR] indicates that there was no discussion of or commands regarding initiation of the RTO."

- In July 1988, the crew of an Air France Boeing 747 initiated an RTO after a fire-warning horn for the no. 4 engine sounded at V_1 or an airspeed slightly higher than V_1 during a takeoff from Delhi, India. The airplane was destroyed when it struck a ditch beyond the end of the runway; one passenger sustained minor injuries.

  "The crew's reduction of power occurred as the airplane reached 167 knots; V_1 was 156 knots," said NTSB.

- In May 1988, the captain of an American Airlines McDonnell Douglas DC-10 rejected a takeoff from Dallas-Fort Worth (Texas, U.S.) International Airport as the airplane reached V_1 because the takeoff-warning horn had sounded and the slat-disagree warning light had illuminated. The airplane was destroyed when it traveled off the end of the runway, and two occupants were seriously injured. NTSB said that the takeoff warning and slat-disagree warning were false.

  "The crew was unable to bring the airplane to a stop on the runway," said NTSB. "Although the brakes were within FAA-approved wear limits, they were not capable of stopping the airplane on the runway."

- In September 1982, the crew of a Spantax McDonnell Douglas DC-10 initiated an RTO because of severe vibrations during rotation on takeoff from Malaga, Spain. The airplane was destroyed, and 50 occupants were killed.

  "The vibrations were determined to have been caused by a failure of the nose-gear tire," said NTSB.

- In March 1978, the crew of a Continental Airlines McDonnell Douglas DC-10 initiated an RTO three knots above V_1 after hearing loud noises on takeoff from Los Angeles (California, U.S.) International Airport. The airplane was destroyed, two passengers were killed, and 31 occupants were seriously injured.

  NTSB said that the loud noises were caused by a tire failure.

- In November 1976, the crew of a Texas International McDonnell Douglas DC-9 initiated an RTO because of a stall warning (stick-shaker activation) two seconds after the airplane reached V_2 (takeoff safety speed) during a departure from Denver, Colorado, U.S. The airplane was destroyed, and two passengers were seriously injured.

  "The investigation determined that the stall warning was false," said NTSB.

- In September 1972, the crew of a Trans World Airlines Boeing 707 initiated an RTO after reaching V_1 at San Francisco, California, U.S., because of severe vibrations. The airplane was destroyed; the crew, alone aboard the airplane, survived the accident.

  "[The] vibrations were later determined to have been caused by a failure of [a] main gear tire," said NTSB.

- In August 1972, the crew of a Jugoslovenski Aerotransport Boeing 707 initiated an RTO three seconds after reaching V_1 at John F. Kennedy

> International Airport in New York, New York, U.S., because the first officer's window had opened partially. The airplane was destroyed and 15 people were injured.
>
> "Had the crew continued the takeoff, the first officer, because of the subsequent airplane pressurization, might have been able to close the window in flight," said NTSB.

NTSB said that in each example, the RTO should not have been initiated. "The airplanes should have been able to continue the takeoff without incident," said NTSB.

NTSB said that a study by The Boeing Co. concluded that late initiation of an RTO was the leading cause of runway-overrun accidents from 1959 through 1988. "Many of the RTOs were initiated after V_1," said the board. "Boeing concluded that over half the RTO cases examined did not warrant RTOs."

As a result of the 1990 special investigation, NTSB recommended that FAA:

- "Redefine V_1 … to clearly convey that it is the takeoff commitment speed and the maximum speed at which rejected-takeoff action can be initiated to stop the airplane within the accelerate-stop distance."

FAA said that the new definition of V_1 states clearly that the decision to reject the takeoff must be made no later than V_1. "Typically, the pilot not flying the airplane will call out V_1 as the airplane accelerates through this speed," said FAA. "If the pilot flying the airplane has not taken action to stop the airplane before this call-out is made, the takeoff should be continued unless the airplane is unsafe to fly."

Adjustment of accelerate-stop performance data to compensate for pilot reaction time has been changed. Test pilots involved in demonstrating accelerate-stop performance and developing data during certification flight tests fully expect to conduct RTOs. FAA said that in actual transport-category-airplane operations, the events that cause RTOs are relatively rare, and pilots do not expect these events.

In its 1990 report, NTSB said, "Based on an analysis of its data for transport-category aircraft, Boeing projected one RTO in every 3,000 takeoffs and one high-speed RTO in every 150,000 takeoffs."[2] (A chart from the NTSB report of events causing RTO accidents and incidents is shown in Figure 2. A chart by Boeing of events that have caused recent takeoff accidents is shown in Figure 3, page 8).

Part 25 requires adjustments of accelerate-stop performance data obtained during certification flight tests to compensate

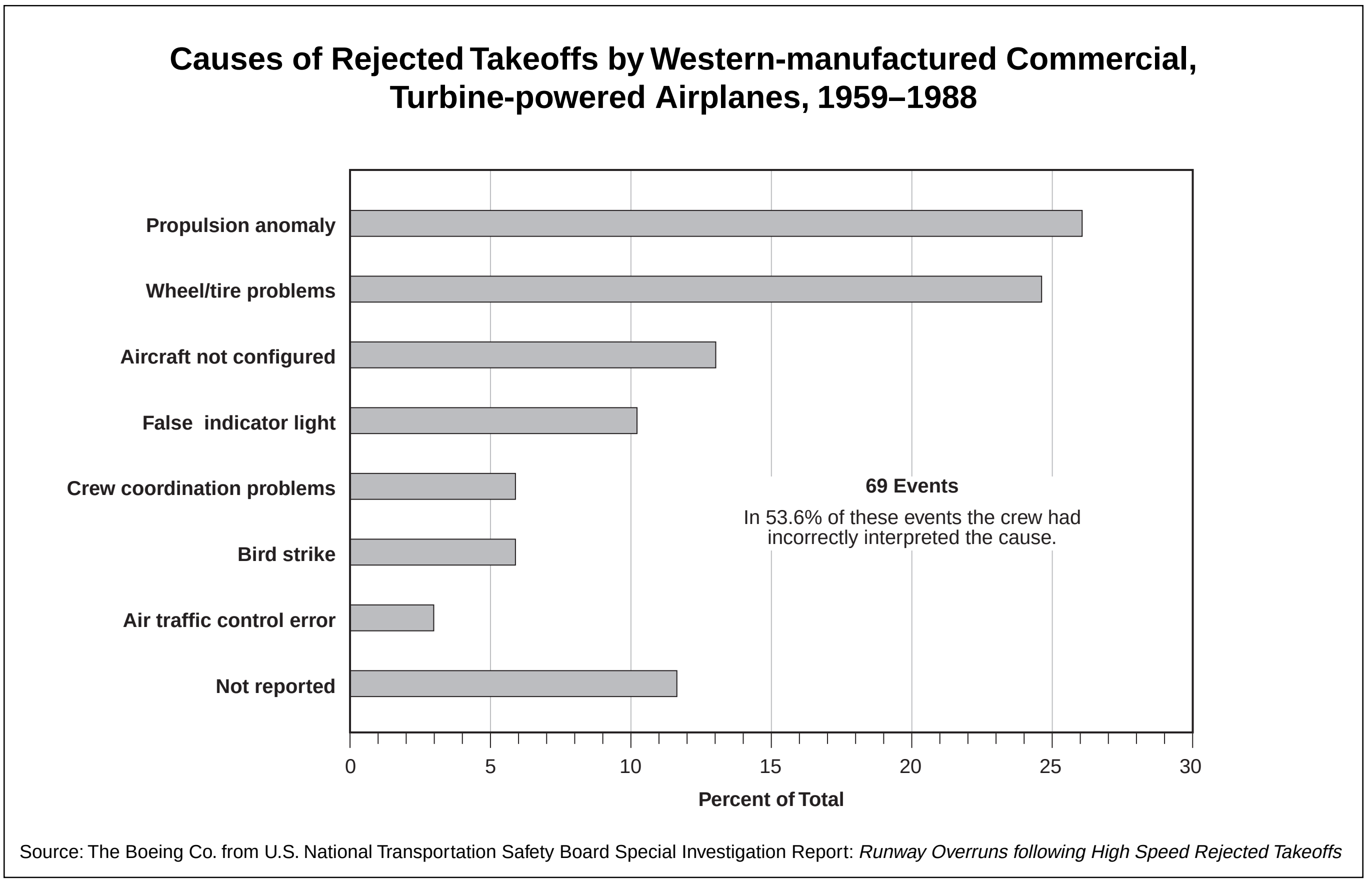


Figure 2

for the potential differences in the reaction times and action times of test pilots and line pilots.

Before 1978, manufacturers were required to adjust accelerate-stop distances to allow for two seconds of airplane travel beyond V_1. Manufacturers were required to add the distance equivalent to one second of travel between the first and second actions to reject the takeoff, and the distance equivalent to one second of travel between the second and third actions to reject the takeoff.

"In calculating the resulting accelerate-stop distances for the AFM, no credit was allowed for any deceleration during this two-second time period," said FAA.

In 1978, Part 25 was changed to require manufacturers to add the distance equivalent to two seconds of *continued acceleration beyond V1*. FAA said that this change was made to more realistically compensate for the time required by pilots to take action to reject a takeoff.

"This change resulted in longer accelerate-stop distances," said FAA. "Consequently, turbine-powered transport-category airplanes that are currently being manufactured under a type certificate that was applied for prior to March 1, 1978, have a significant operational economic advantage over airplanes whose type certificate was applied for after that date."

