# National Transportation Safety Board

Washington, D.C. 20594

## Safety Recommendation

**Date:** December 2, 2003
**In reply refer to:** A-03-51 through -54

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On October 25, 2002, about 1022 central daylight time, a Raytheon (Beechcraft) King Air A100, N41BE, operated by Aviation Charter, Inc., crashed while the flight crew was attempting to execute the VOR[1] approach to runway 27 at Eveleth-Virginia Municipal Airport, Eveleth, Minnesota. The crash site was located about 1.8 nautical miles southeast of the approach end of runway 27. The two pilots and six passengers were killed, and the airplane was destroyed by impact forces and a postcrash fire. The airplane was being operated under the provisions of 14 *Code of Federal Regulations* (CFR) Part 135 as an on-demand passenger charter flight. Instrument meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan.[2]

The National Transportation Safety Board determined that the probable cause of this accident was the flight crew's failure to maintain adequate airspeed, which led to an aerodynamic stall from which they did not recover.

**Federal Aviation Administration Surveillance of Part 135 On-Demand Operations**

Federal Aviation Administration (FAA) Order 8400.10, "Air Transportation Operations Inspector's Handbook," states that "en route inspections are one of the most effective methods for accomplishing surveillance objectives and responsibilities" and that the primary objective of these inspections is to evaluate in-flight operations, including, but not limited to, crew coordination, cockpit procedures, and crewmember proficiency, of a certificate holder. However, although FAA Order 1800.56C, "National Flight Standards Work Program Guidelines," requires inspectors to conduct en route inspections at Part 121 operations and Part 135 scheduled (commuter) operations, it does not require inspectors to conduct en route inspections at Part 135 unscheduled (on-demand) charter operations. Further, the Safety Board is aware that principal operations inspectors (POI) of Part 121 operations routinely observe flight training and proficiency checks as a means to provide adequate surveillance of these operations.

[1] VOR stands for very high frequency omnidirectional range.

[2] For more detailed information about this accident, see National Transportation Safety Board, *Loss of Control and Impact with Terrain, Aviation Charter, Inc., Raytheon (Beechcraft) King Air A100, N41BE, Eveleth, Minnesota, October 25, 2002,* Aircraft Accident Report NTSB/AAR-03/03 (Washington, DC: NTSB, 2003).

Aviation Charter's POI and the FAA's Minneapolis Flight Standards District Office's operations supervisor indicated that because there was no FAA requirement to conduct en route inspections of 14 CFR Part 135 on-demand charter flights, such inspections were rarely performed. The POI added that the best way for him to ensure adequate oversight of an on-demand Part 135 operator was to monitor ground training. The Safety Board does not concur with the POI's statement. Although ground school surveillance is a valuable tool that allows POIs to evaluate an instructor and the adequacy of course content, it does not allow POIs to conduct comprehensive and in-depth assessments of an operator's policies and procedures or to determine how well the trained procedures are being assimilated into line operations, which could be accomplished through en route inspections and through observations of flight training and proficiency checks (in addition to ground school observations).

The Safety Board is concerned that even though the FAA's surveillance of Aviation Charter was in accordance with FAA Order 1800.56C, the POI did not detect the discrepancies[3] that existed at Aviation Charter during his manual/procedures or training inspections, some of which might have been detected through en route inspections or through observations of flight training or proficiency checks. The Board is also concerned that the FAA requires en route inspections of Part 135 scheduled operations, but not for Part 135 on-demand operations, despite its own acknowledgement that en route inspections are one of the best means for ensuring adequate surveillance.

The Safety Board is aware that subsequent to the accident, Aviation Charter implemented random line checks to evaluate SOPs, crew resource management (CRM), and crew coordination. Although the Board commends the company for its actions, it is concerned about the FAA's relying too much on company check airmen and not enough on its own staff to evaluate these areas. Therefore, the Safety Board concludes that en route inspections, combined with ground training, flight training, and proficiency check observations, are essential for ensuring adequate oversight of a company's operations and should be conducted on flights operated by 14 CFR Part 135 on-demand charter operators. Therefore, the Safety Board believes that the FAA should conduct en route inspections and observe ground training, flight training, and proficiency checks at all 14 CFR Part 135 on-demand charter operations as is done at Part 121 operations and Part 135 commuter operations to ensure the adequacy, quality, and standardization of pilot training and flight operations.

**Federal Aviation Administration Crew Resource Management Training Requirements**

Most Part 121 and scheduled Part 135 operators provide several days of dedicated CRM training in which accidents are reviewed and skills and techniques for effective crew coordination, resource allocation, and error management are presented. CRM training augments technical training and enhances pilots' performance in the cockpit.