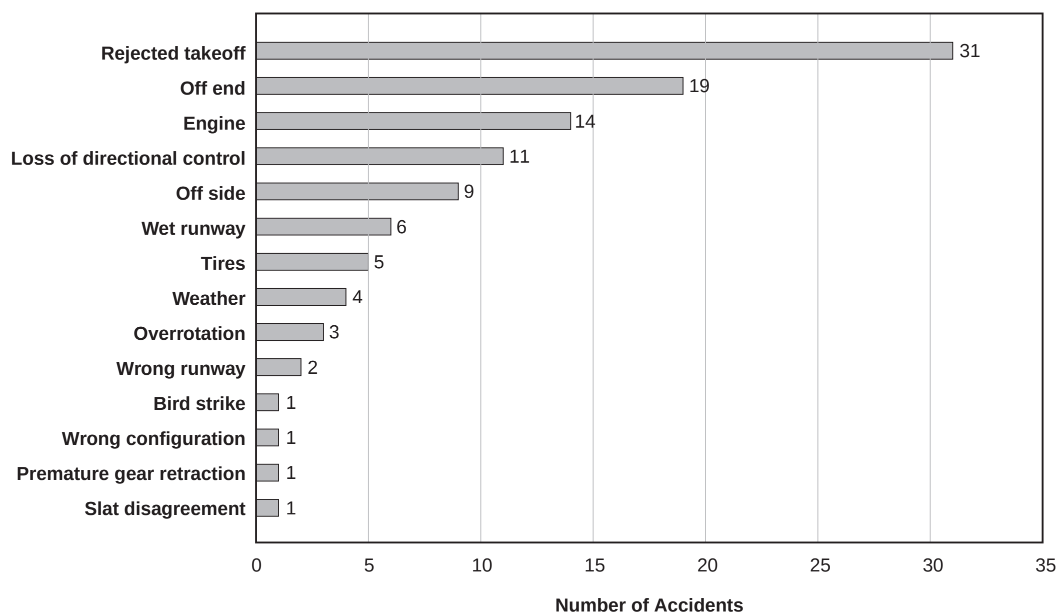
Therefore, FAA has changed Part 25 to require that manufacturers add the distance equivalent to two seconds (one second between the first and second actions to reject the takeoff, and one second between the second and third actions) *at the V1 speed*.

FAA said that when public comment was solicited on this change, some respondents criticized the change as detrimental to safety. The critics said that the change would allow an increase in the maximum allowable takeoff weight for a runway that would not have been long enough for safe takeoff using accelerate-stop data obtained under the then-current standards.

"Although FAA agrees with the [critics] on the effect of this particular [change] on takeoff weight limits … FAA disagrees that safety is degraded when this [change] is considered in combination with the other [changes]," said FAA. "Depending on whether the runway is wet or dry and on the particular airplane's stopping capability with worn brakes, the maximum allowable takeoff weight for a given runway length could end up being either increased or decreased."

Certification tests now must allow for fully worn brakes. Part 25 was revised in February 1998 to require that accelerate-stop distances (and landing distances) be determined with all of the airplane's wheel brakes at the fully worn limit of their allowable wear range (i.e., to the overhaul limit).

Events Involved in Commercial, Turbine-powered Airplane Accidents, 1988–1997



Note: Statistics apply to civilian, commercial jet airplanes weighing more than 60,000 pounds (27,216 kilograms), except those manufactured in the Commonwealth of Independent States (former Soviet Union).

Source: Boeing Commercial Airplane Group

Figure 3

This change was prompted, in part, by a special investigation of McDonnell Douglas DC-10 brake performance by NTSB following the May 1988 accident at Dallas-Fort Worth International Airport.[5]

NTSB said that the airplane decelerated normally for five seconds to six seconds after the captain initiated the RTO. The airplane's groundspeed slowed from 178 knots to about 130 knots during this period.

"The deceleration then decayed rapidly, and the loss of decelerative force resulted in the airplane departing the end of the runway at about 97 knots," said NTSB. "The nose gear collapsed in soft ground, and the plowing action of the nose slowed the airplane to a stop about 1,000 feet beyond the end of the runway."

"The cause of the accident was total brake failure in eight of the 10 wheel brakes as a result of inadequate certification and test procedures," said NTSB. "The brakes had been certified to FAA-approved procedures, yet failed at only 36 percent of the design requirement."

As a result of the special investigation, NTSB recommended, among other actions, that FAA require transport-airplane manufacturers to develop and publish data on the increased stopping distances caused by worn wheel brakes.

Part 25 now requires that accelerate-stop (and landing) distances, and maximum brake-energy capacity ratings be based on brakes worn to their fully worn limit. The new standards also require that wheel brakes with not more than 10 percent of their allowable brake-wear range remaining be used during the certification flight test demonstration of a maximum-kinetic-energy RTO.

[FAA said that in an action separate from the revision of Part 25, airworthiness directives were issued to require that the wheel brakes on transport-category airplanes with maximum takeoff weights of more than 75,000 pounds (33,750 kilograms) be capable of absorbing the energy from a maximum-kinetic-energy RTO, even when the brakes are worn to limits that require overhaul.]

Wet-runway accelerate-stop requirements incorporate several factors. Some U.S. manufacturers voluntarily have provided information on wet-runway takeoff performance in AFMs. Such information is required by civil aviation authorities in some countries. Nevertheless, wet-runway takeoff data previously were not required by the FARs.

The new standards use formulas for computing takeoff performance on wet runways. The formulas allow for several variables, including:

- Airplane groundspeed: This is the most significant variable affecting stopping performance on a wet runway. "At high speeds, the wet-runway braking coefficient is typically less than one-half the dry-runway braking coefficient," said FAA;

- Tire pressure: The maximum tire pressure approved for a particular airplane operation must be used in determining accelerate-stop performance for that operation. "Operating at a tire pressure that is lower than the maximum tire pressure approved for that airplane will tend to improve the airplane's stopping capability on a wet runway," said FAA. [The speed at which a tire begins to hydroplane on a wet runway is proportional to the tire's inflation pressure.];

- Tire tread: A tread depth of two millimeters (0.08 inch) is required. The tread depth on new transport-airplane tires generally is from 10 millimeters to 12 millimeters (0.4 inch to 0.48 inch). "Airplane manufacturers' maintenance manuals usually recommend removal [of the tire] when the tread depth is less than 1.2 millimeters (0.048 inch)," said FAA;

- Runway surface texture: Tests must be performed on smooth runways. FAA said that runways are grouped into five categories, labeled A through E. A category-A runway has the smoothest surface texture; a category-E runway has the roughest surface texture. Runways in the first three categories, A through C, are not grooved or treated with a porous friction course (PFC) overlay. (PFC is an asphalt aggregate that provides a rough surface texture.) Runways in categories D and E are grooved or have PFC overlay. The new certification standards require a runway texture midway between categories B and C. The standards also permit demonstration of wet-runway takeoff performance on grooved or PFC-overlaid runways to develop accelerate-stop data for use during takeoffs on wet runways that are grooved or have PFC overlay; and,

- Depth of water on the runway: FAA said that the new standards require a well-soaked runway but no significant areas of standing water.

After the wet-runway takeoff-performance data are calculated, the manufacturer is required to conduct flight tests to demonstrate the capability of the airplane's antiskid-braking system to achieve the maximum friction capability computed for the airplane.

Reverse thrust can be used in determining wet-runway takeoff performance. The new standards allow the decelerative effect of reverse thrust to be used in determining wet-runway accelerate-stop distances; reverse thrust cannot be used in determining dry-runway accelerate-stop distance.

"Although reverse thrust should and probably would be used during most rejected takeoffs, FAA believes that the additional safety provided by not compensating for reverse thrust in calculating the accelerate-stop distance on a dry runway is necessary to offset other variables that can significantly affect the dry-runway accelerate-stop performance determined under the current standards," said FAA.

"Examples of variables that can significantly affect the dry-runway accelerate-stop performance include: runway surfaces that provide poorer friction characteristics than the runway used during flight tests to determine stopping performance, dragging brakes [and] brakes whose stopping capability is reduced because of heat retained from previous braking efforts." FAA said that the reduced braking force available on a wet runway is more significant than these variables.

Lower "screen height" but no clearway can be used for wet-runway accelerate-go performance. Screen height is the height of an imaginary screen that the airplane would just clear with the wings level when taking off. The wet-runway accelerate-go distance is based on the airplane's achieving a minimum screen height of 15 feet (4.6 meters) over the runway.

The minimum screen height for dry-runway accelerate-go distance is 35 feet (10.6 meters). FAA said that the lower screen height prescribed for wet-runway accelerate-go performance reduces the balanced-field-length V_1 speed and, thus, will reduce the risk of a runway overrun during a rejected takeoff.

The wet-runway accelerate-go certification standards do not allow clearway to be used. (Clearway basically is an area beyond the runway that is clear of obstacles.) "The combination of a clearway with the … 15-foot screen height for wet runways could result in a minimum [aircraft] height over the end of the runway of near zero (i.e., liftoff very near the end of the runway), if clearway credit were to be permitted for wet runways in the same manner that it is currently permitted for dry runways," said FAA.

"The possible presence of standing water or other types of precipitation (e.g., slush or snow) and numerous operational factors (e.g., late or slow rotation to liftoff attitude) emphasize the need to provide more of a safety margin than would be present if liftoff were permitted so near the end of the runway."

FAA deferred action on takeoff-performance monitors. When public comment was solicited by FAA on the proposed revision of Part 25, the Air Line Pilots Association International recommended that takeoff-performance monitors be required aboard transport-category airplanes. Takeoff-performance monitors compare data from the airplane's instruments with data from the AFM during takeoff and provide immediate information to the flight crew on whether the takeoff should be continued or rejected.

FAA said that it has published information on how to obtain approval for takeoff-performance monitors in Advisory Circular 25-15, *Approval of Flight Management Systems in Transport Category Airplanes*. "However, takeoff-performance monitors are not yet sufficiently reliable, nor are they sophisticated enough, to warrant requiring their addition to the flight decks of transport-category airplanes," said FAA.

Flight test guide revisions are being developed. FAA said that manufacturers will need extensive guidance on how to comply with the new transport-category-airplane takeoff-performance standards. FAA said that Advisory Circular 25-7 is being revised to incorporate the changes to Part 25 and to provide detailed guidance on acceptable means of complying with the wet-runway and worn-brake requirements.♦

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Flight-crew Reports Provide Details of Causes and Results of High-speed Rejected Takeoffs

Engine problems, master-warning lights, control problems and open windows caused more than half of the high-speed rejected takeoffs reported recently by transport-aircraft flight crews.

FSF Editorial Staff

Reports to the U.S. National Aeronautics and Space Administration's Aviation Safety Reporting System (ASRS) show that a variety of events has caused flight crews of transport-category aircraft to conduct high-speed rejected takeoffs (RTOs).

An analysis of recent ASRS reports (as of mid-August 1998) showed that 24 reports described incidents that involved high-speed RTOs.

The U.S. National Transportation Safety Board defines a high-speed RTO as one that is initiated at or above 100 knots. Some reports did not specify the airspeed, but said that the RTO was initiated near V_1.

[V_1, previously called the "takeoff-decision speed," has been redefined by the U.S. Federal Aviation Administration to mean, in part, "the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance."]

Events that caused the 24 RTOs included engine problems (eight reports), master-warning lights (two reports), control problems (two reports), open windows (two reports), an open door, a sudden deceleration, a conflict with another aircraft on the runway, an airspeed stagnation, an airspeed-indicator discrepancy, a cargo-fire warning, an electrical failure, a partially set parking brake, an auto-pack-trip system misconfiguration, and a broken crew-seat latch.

Following are excerpts from the reports. Descriptions quoted from the reports have been edited for clarity by the FSF editorial staff. (The information is intended to provide insight into the potential causes and results of RTOs, and is not a formal study of RTOs. The reports often reflect the subjective perceptions of the reporters, rather than objective analyses by qualified investigators.)

RTOs were initiated at airspeeds above V_1. Many transport-aircraft operators and manufacturers recommend that RTOs be initiated above V_1 only if the flight crew seriously doubts the airplane's condition to fly safely.

- Comments by the captain and the first officer of a McDonnell Douglas MD-88 were included in a report of an RTO initiated when the master-warning light illuminated. The captain said that the first officer had just called "V_1."

  "My hand was just leaving the throttles when I saw a red master-warning light and a lot of dry pavement remaining in front of me," said the captain. The warning was caused by a high-temperature condition in the airplane's tail compartment. The warning light extinguished during the RTO.

  "The aircraft stopped easily, with runway to spare," said the captain. "We followed up with the applicable procedure, and the light remained extinguished.

  "The aircraft was taxied clear of the runway onto a parallel taxiway and kept away from congested areas while we ascertained brake and tire status. We observed brake temperatures and eventually had the fuse plugs melt on two of the four main tires [causing the tires to deflate]. Passengers were bused to the terminal building … after the brakes had cooled."

"I plan to incorporate a personal 'buffer' relative to V_1 speed for reaction time and go/no-go decision making, even for long runways," said the captain. "It just might save tires, brakes, passenger inconvenience or more in the future."

The first officer's report of the incident was different from the captain's report. Noting that V_1 was 133 knots, V_R (rotation speed) was 138 knots and V_2 (takeoff safety speed) was 142 knots, the first officer said:

"We were at 140 knots to 145 knots with the nose wheel off the ground; the main wheels had not lifted off yet. A 'tail compartment temp high' light illuminated with associated master warning. The captain elected to reject the takeoff.

"Spoilers deployed and autobrakes activated. The nose wheel came back down firmly when the autobrakes activated. The aircraft stopped with approximately 2,000 feet [of runway] remaining."

"The captain's decision to abort is debatable, but with the advantage of hindsight, I believe it was a mistake," said the first officer. "He reacted to the red master-warning [light] without knowing its source. … The captain did an excellent job of controlling the aircraft, but we were very lucky the main gear had not lifted off, or we would not have been able to stop within the remaining runway."

- The captain of a Learjet 60 rejected the takeoff after the airplane suddenly decelerated and began to drift from the runway centerline at rotation speed. The airplane was taking off with a 20-knot crosswind on a runway that was 8,500 feet (2,576 meters) long and 150 feet (46 meters) wide.

The captain said that the airport had another runway that was longer and better oriented with the surface wind direction, but the longer runway was being cleared of snow and was not available for takeoff. The captain said that a McDonnell Douglas DC-9 had departed minutes earlier from the open (shorter) runway without difficulty. The open runway apparently had some packed snow and drifted snow on its surface.

"We had back-taxied down a portion of [the runway] and felt it was OK to use, because I had taken off before on runways with the same conditions with no problem," said the captain. (Back-taxi means to taxi on an active runway in a direction opposite to the direction in which operations are being conducted on the runway.)

"During the takeoff roll, we were experiencing slight decelerations, which I fully expected, given the conditions," said the captain. "However, at V_R, a sudden rapid deceleration was felt, which seemed very abnormal. I attempted to continue and try to regain rotation speed, but the aircraft started to drift off the center of the runway.

"I performed a high-speed abort due to the sudden rapid deceleration at V_R and the inability to maintain the center of the runway when rotation was initiated. I elected to abort because I felt this was the safest option, due to the remaining runway length and width available. The abort was successful, as control of the aircraft was maintained throughout [the RTO]."

"I feel the reason for the deceleration and subsequent drift from centerline was due to a combination of the [crosswind] and a possible large snowdrift on the runway," said the captain.

"In retrospect, I feel I should have … waited for [the longer runway] to open," said the captain. "I feel there was a bit of complacency involved due to my past experiences and successful takeoffs in these conditions, and also the fact that [other] jet aircraft were successfully departing."

- A crosswind also was mentioned as a factor in an RTO incident reported by the captain of a CASA 212 cargo flight.

"During the acceleration, at approximately 60 knots, the aircraft drifted to the left, which I attributed to the crosswind," said the captain. "I corrected the drift, and, soon after, the first officer called 'V_1' and 'rotate.' I rotated the nose, and, a second later, the main wheels lifted off.

"The aircraft seemed to handle abnormally — more specifically, the flight controls felt mushy. We were at approximately 5 feet to 10 feet AGL [above ground level] when I told the first officer that 'the plane doesn't feel right, and I'm going to put it back on the runway.'"

The captain said that he believed the airplane was grossly overloaded.

The airplane began to turn left after touchdown. "I attempted to correct this situation by applying brakes and nose-wheel steering," said the captain. "However, I was unable to regain control. The plane skidded off of the left side of the runway."

The report said that the nose-wheel-steering system apparently had failed. "The nose wheel had turned to approximately its limits, and the tire left a large skid mark that started along the center of the runway and ended at the point where the aircraft departed the runway," said the report.

- The pilot of an airplane identified by the report only as a "small transport" (with a gross weight between 5,000 pounds and 14,500 pounds [2,250 kilograms and 6,525 kilograms]) said that the RTO was initiated after the right-front cabin door opened after the airplane lifted off the runway.

  "I put the airplane back down on the runway and applied braking action," said the pilot. "The left- front tire blew out. I maintained directional control, slowed the aircraft down and taxied off the runway onto the grass shoulder."

- The first officer of a Saab-Fairchild 340B was the pilot flying when the captain ordered an RTO after liftoff due to the illumination of a master-warning light.

  "After the captain called 'V_1, rotate,' and after the main gear had lifted off, a red master-warning light flashed on, then off," said the first officer. "The captain called 'abort' and pulled the power levers to flight idle. I was forced to land. The captain then applied heavy braking and taxied off the runway."

  The first officer said that the captain consulted the airplane's maintenance log and discovered an entry concerning an intermittent lavatory-smoke light. "He then decided to take off again," said the first officer.

  "I informed the captain that I was not comfortable with aborting after V1 and after liftoff, but he ignored me."

  "I informed the captain that I was not comfortable with aborting after V_1 and after liftoff, but he ignored me," said the first officer. "He also was required to call maintenance and dispatch about the abort, but neglected to do so.

  "Also, when heavy (high-speed) braking has occurred, a cool-down period of one minute per knot is required."

  The report said that the time between the RTO and the airplane's second, successful, takeoff attempt was not sufficient to have allowed for the brakes to cool.

  "The captain became argumentative and childish in the cockpit when I informed him of my concern about this situation, which resulted in my talking with the chief pilot about it," said the first officer. "The captain has been pulled off the line and has been required to be retrained in focus, CRM [crew resource management], V_1 cuts and procedures."

- A report on an incident involving a Learjet 23 said that the takeoff from a 7,598-foot (2,302-meter) runway appeared normal until the airplane reached V_R and rotation could not be achieved.

  "The plane accelerated normally," the report said. "The copilot voiced 'takeoff power set,' 'airspeed alive,' 'V_1' and 'V_R.' At V_R, the captain pulled on the control yoke to establish takeoff attitude. Nothing happened. He tried again, but still nothing happened; the nose of the plane did not move up.

  "At that time, the captain took the decision to abort, initiating full reverse and braking. (The plane's speed was approximately 140 knots.) With approximately 1,000 feet [303 meters] of runway remaining, the captain exercised maximum braking and turned off the runway onto the last taxiway. The plane stopped just beyond the hold-short line.

  "We inspected the landing gear and noticed smoke. The captain used the fire extinguisher to start cooling down the brakes; and, as a safety precaution, he had the copilot call for fire trucks."

  The report said that maintenance personnel discovered that the flaps extended to 33 units when 20 units (the takeoff setting) was selected, and that the stabilizer moved to a position causing a nose-down trim condition when the stabilizer-position indicator showed a takeoff-trim condition.

  High-speed RTOs (initiated between 100 knots and V_1) were caused by engine problems or perceived engine problems.

- Three reports said that the engine problems were caused by bird strikes:

  – One report said that a large black bird with a wingspan of about four feet (1.2 meters) was ingested by the no. 1 engine of a Boeing 727.

    "The crew felt the bump of impact, heard the bang of a compressor stall and saw low EPR [engine pressure ratio] on the no. 1 engine," said the report.

    Indicated airspeed was 120 knots (eight knots below V_1) when the captain took over control from the first officer, successfully rejected the takeoff and taxied back to the terminal.

    "At the gate, mechanics confirmed damage to the first-stage and second-stage fan blades," said the report. “All damage was contained inside the engine nacelle.”

“I am very proud of the fact that everything in this event went just like our training,” said one flight crewmember. “The control transfer from first officer to the captain during a high-speed abort is probably the most dangerous [procedure], requiring the most physical coordination between people, that we do.”

– Another report said that a bird was ingested by the no. 1 engine of a Boeing 737 at 135 knots, just prior to reaching V_1. In a terse fashion, the report said, “Successful abort. Returned to the gate [and] deplaned passengers. All four main gear tires deflated in the chocks. No injuries.”

– The captain of an airplane identified as a “light transport” (with a gross weight between 14,500 pounds and 30,000 pounds [6,525 kilograms and 13,500 kilograms]) said, “During our takeoff roll, and 10 knots prior to V_1, we noticed a flock of sea gulls sitting in the middle of the runway right in front of us. We initiated an abort, knowing a collision was imminent.

“The sea gulls burst into flight, and we struck several of them. Upon inspection after clearing [the runway], maintenance informed us that 21 [fan] blades on the no. 2 engine were damaged and had to be replaced. There was damage to the radome, as well.”

The captain said that the runway was wet from a rainfall the night before. “Sea gulls tend to flock to [wet runways] for whatever reason,” the captain said. “Perhaps a sweep of the runway after rain — before being cleared for takeoff — would prevent [bird] strikes.”

- The flight crew of a Lockheed L-1011 initiated an RTO a few knots below V_1 because of an engine failure of unknown nature. The report said that all of the airplane’s tires deflated during the RTO. The report included comments by the captain and the first officer.

  “The airplane was near maximum allowable takeoff weight when it became necessary to abort at 145 to 147 knots [V_1 was 151 knots] due to failure of the no. 3 engine and what seemed like some blown tires,” said the captain. “We were able to stop and clear the runway at the end before all the tires blew out. Fortunately, no fire developed, so the passengers remained on board until portable stairs and mobile lounges arrived. No one was injured.”