In its April 1997 Regional Aviation Safety Inspection Program report, the FAA stated that CRM should be addressed in all of Aviation Charter's training curriculums because, if not, "it

[3] These discrepancies included the following: Aviation Charter was not operating in accordance with its weight and balance load manifest procedures, it did not have adequate stall recovery guidance, it did not have consistent deicer boot operational guidance, it did not have an in-range checklist, it was not adequately making its pilots aware of its standard operating procedures (SOPs), and it was not training its pilots on CRM in accordance with its FAA-approved training module.

could possibly result in improper crew coordination requirements in aircraft operated with a flight crew of more than one member." On May 21, 1997, the FAA approved the company's CRM training module. Although Aviation Charter was not required by Federal regulations to provide CRM training to its pilots, it became mandatory to teach CRM in accordance with the CRM training module once the module was approved by the FAA. However, postaccident interviews with Aviation Charter's lead ground instructor and its chief pilot and the FAA POI for the company revealed that CRM was not being taught during ground school in accordance with the training manual curriculum.

As a result of its investigation of the March 29, 2001, Avjet Corporation accident in Aspen, Colorado, the Safety Board issued Safety Recommendation A-02-12, asking the FAA to "revise 14 *Code of Federal Regulations* (CFR) Part 135 to require on-demand charter operators that conduct operations with aircraft requiring two or more pilots to establish an FAA-approved CRM training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O." The Safety Board concludes that the circumstances of the October 2002 Aviation Charter accident[4] indicate that CRM training should be extended to include all 14 CFR Part 135 on-demand charter operations that conduct dual-pilot operations regardless of whether the aircraft requires two or more pilots. Therefore, the Safety Board believes that the FAA should require that 14 CFR Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement an FAA-approved CRM training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O.

**Low-Airspeed Alert Systems**

**Background**

Current Federal airworthiness standards require that airplanes be equipped to provide a clear and distinctive stall warning to the flight crew at a speed that is at least 5 knots higher than stall speed. However, stall warnings do not always provide flight crews with timely notification of developing hazardous low-airspeed conditions. For example, abrupt maneuvering can increase angle-of-attack so rapidly that a stall could occur nearly simultaneously with the stall warning, and ice accumulation, which raises the stall speed, could degrade the stall warning margin to the point at which little or no stall warning is provided.

The accident airplane was equipped with a stall warning system designed to sound a horn in the cockpit 5 to 8 knots before the actual stall speed of the airplane in any configuration. However, because the airplane was not equipped with a cockpit voice recorder (CVR),[5] because of the approximate nature of the airspeed calculations, and because abrupt airplane maneuvering or even small amounts of ice accumulation can defeat the airplane's stall warning system, the Safety Board was not able to determine when or if the stall warning horn activated before the onset of the stall. Regardless of when or whether the stall warning horn activated, it is clear that

[4] In its final report on this accident, the Safety Board noted that if the flight crew had been adhering to Aviation Charter's approach procedures and effectively applying CRM techniques in the cockpit, at least one of the flight crewmembers should have been monitoring the instruments. The evidence clearly indicated that neither flight crewmember was monitoring the airspeed indicator or course deviation indicator during the approach. Therefore, the Safety Board concluded that the flight crew was not adhering to Aviation Charter's approach procedures and was not effectively applying CRM techniques during the approach segment of the flight.

[5] The accident airplane was not required by Federal regulations to be equipped with a CVR.

the accident flight crew failed to maintain airspeed during the approach. Radar data indicate that the accident flight was operated below Aviation Charter's recommended approach speed for about the last 50 seconds of the flight.

The Safety Board has investigated numerous accidents and incidents involving commercial flight crews that inadvertently failed to maintain adequate airspeed. For example, the Board has investigated at least 11 events since 1982 involving Part 135 flights and at least 7 events involving Part 121 flights in which stall or failure to maintain airspeed during the approach or landing phases was cited as a causal or contributing factor and in which icing was not cited as a factor. In addition, the Board has investigated other events in which the drag associated with airframe ice and pilot inattention led to a critical loss of airspeed. Failure to maintain airspeed during these flights resulted in catastrophic and other unsafe circumstances, such as loss of control, impact with terrain or water, hard landings, and tail strikes.