  The first officer’s report described the sensations of the engine failure: “At approximately 145 knots, I started to feel a slight vibration. At 145 to 147 knots, I felt a muffled explosion, followed by a stronger vibration. The aircraft yawed to the right and rolled slightly to the right. The aircraft then veered off the runway centerline.”

  “The cockpit indications were a red vibration light illuminated on the pilot’s annunciator panel,” said the first officer. “The captain initiated an abort and brought the aircraft back to centerline. … The captain did an excellent job of bringing the aircraft to a safe and complete stop at the end of the runway.”

- Several reports said that the flight crews heard and felt engine problems before they saw indications of engine problems on the instruments:

  – The first officer of an Airbus A300 said, “We experienced a thumping vibration and a loud bang, which seemed to come from the right side of the aircraft. The captain executed an abort below V_1, at approximately 145 to 150 knots. … The engine instruments indicated that [the right engine] had failed.”

  – The captain of a Boeing 747-400 said, “Just prior to V_1, I heard and felt multiple loud compressor stalls on the left side. A slight yaw to the left confirmed that engine no. 1 or no. 2 had suffered some power degradation, although no apparent abnormal engine indications were observed.”

  – The captain of a McDonnell Douglas MD-80 said that there was little indication of an engine abnormality before the engine failed on takeoff.

  “All engine-starting indications had been normal,” said the captain. “On the takeoff roll, we did notice that the left engine was running hotter than the right engine, but still in the normal range.”

  “[Then,] at about 90 knots, we heard a loud bang, followed by the aircraft swerving,” said the captain. “I saw a flickering of an EPR gauge.

  “We aborted [at 100 knots]. The abort was uneventful. After we returned to the gate, maintenance found metal shavings in the tail pipe.”

- Engine fuel-flow fluctuations prompted an RTO in a Boeing 727.

"As power was applied for takeoff and the takeoff roll started, the no. 1 and no. 2 fuel-flow indicators began to fluctuate wildly — 3,000 to 4,000 pounds per hour," said the second officer. "The captain decided to reject the takeoff at 100 knots. The brakes were applied gently at 90 knots, and the airplane stopped with plenty of runway remaining."

"The fuel-flow problem was diagnosed by maintenance, and the fuel-flow power supply was replaced," said the report. "Operations checked normal, and the flight was continued without incident."

RTOs were initiated when flight crews saw other aircraft on the runways. Such conflicts are called runway incursions.

- Two Boeing 737s were preparing to depart from an airport with parallel runways, 26L and 26R. Visibility was reduced by fog.

  The captain of one airplane said, "Patches of fog … reduced visibility to 1,500 feet to 2,000 feet [456 meters to 606 meters]. We were cleared for takeoff on Runway 26L. As we were rolling down the runway, approaching 125 knots, an aircraft appeared out of the fogbank taxiing directly towards us on the runway, approximately 3,500 feet [1,061 meters] ahead.

  "We rejected the takeoff with maximum braking and cleared the runway … missing the other aircraft by approximately 300 feet [91 meters]."

  "We rejected the takeoff with maximum braking and cleared the runway … missing the other aircraft by approximately 300 feet [91 meters]."

  Both airplanes exited the runway and stopped on adjacent taxiways. "Both aircraft came to a stop wing tip to wing tip, approximately two aircraft widths apart," said the captain who conducted the high-speed RTO. "[The other B-737] captain had evidently gotten lost and crossed Runway 26R … and taxied onto Runway 26L, thinking he was on Runway 26R.

  "What made the situation worse was that he had no exterior lights on, except his red anticollision light."

  The captain of the other airplane said, "I believe the first officer read back [to the tower controller] the proper instruction to back-taxi on Runway 26R, and I repeated the proper instruction to him. Unintentionally, I transposed the runways and had the [mental] picture that I was to back-taxi on Runway 26L."

  "I made a left turn down Runway 26L," said the captain. "We did not hear [the other B-737] get cleared for takeoff. The reported visibility was a quarter mile [0.4 kilometer] in fog. We were not performing any duties at that point, and my whole focus was on visually clearing the runway.

  "I noticed two dim lights at the [end of the runway], followed quickly by an aircraft shape. The aircraft appeared to be at the end and stationary. I went for a taxiway. I could tell the aircraft had rolled. Halfway through my turn, the aircraft was still at least 3,000 feet [909 meters] away, and I knew I could be out of the way."

  "I cleared [the runway] and told tower I saw [the other B-737] and was clear of the runway," said the captain. "I watched [the other airplane] finish the abort and then clear the runway. … We did not cross paths and had approximately 2,000 feet [606 meters] separation of unused runway between us. [The crew of the other airplane] did a good job."

  The captain said that similar incidents might be avoided if tower controllers refrained from issuing instructions to back-taxi on runways when taxiways can be used during low-visibility conditions.

- A McDonnell Douglas MD-80 was rolling for takeoff when a Beech 1900 inadvertently taxied onto the runway ahead. The crew of the Beech 1900 had responded to a clearance — to taxi onto the runway and hold position — issued to another Beech 1900 with a similar call sign. The other Beech 1900 was on a taxiway near the approach end of the runway.

  The captain of the MD-80 said, "I had just made the 80-knot call-out when the copilot noticed an aircraft taxiing in front of us, from right to left."

  The first officer said, "As far as I can recall, the aircraft had never talked to the tower, did not look in either direction and just slowly taxied across the active runway. Upon seeing him cross the hold-short line, I realized that he was not going to stop and immediately aborted my takeoff."

  The report also included comments by a tower controller. "I was working the local control assistant position," said the controller. "During a heavy arrival and departure rush, we were [clearing aircraft to depart on the runway] full length and from an intersection.

  "The local controller cleared the MD-80 for takeoff and the Beech 1900 ('Aircraft Z') to taxi into position and hold [at the approach end of the runway]. The other

Beech 1900 ('Aircraft Y') read back 'into position and hold,' and went onto the runway in front of the MD-80.

"The MD-80 aborted his takeoff and was stopped by 500 feet to 1,000 feet [152 meters to 303 meters] from the Beech 1900, Aircraft Y. Similar call signs, Aircraft Y and Aircraft Z."

RTOs were initiated when cockpit windows opened.

- The captain of a B-767 said that the cockpit became unusually noisy at 100 knots. "At approximately 130 knots, the captain's window flew open, and the takeoff was rejected without incident," said the captain.

  "The captain's window appeared to be closed and locked during preflight, and was verified closed and locked [while conducting the] before-start checklist," said the captain.

  After the RTO, maintenance technicians inspected the window and found no defects.

  "The captain's window lock was never physically pushed to ensure that it was completely locked," said the captain. "It is not listed in our procedures to physically push this handle to ensure that it is in the completely latched position.

  "In the future, I plan to physically push this handle to ensure that it is fully latched."

- The captain of another B-767 said that the RTO was initiated when the window opened at about 100 knots.

  "This captain had grabbed the handle and looked at the window during the preflight, and called 'closed and latched,'" said the captain. "On the takeoff roll, at about 80 knots, I looked at the window because an air leak was developing and saw that the handle was back instead of forward.

  "As I grabbed for the handle, the window popped in, and I was forced to do the abort. We timed the brake cooling and had a visual inspection done on the brakes, then took off for [our destination] with egg on the face.

  "I cannot remember opening the window after completing the preflight checklist and can only assume that when I grabbed the handle during the checklist, it was already open."

Airspeed anomalies were cited as causes for RTOs.

- The captain of a Boeing 737-200 said that all indications were normal before the airspeed stagnated.

  "The brakes were held at the end of the runway, and the engines were stabilized at 1.4 EPR," said the captain. "The brakes were released simultaneously with setting takeoff thrust. At 80 knots, the engines were checked, and all indications were normal.

  "At 100 knots, the airspeed indicators were cross-checked. At 110 knots, the airspeed stagnated. All engine indications checked normal, but V_1 speed was not achieved. I called 'airspeed stagnation' and 'reject takeoff.'"

  "The aircraft remained in positive control throughout the rejected takeoff," said the captain. "The aircraft was slowed to below normal taxi speed by the end of the runway."

  The crew turned onto a taxiway and stopped to allow the brakes to cool. When they learned that one of the tires on a main landing gear had deflated, they arranged to have the passengers bused to the terminal.

  "In conclusion, the weight and balance computations were correct, the fuel load was correct, the performance computations were correct and the flaps, bleeds, EPR settings, target N1 [low-pressure shaft speed] and airspeeds were properly set and correct," said the captain. "The cause of the airspeed stagnation is unknown."

- Disruption of airflow from an open oxygen-service door on a Canadair Regional Jet caused a discrepancy between the captain's airspeed indicator and the first officer's airspeed indicator.

  "Normal procedure on takeoff at our company is for the pilot not flying to call '100 knots' to verify [agreement] between the airspeed indicators," said the captain. "During this takeoff, I, as pilot flying, noticed that I was indicating a little more than 100 knots without hearing the call. I called '100 knots.'

  "The first officer said, 'I don't have 100 knots.' I had an amber airspeed miscomparitor icon displayed [on the flight management system], but we got no warning message (these are inhibited during takeoff) or chime.

  "While I was chewing on these events for about two seconds, the first officer called 'abort.' I aborted the takeoff well below V_1, and we pulled off the runway and called maintenance.

  "They thought this was perhaps a momentary glitch and suggested we attempt another takeoff. (We told them we had about a 20-knot discrepancy in the no. 1 and no. 2 airspeed indicators, with the left one indicating higher.)

"A second attempt [to take off] produced the same result. This time, we checked the standby airspeed indicator, and it seemed to agree with the left one.

"Upon returning to the gate, we discovered that the oxygen service access door was not latched. The door is located in front of the right pitot tube. The door was stowed, and the subsequent takeoff was normal."

"The door was not open when the preflight walk-around check was accomplished," said the captain.

The captain said that another door, located below the oxygen-service door, provides access to the nose-gear downlock pin, which is removed by ground-service personnel after the airplane is pushed back from its gate.

The report said, "The [captain] said this was a first-time experience of the oxygen door causing airspeed problems, but [the captain] does know it has happened before [to other pilots]."

Isolated factors were involved in several RTOs. Transport aircraft manufacturers and operators generally recommend that high-speed RTOs be initiated only because of an engine failure or engine fire, or because the flight crew perceives that the airplane is unable to fly or that continuation of the takeoff would be unsafe. The following reports show various circumstances perceived by pilots as threatening continuation of the takeoff.

- The crew of a Saab-Fairchild 340B initiated an RTO because of a cargo-fire warning.

  "We received a 'cargo smoke' indication on the central warning-annunciator panel at 100 knots, just prior to V_1," said the first officer. "We aborted the takeoff, and during the abort, the warning reoccurred."

  The crew stopped the airplane on a taxiway, called crash, fire and rescue (CFR) personnel for assistance, completed the cargo-smoke checklist memory items and alerted the flight attendant that an emergency evacuation might become necessary.

  "During the time we were securing the aircraft, CFR [personnel] inspected the cargo area for evidence of smoke and fire," said the first officer. "They reported seeing none; however, the compartment was flooded with extinguishing agent."

  "Whether it was a false warning or not, we were certainly glad that the aircraft has a cargo fire-extinguishing system," said the first officer.

- Failures of both integrated drive generators (IDGs) prompted an RTO in a Boeing 757-200.

  "At about 120 knots, we had an electrical failure, and everything except the standby instruments went blank," said the first officer. "The captain immediately closed the throttles and applied the brakes. Deceleration felt normal."

  The report said that the airplane reverted to the standby electrical system, which does not provide power to the antiskid systems for the outboard main-landing-gear brakes. "This caused these tires to skid under the heavy braking, and the left-outboard tires overheated and blew," said the report.

  Maintenance personnel found that both IDGs were low on oil. A bearing in the no. 2 IDG had failed. "When the no. 2 generator failed, the already stressed no. 1 generator failed also," said the report.

- The crew of a Beech 1900D used the parking brake to hold position on the runway and then did not fully release the parking brake when takeoff clearance was issued.

  "The aircraft handled and accelerated normally until reaching approximately V_1 speed, where a hesitation to rotate was noticed," said the first officer. "Both crewmembers simultaneously called for an abort, which was accomplished without further incident."

  "Shortly thereafter, we discovered the parking brake was partially set," said the first officer. "After fully releasing the brake, we departed."

  The first officer said that after landing, a postflight inspection revealed that the outboard tire on the right-main landing gear was flat-spotted and deflated.

  "We had not followed our company's general-operations-manual procedures on obtaining an amended release after a 'mechanical irregularity,'" said the first officer. "The captain and I were removed from active flight status and have received additional training on the subject.

  "The situation could have been avoided by ensuring that the parking brake was fully released, as required by the takeoff checklist, or perhaps not setting it on an active runway."

- A switch that was not placed in the proper position by a newly hired second officer (flight engineer) during a rushed departure resulted in a Boeing 727-200's RTO.

"At about 120 knots, we had an electrical failure, and everything except the standby instruments went blank."

"During the takeoff roll, the auto-pack-trip system did not arm [as indicated by a green light], and the takeoff was discontinued at 100 knots," said the captain. "It turns out that the arming switch was not moved to the armed position."

The auto-pack-trip system was required for takeoff, due to runway length and airplane weight, said the report. The system automatically disconnects the engine-driven pack (which supplies conditioned air to the cabin) if the engine loses power.

"The cause of the forgetting of the switch was my allowing things to get rushed just prior to takeoff and not allowing enough time for an inexperienced flight engineer to catch up," said the captain. "All checklists were accomplished, but not in the smooth controlled fashion one would like."

The second officer said that takeoff clearance was obtained sooner than expected, and the crew rushed to complete the before-takeoff checklist and did not complete the checklist until the airplane had accelerated to about 60 knots.

"I'm not willing to take an aircraft airborne if I suspect flight-control problems."

"In retrospect, we should have stopped the operation instead of rushing during a critical phase of flight," said the second officer. "I should have voiced that I was being rushed and did not feel comfortable."

- Not informed by his first officer of the actual reason the airplane was veering toward the side of the runway, the captain initiated an RTO, believing that there was a flight-control problem. The report identified the airplane only as a "medium-large transport" (with a gross weight between 60,000 pounds and 150,000 pounds [27,000 kilograms and 67,500 kilograms]).

"I lined the aircraft on the centerline and turned the controls over to the first officer," said the captain. "He applied the power and commenced the takeoff roll. I fine-tuned the power settings and monitored the takeoff and the engine instruments.

"At 104 knots, I made the 100-knot call and then checked the engine instruments again. By now, we were passing 115 knots, and I noticed that the aircraft was drifting left. I thought that the first officer was a little slow in correcting for a wind gust.

"When we reached about 120 knots, the aircraft continued to drift left. I'm guessing that the right main gear was about to cross the centerline. Suspecting a possible problem at this time, I was just about to say something to the first officer when he said something to the effect of 'you need to take the aircraft.'

"We were now at approximately 125 knots with approximately 3,700 feet of runway remaining. (Note: V_1 was 155 knots.) I immediately took control of the aircraft. I checked the engine instruments; they were normal. The aircraft was wings-level, so I didn't think we blew a tire.

"I ultimately came to the conclusion that we had a possible flight-control (rudder) problem. In light of this consideration, I elected to abort the takeoff."

"I'm not willing to take an aircraft airborne if I suspect flight-control problems," said the captain.

The captain later discovered that the first officer's seat-latching mechanism had failed. The seat had moved back during the takeoff, and the first officer could not reach the rudder pedals.

"I could say that the first officer could have given me more information," said the captain. "[Nevertheless], I'm quite sure the seat rolling back startled the first officer and the most important thing on his mind, rightly so, was that someone take control of the aircraft."

The report said that the RTO resulted in the replacement of the airplane's tires and brakes, and the requirement for the captain to take a few hours of simulator training on RTO procedures and a line check.

"I guess it's easier to attach some sort of blame to the pilot, rather than a defective part or possible lax maintenance procedures," said the captain. "I hope that in the future, my decisions will continue to be based on what's right and safe, and not on what's expedient."♦

U.K. Civil Aviation Authority Reports 1996 Fatalities in Public-transport Airplane Accidents Worldwide Were Highest in 12 Years

Nevertheless, CAA data and International Civil Aviation Organization data show a continuing decline of fatal-accident rates in public-transport airplane operations worldwide.

FSF Editorial Staff

During 1996, 2,099 fatalities occurred in public-transport airplane accidents worldwide — the highest number of fatalities in 12 years, according to data reported in the U.K. Civil Aviation Authority (CAA) document, *Aviation Safety Review*.

Nevertheless, the CAA data, supplemented with data from the International Civil Aviation Organization, show a continuation of the general decline in the *rates* at which fatal accidents have occurred in scheduled passenger-transport operations since 1975.

Figure 1 (page 20) shows that 13,996 fatalities occurred in public-transport airplane accidents worldwide in 1985 through 1996. "In 1996, there was a substantial increase in fatalities due to [airplane] accidents, including the [Boeing 747 and Ilyushin Il-76] mid-air collision over India, killing 349 people," said CAA.

Figure 2 (page 20) shows that 498 fatal accidents occurred in public-transport airplane operations worldwide in 1985 through 1996. The data in Figure 1 and Figure 2 are for jet and turboprop airplanes with maximum takeoff weights more than 5,700 kilograms (12,566 pounds). The data do not include accidents in 1985 through 1989 involving aircraft built in what was then the Union of Soviet Socialist Republics, now the Commonwealth of Independent States (CIS).

Figure 3 (page 21) shows that although there were increases in some years, the rates at which fatal accidents occurred in scheduled passenger operations worldwide have decreased significantly since 1975. The data do not include accidents in the CIS.

The number of fatal accidents per 100 million kilometers (54 million nautical miles) flown decreased from about 0.27 in 1975 to 0.11 in 1996. The number of fatal accidents per 100,000 landings decreased from about 0.23 to 0.12. The number of fatal accidents per 100,000 flight hours decreased from about 0.17 to 0.07.

The CAA report included data on U.K. public-transport accidents involving airplanes with maximum takeoff weights more than 2,300 kilograms (5,071 pounds).

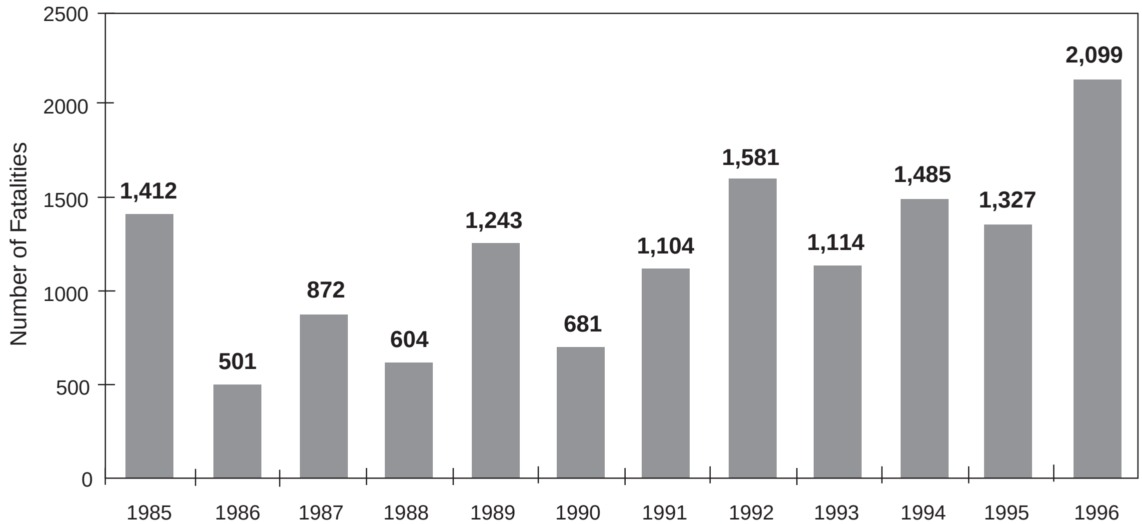
"For 1996, the U.K. continued to have one of the safest aviation industries in the world, both in terms of absolute numbers of fatal accidents and fatal-accident rates," said CAA. "Over the past 30 years, the number of U.K. aviation-related fatalities has steadily reduced, and occupant survivability has improved in a climate of growth in most sectors."

Only one fatal accident involving a U.K.-registered airplane occurred in 1996. The accident involved a Britten-Norman Islander that struck the ground during an approach at night. The pilot, alone aboard the airplane, was killed.

Figure 4 (page 21) shows that in 1987 through 1996, 65 fatalities occurred in public-transportation accidents involving airplanes registered in the United Kingdom. Figure 5 (page 22) shows that during the same period, 152 reportable accidents, including seven fatal accidents, occurred.

Figure 6 (page 22) shows the number of reportable accidents and fatal accidents that occurred per million hours flown in 1987 through 1996 by U.K. airplanes with maximum takeoff weights over 2,300 kilograms.♦

Worldwide Airplane Fatalities — Public Transport Operations*
Jet-powered and Turboprop-powered Airplanes with Maximum Takeoff Weights More than 5,700 Kilograms (12,566 Pounds)

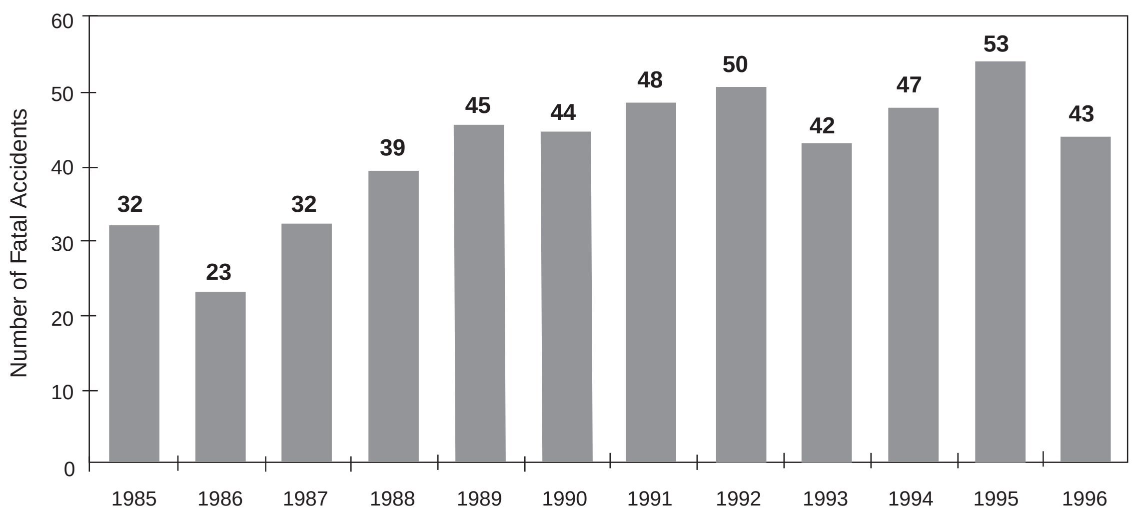


* Public transport operations include scheduled and unscheduled passenger and freight operations, and pleasure flights such as helicopter tours.

Source: U.K. Civil Aviation Authority

Figure 1

Worldwide Airplane Fatal Accidents — Public Transport Operations
Jet-powered and Turboprop-powered Airplanes with Maximum Takeoff Weights More than 5,700 Kilograms (12,566 Pounds)

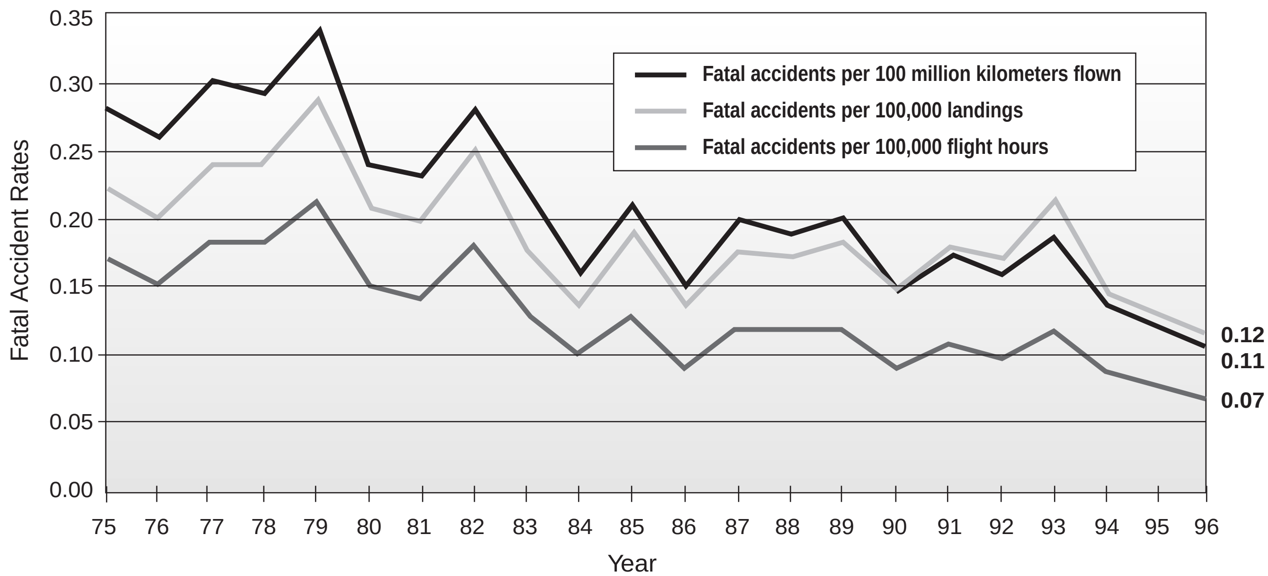


* Public transport operations include scheduled and unscheduled passenger and freight operations, and pleasure flights such as helicopter tours.

Source: U.K. Civil Aviation Authority

Figure 2

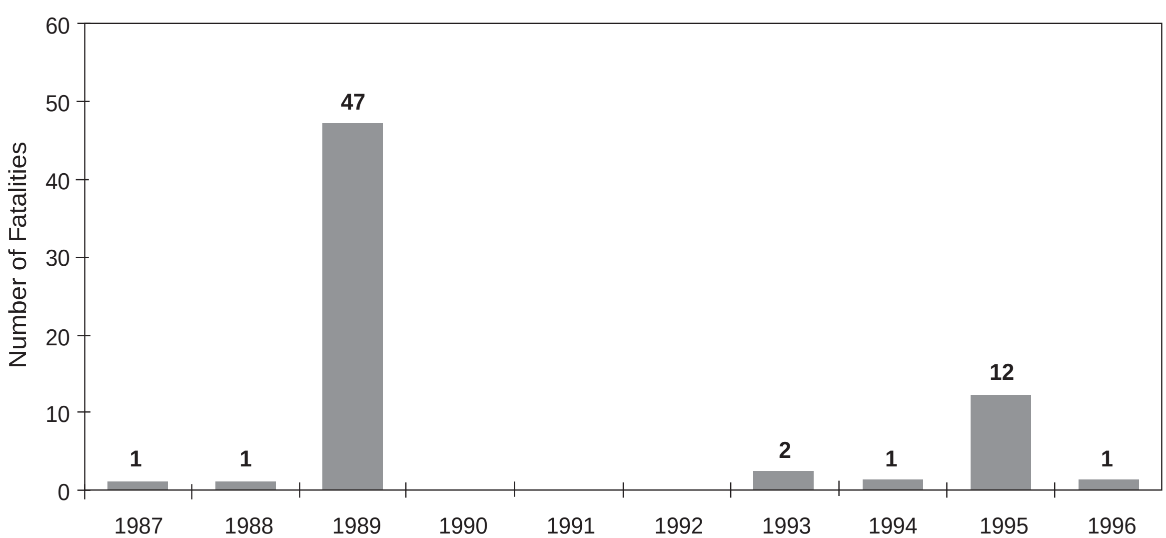
Worldwide Airplane Fatal Accident Rates — Scheduled Passenger Services



Source: U.K. Civil Aviation Authority and International Civil Aviation Organization

Figure 3

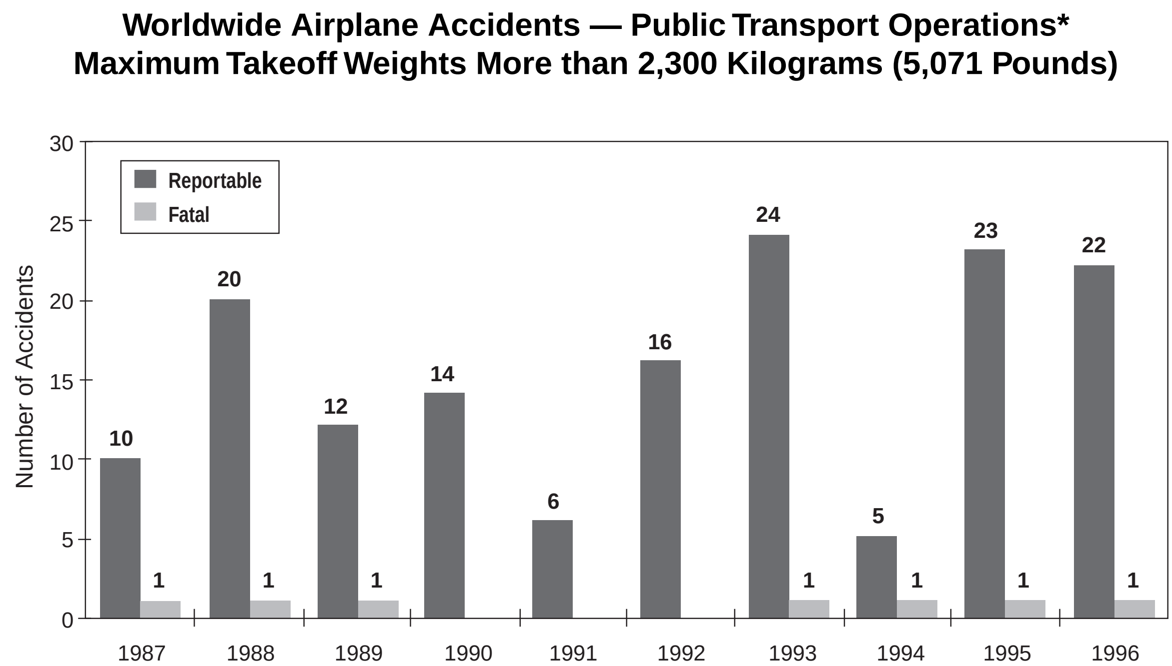
U.K. Airplane Fatalities — Public Transport Operations* Maximum Takeoff Weights More than 2,300 Kilograms (5,071 Pounds)



* Public transport operations include scheduled and unscheduled passenger and freight operations, and pleasure flights such as helicopter tours.

Source: U.K. Civil Aviation Authority

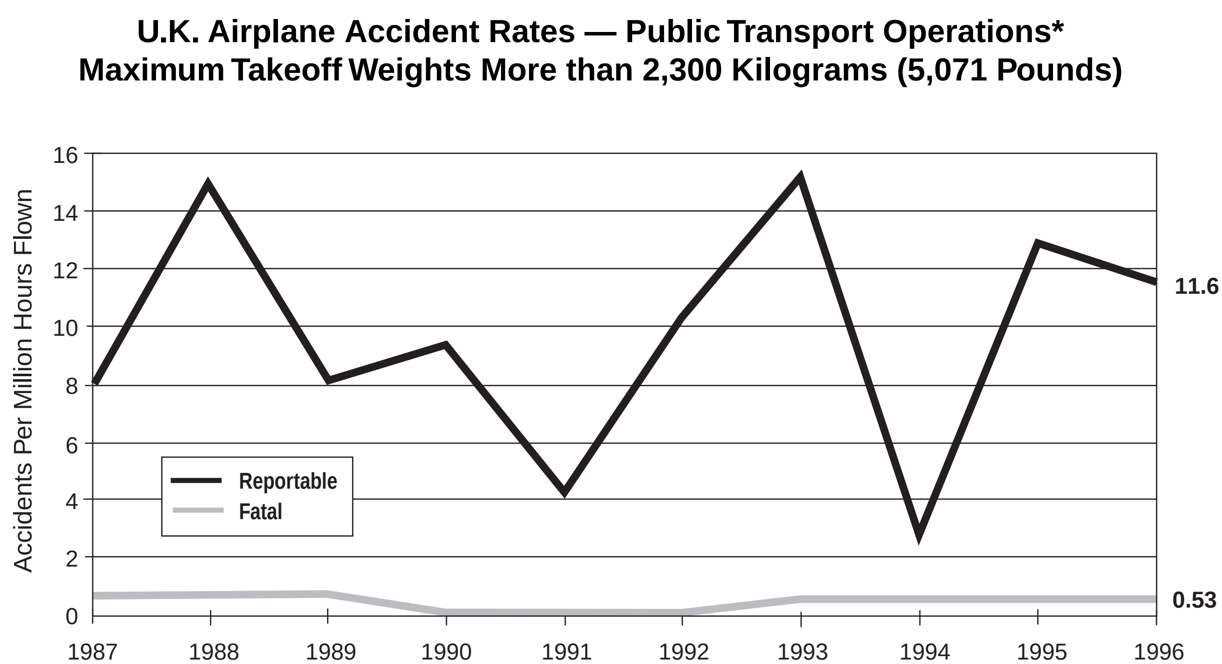
Figure 4



* Public transport operations include scheduled and unscheduled passenger and freight operations, and pleasure flights such as helicopter tours.

Source: U.K. Civil Aviation Authority

Figure 5



* Public transport operations include scheduled and unscheduled passenger and freight operations, and pleasure flights such as helicopter tours.

Source: U.K. Civil Aviation Authority

Figure 6

Publications Received at FSF Jerry Lederer Aviation Safety Library

GAO Report Says FAA Lags in Acting on Weather-related Recommendations

FAA's Office of Aviation Medicine analyzes ditching and water-survival data and training. Study reveals need to update cabin-crew and passenger instruction.

FSF Library Staff

Reports

Aviation Safety: FAA Has Not Fully Implemented Weather-Related Recommendations. U.S General Accounting Office (GAO), Report to Subcommittee on Technology, Committee on Science, U.S. House of Representatives, June 1998. Report No. GAO/RCED-98-130. 72 pp. Tables, figures, appendixes. Available through GAO.*

During the past 10 years, the U.S. National Transportation Safety Board has cited weather conditions such as icing or turbulence as causes or contributing factors in nearly a quarter of aviation accidents. Between 1995 and 1997, reports issued by the U.S. Federal Aviation Administration (FAA) advisory committee and the National Research Council (NRC) have pointed to problems in FAA's management of its aviation weather activities such as inadequate interagency coordination and lack of clarity about the agency's role.

This GAO report examines actions taken by FAA to address the recommendations of the NRC and FAA advisory-committee reports. The examination involves four areas of concern: policy and leadership, interagency coordination, meeting the weather-information needs of different users, and funding for weather activities.

FAA has made limited progress in implementing the weather-related recommendations of NRC and FAA's advisory committee. However, the proposed implementation plan to be issued by FAA later in 1998 provides an opportunity to demonstrate FAA's commitment to weather issues. [Adapted from Introduction and Results in Brief.]

Analysis of Ditching and Water Survival Training Programs of Major Airframe Manufacturers and Airlines. Cosper, Donna K.; McLean, Garnet A. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-98/19. July 1998. 33 pp. Figure, tables, references, appendixes. Available through NTIS.**

<u>Keywords:</u>
1. Ditching
2. Evacuations
3. Training
4. Water Survival

In 1994, the International Civil Aviation Organization reported that there were 33 water-impact accidents (ditchings) worldwide between 1982 and 1989 in the commuter category alone. Furthermore, 44 of the 50 busiest U.S. airports (in 1996) are situated within five miles of a significant body of water. These statistics combined with the expected future increase in transport-aircraft operations suggest a corresponding increase in the likelihood of unplanned water landings. To address this problem, emergency equipment, flight-crew and cabin-crew training, and water-survival procedures are likely to become important.

This analysis reviewed emergency procedures recommended by airframe manufacturers and information from airline flight-attendant training programs. Six major airframe manufacturers and nine major airlines provided written information. Interviews were also conducted with training instructors and flight attendants. The objective was to examine the information provided to flight attendants and passengers concerning water landings and water-survival equipment and procedures, to evaluate current training practices. The study recommends that ditching and water-survival training materials be updated to make use of the most current information so that flight attendants can operate as effectively as possible. Significant water-survival skills training and other specific supporting activities for flight attendants are also recommended. [Adapted from Introduction and Discussion.]

DNA Profiling as an Adjunct Quality Control/Quality Assurance in Forensic Toxicology. Chaturvedi, Arvind K.; Vu, Vicole T.; Ritter, Roxane M.; Canfield, Dennis V. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-98/18. July 1998. 10 pp. Tables, references. Available through NTIS.**

Keywords:
1. Quality Control/Quality Assurance
2. DNA Profiling
3. Polymerase Chain Reaction
4. Cyanide Analysis
5. Atropine Administration
6. Aircraft Accident Investigation

During aircraft accident investigations, forensic toxicology laboratories need accurate and authentic analytical data on biological evidence to determine the cause of an accident or death. Following strict quality control/quality assurance) procedures allows for correct scientific interpretation as well as judicial admissibility of results with a high degree of confidence. Depending on the nature of a particular aircraft accident, the bodies of victims may be scattered, disintegrated, commingled, contaminated and/or putrefied. This situation frequently causes complications with the identification of remains and the matching of tissues, and can impede an investigation. In the Civil Aeromedical Institute (CAMI) laboratory, such complications are effectively resolved by using deoxyribonucleic acid profiling.

This report examines three situations where DNA profiling proved to be effective and practical in resolving some postmortem toxicology-related issues. The polymerase-chain-reaction technique is simple, less time consuming than other techniques, and well suited for analyzing degraded DNA. This type of DNA analysis will be possible only in toxicology labs with in-house DNA facilities. [Adapted from Introduction and Results and Discussion.]

Aviation Safety: FAA's Use of Emergency Orders to Revoke or Suspend Operating Certificates. U.S. General Accounting Office (GAO), Report to the Honorable James M. Inhofe, U.S. Senate, July 1998. Report No. GAO/RCED-98-199. 40 pp. Tables, figures, appendixes. Available through GAO.*

The U.S. Federal Aviation Administration (FAA) is responsible for examining, testing, and periodically inspecting the compliance of pilots, mechanics, and flight engineers, as well as airlines, airports, and repair stations that need a certificate to operate. When violations of the Federal Aviation Regulations are found, FAA has a variety of enforcement actions it can take (depending on how serious the violation is) from issuing a warning letter to suspending an operating certificate. An emergency order immediately revokes or suspends an operating certificate if FAA determines that the public interest and safety are at risk.

This report reviews FAA's use of emergency orders for fiscal years 1990 through 1997. Three types of information are provided: the extent to which FAA used emergency orders, with data on regional variations in their use, the types of certificate holders affected and the results of cases initiated using emergency orders; how changes in FAA's policies might have affected the use of emergency orders; and how much time FAA needed to investigate alleged violations and issue emergency orders.

Among the findings, FAA used emergency orders in 2.7 percent (3,742) of the 137,506 enforcement cases closed during fiscal years 1990 through 1997. More than 75 percent of the enforcement cases involving emergency orders resulted in the suspension or revocation of a certificate holder's operating certificate, and less than five percent resulted in FAA's dropping the case because no violation occurred or the evidence was insufficient. [Adapted from Introduction and Results in Brief.]

Aviation Competition: Proposed Domestic Airline Alliances Raise Serious Issues. U.S. General Accounting Office (GAO), Testimony before the Subcommittee on Aviation, Committee on Commerce, Science, and Transportation, U.S. Senate, June 4, 1998. Report No. GAO/T-RCED-98-215. 20 pp. Tables. Available through GAO.*

Deregulation of the U.S. airline industry in 1978 was generally a success. Increased competition delivered lower fares and better service for most travelers. Six airlines that carry about 70 percent of domestic passengers have announced plans to form three alliances. The airlines contend that these alliances will produce benefits such as expanded route networks and combined frequent-flier programs. Critics fear that the alliances will undermine the benefits of deregulation by reducing competition, reducing consumer choice and increasing fares.

This testimony consists of preliminary findings and describes the competitive implications of the proposed alliances. Three issues are discussed: (1) potential consumer benefits, (2) potential harm to consumers, and (3) issues policy makers need to consider when evaluating the ultimate effects of the proposed alliances.

Among the important issues to be considered by policy makers is whether airline assumptions concerning additional traffic and other benefits are realistic. It will also be critical to determine if an alliance increases or reduces the incentives for alliance partners to compete by reducing fares. [Adapted from Introduction.]

Advisory Circulars

Announcement of Availability: List of Air Carriers Certificated by Title 14 of the Code of Federal Regulations (14 CFR) Part 135. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) No.135-13F. June 18, 1998. 1 p. Available through GPO.***

This advisory circular announces the availability of and provides ordering instructions for AC 135-13F, which contains a list of air carriers (current as of March 17, 1998) certificated by FAA under the provisions of 14 CFR part 135. [Adapted from AC.]

Books

World Encyclopedia of Aero Engines, 4th Edition. Gunston, Bill. Sparkford, Nr. Yeovil, Somerset, U.K.: Haynes Publishing, 1998.

This is a new and enlarged fourth edition of the successful reference encyclopedia. The updated work includes details of the latest aircraft engines of all types. Each engine is discussed in its historical context to highlight engine development and its contribution to the evolution of aircraft.

This edition of the encyclopedia is arranged in alphabetical order by manufacturer and contains many new entries, photographs and updated information. Every major aircraft-engine manufacturer is listed, and aircraft engines ranging from the earliest piston engines of the Wright brothers to the latest modern jets are included. The author's research also uncovered a large number of previously unknown facts about many Russian and American engines. [Adapted from Introduction.]♦

Sources

* U.S. General Accounting Office (GAO)
P.O. Box 6015
Gaithersburg, MD 20884-6015 U.S.
Telephone +(202) 512-6000; Fax +(301) 258-4066

** National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161 U.S.
+(703) 487-4600

*** Superintendent of Documents
U.S. Government Printing Office (GPO)
Washington, DC 20402 U.S.

Updated U.S. Federal Aviation Administration (FAA) Regulations and Reference Materials

Advisory Circulars (ACs)

AC No.	Date	Title
43-9C	June 8, 1998	*Maintenance Records.* (Cancels AC 43-9B, *Maintenance Records,* dated January 9, 1984.)
20-105B	June 15, 1998	*Reciprocating Engine Power-Loss Accident Prevention and Trend Monitoring.* (Cancels AC 20-105A, *Engine Power-Loss Accident Prevention,* dated November 20, 1980.)
25.629-1A	June 23, 1998	*Aeroelastic Stability Substantiation of Transport Category Airplanes.* (Cancels AC 25.629-1, *Flutter Substantiation of Transport Category Airplanes,* dated January 4, 1985.)
21-16D	July 21, 1998	*RTCA Document DO-160D.* (Cancels AC 21-16C, *Radio Technical Commission for Aeronautics Document DO-160C,* dated February 14, 1990.)

International Reference Updates

Airclaims

Update No.	Date	
109	Aug. 5, 1998	Updates *Major Loss Record.* Worldwide aircraft accident summaries.

Boeing 747 Wing-tip Vortices Upset MD-11 during Parallel Approaches

The following information provides an awareness of problems through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

FSF Editorial Staff

Air Carrier

B-747 Wake Turbulence Upsets MD-11 during VFR Approach

McDonnell Douglas MD-11. Substantial damage. One minor injury.

The MD-11 was conducting a visual approach to Runway 24R at a U.S. airport. The airplane was flying three nautical miles (5.6 kilometers) behind a Boeing 747 that was approaching to land on Runway 24L.

The parallel runways were 550 feet (168 meters) apart and staggered, with the threshold of Runway 24L located 4,300 feet (1,312 meters) beyond the threshold of Runway 24R. Both airplanes had a 21-knot left crosswind on final approach. Air traffic control did not caution the MD-11 flight crew about possible wake turbulence from the B-747.

The MD-11 was 100 feet (31 meters) above the ground when it rolled left, then right and developed a high sink rate. The captain initiated a go-around, but the airplane contacted the runway and bounced back into the air. The captain discontinued the go-around and landed the airplane on the runway.

The MD-11's lower aft fuselage and aft pressure bulkhead were substantially damaged. One of the flight crewmembers, who were alone on the cargo flight, sustained minor injuries.

The accident was ascribed to improper planning by the MD-11 pilot-in-command. The report said that the U.S. *Aeronautical Information Manual* recommends that when an airplane is following a larger airplane on parallel approaches to runways closer than 2,500 feet (763 meters), the trailing airplane should remain at or above the other airplane's flight path, to avoid the other airplane's wake turbulence.

Engine Shut Down After Bird Strike on Takeoff

McDonnell Douglas DC-9. Substantial damage. No injuries.

The captain observed numerous sea gulls near the left side of the airplane as the first officer, the pilot flying, rotated the airplane for takeoff at a Canadian airport. The captain advised the first officer of the birds, selected continuous engine ignition and activated the weather radar. (Some pilots believe that weather-radar emissions disperse birds.)

The flight crew then heard the sounds of birds striking the airplane. One bird struck the first officer's windshield. The left engine lost power momentarily. The flight crew conducted the power-loss checklist, and the left engine stabilized at takeoff power. Nevertheless, the crew elected to shut down the left engine because of an indication of abnormal vibration.

The crew flew the airplane back to the departure airport and landed without further incident. Examination of the airplane disclosed damage to the left engine, feathers in the right engine and impact marks on the nose, first officer's windshield and right wing root.

Air Taxi Commuter

Learjet Skids off Wet Runway, Strikes Two Parked Aircraft

Learjet 35. Substantial damage. No injuries.

The flight crew conducted an instrument landing system approach to a U.S. airport during a cargo flight. The airport had a 100-foot overcast and one statute mile (1.6 kilometers) visibility. The final approach was flown with excessive airspeed and a 10-knot tailwind. The flaps were extended 20 degrees, rather than 40 degrees as recommended by the airplane flight manual.

The Learjet touched down on the wet, 5,000-foot (1,525-meter) runway with about 2,000 feet (610 meters) of runway remaining. "Tire skid marks were seen for approximately 2,000 feet on the runway," the report said.

The flight crew did not use the airplane's drag chute. The airplane ran off the departure end of the runway and collided with two parked aircraft and a hangar.

Ice Ingestion Causes Engine Flameout on Final Approach

Fairchild Metro III. Destroyed. Two minor injuries.

The flight crew missed the approach to the destination airport because of weather and diverted to their alternate airport. The crew said that they cycled the airplane's deice boots to shed one-eighth inch (3.2 millimeters) of ice that had accumulated on the wings.

"They did not observe ice on the propeller spinners, and they did not activate the engines' override [continuous] ignition systems, as required by the airplane's flight manual," the report said. "Use of override ignition was required for flight into visible moisture at or below 5 degrees Celsius (41 degrees Fahrenheit) to prevent ice ingestion/flameouts."

The airplane was on a three-nautical-mile (5.6-kilometer) final approach to the alternate airport when both engines flamed out. Two of the 21 occupants sustained minor injuries during the subsequent forced landing.

Corporate Executive

Aero Commander Collides With Grob Sailplane

Aero Commander 690. Substantial damage. No injuries.

The Aero Commander pilot announced his departure on the airport's unicom frequency. The pilot of the Grob 102 glider was monitoring another frequency used by glider pilots while orbiting in a thermal four miles south of the airport.

The Aero Commander pilot was tuning a navigation radio and looked up and saw the glider in his windshield. "The glider pilot never saw the Aero Commander," the report said. The aircraft collided at 9,800 feet (about 4,000 feet above the ground). The Aero Commander's left wing struck the glider's left wing and fuselage. Both pilots were able to land their aircraft safely after the collision.

Structural Icing Cited In MU-2 Accident

Mitsubishi MU-2B-36. Destroyed. 8 fatalities.

The airplane was cruising at 16,000 feet when it encountered structural icing conditions during a corporate flight in the United States. Air traffic control (ATC) radar showed that the airplane began to slow from a cruise speed of 190 knots and deviate from heading and altitude.

ATC radar showed that the MU-2's airspeed was 100 knots when the pilot declared an emergency. Radio contact then was lost. The airplane began a right turn and entered a steep descent. The eight occupants were killed when the airplane struck the ground.

The pilot of a Beech 1900 following about 12 minutes behind the MU-2 said that he had encountered moderate icing conditions at 16,000 feet and had descended to exit the icing conditions.

The report said that the MU-2 flight manual recommends a minimum cruise speed of 180 knots to minimize ice accumulation; the manual also recommends that pilots exit known icing conditions.

Simulated Engine Failure Leads to Loss of Control

Piper Seminole. Destroyed. No injuries.

The airplane was on a multi-engine training flight in the United States. The flight instructor reduced power from one engine to simulate an engine failure on takeoff. The multi-engine student pilot did not maintain directional control, and the airplane veered off the side of the runway.

The flight instructor took control and continued the takeoff. The instructor attempted to return to the runway. The airplane lifted off the ground, stalled and struck the runway. The airplane was destroyed, but none of the three occupants was injured.

Airplane Runs off Runway End During Rejected Takeoff

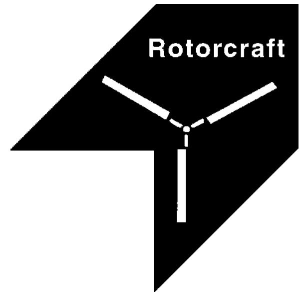
Socata TB10 Tobago. Substantial damage. No injuries.

The airplane was taking off to the west on a grass runway in England. The runway was 2,650 feet (808 meters) long and wet from an earlier rainfall. The report said that there were areas of standing water on the runway. The surface wind was from the west at 15 knots to 20 knots.

The airplane momentarily became airborne in a gust of wind, but settled back onto the runway. The pilot elected to reject the takeoff because of slow acceleration when the airplane was 660 feet (200 meters) from the end of the runway and traveling at 60 knots.

"Deceleration also was poor, and the aircraft skidded for some considerable distance," said the report. The airplane ran off the end of the runway, traveled through the airport boundary fence and came to a stop in a plowed field. The nose landing gear collapsed, and the propeller struck the ground. None of the three occupants was injured.

The report said that the airplane could have been brought to a stop if the runway were dry, but probably hydroplaned on the wet grass.



Engine Fire Warning Proves to Be a False Alarm

Eurocopter AS 355. Minor damage. No injuries.

The helicopter was in cruise flight over England when the master-caution light and the fire-warning light for the left engine illuminated. The pilot decreased power from the left engine to idle, but the warning lights remained illuminated.

Passengers seated in the rear of the helicopter said that they smelled smoke. The pilot shut down the left engine and discharged both fire bottles. The fire-warning light remained illuminated throughout the otherwise uneventful single-engine landing.

Preliminary investigation revealed no signs of fire. Subsequent investigation disclosed a broken wire in the left-engine fire-detection system. "The reported smell of smoke [is] thought to have been due to the aircraft's position downwind of an industrial area at the time of the incident," said the report.

Loose Seat Belt Inflicts Severe Fuselage Damage

Bell 206. Substantial damage. No injuries.

The helicopter was on an aerial-photography flight in England. The right-rear door had been removed to provide an unobstructed view for the photographer. During the flight, the photographer unfastened his seat belt. One of the loose seat-belt straps trailed in the slipstream outside the helicopter.

After the helicopter landed, the fuselage behind the right rear door was found to have been severely damaged by the buckle on the loose seat-belt strap. The report said that the damage was not repairable.♦

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