A 1996 FAA Human Factors Team[6] Report titled, "The Interfaces Between Flight Crews and Modern Flight Deck Systems," expressed concern about the history of accidents involving lack of low-airspeed awareness in the context of flight crews monitoring automated systems. This report states the following:

> flight crews may not be provided adequate awareness of airplane energy state, particularly when approaching or trending toward a low energy state…Transport category airplanes are required to have adequate warnings of an impending stall, but at this point the airplane may already be in a potentially hazardous low energy state. Better awareness is needed of energy state trends such that flight crews are alerted prior to reaching a potentially hazardous low energy state.[7]

This accident history was also cited by the Flight Guidance System Harmonization Working Group of the Aviation Rulemaking Advisory Committee (ARAC), when, in March 2002, it proposed revisions to *Federal Aviation Regulations* (FAR) 25.1329 and Advisory Circular (AC) 25.1329[8] to provide low-airspeed protection and alerting during autopilot operations for newly certified transport-category airplanes. The proposed regulatory revision would require, "[w]hen the flight guidance system [FGS] is in use, a means…to avoid excursions beyond an acceptable margin from the speed range of the normal flight envelope." The proposed new AC, which is intended to provide an acceptable means for showing compliance with this new requirement, states the following:

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[6] This team comprised FAA and industry representatives.

[7] Federal Aviation Administration, Human Factors Team Report, *The Interfaces Between Flightcrews and Modern Flight Deck Systems* (Washington, DC: FAA, 1996).

[8] Similar changes were also proposed to *Joint Aviation Requirements* (JAR) 25.1329 and Advisory Circular Joint 25.1329. The FAR/JAR and ACs are currently titled, "Automatic Pilot System"; the proposed new titles would be "Flight Guidance System."

> The requirement for speed protection is based on the premise that reliance on flight crew attentiveness to airspeed indications, alone, during FGS…operation is not adequate to avoid unacceptable speed excursions outside the speed range of the normal flight envelope….Standard stall warning and high speed alerts are not always timely enough for the flight crew to intervene to prevent unacceptable speed excursions during FGS operation….A low speed alert and a transition to the speed protection mode at approximately 1.2 $V_{s,}$[9] or an equivalent speed defined in terms of $V_{sr,}$[10] for the landing flap configuration has been found to be acceptable.

The proposed changes to FAR 25.1329 reflect the advanced avionics capabilities characteristic of modern transport-category airplanes. However, the Safety Board notes that a low-airspeed alert system has been developed for Embraer EMB-120 airplanes; installation of the alert system was mandated by FAA Airworthiness Directive 2001-20-17.[11] The system is designed to alert flight crews of low-airspeed conditions in certain airplane configurations and in icing conditions through the use of an amber-colored indicator light installed in the control panel and an audible alert. The Board is also aware that several avionics manufacturers offer low-airspeed alert devices associated with approach and maneuvering speeds for use in less sophisticated general aviation airplanes. This demonstrates that it may be feasible to develop low-airspeed alert systems for most airplane types.

**Need for Improved Low-Airspeed Awareness**

The Safety Board recognizes that the development and requirement of a low-airspeed alert system is a departure from the previously accepted premise that adequate low-airspeed awareness is provided by flight crew vigilance and existing stall warnings. However, the circumstances of this accident and the history of accidents involving flight crew lack of low-airspeed awareness suggest that flight crew vigilance and existing stall warnings are inadequate to reliably prevent hazardous low-airspeed situations and that this unsafe condition is not unique to autopilot operations or flight in icing conditions. If a low-airspeed alert system had been installed on the accident airplane, it might have directed the attention of the accident flight crew to the airplane's decaying airspeed in time for them to initiate appropriate corrective action. For example, if a low-airspeed alert had activated when the airspeed dropped below 1.2 $V_s$ (about 92 knots for the accident airplane), the flight crew would have received about 15 seconds advance notice before reaching the airplane's estimated stall speed. In addition, if the flight crew had maintained an airspeed at or above the threshold set by such an early low-airspeed alert, the additional airspeed could have prevented an accelerated stall initiated by an abrupt last-second maneuver or provided an improved speed margin above a premature stall caused by ice accumulation on the wings.

This change in philosophy is evident in the ARAC's proposed changes to FAR 25.1329 and AC 25.1329, Embraer's requirement for a low-airspeed alert system on the EMB-120, and the fact that several avionics manufacturers offer low-airspeed alert devices for general aviation

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[9] $V_s$ is the stall speed or the minimum steady flight speed at which the airplane is controllable.

[10] $V_{sr}$ is the reference stall speed.

[11] This low-airspeed alert system was developed as a result of the January 9, 1997, accident involving Comair flight 3272, an EMB-120RT that crashed near Monroe, Michigan, during a rapid descent after an uncommanded roll excursion in icing conditions and the March 19, 2001, accident involving Comair flight 5054, an EMB-120 that departed controlled cruise flight and descended 10,000 feet after it encountered icing conditions.

airplanes. The Safety Board supports this change in philosophy. A low-airspeed alert associated with the minimum operationally acceptable speed for a particular phase of flight would likely help flight crews maintain airspeed awareness in much the same way that altitude alert systems help flight crews maintain altitude awareness. Enhanced airspeed awareness would also likely provide an additional safety margin against stall and loss of control events at low altitudes where recovery is difficult, as was the case in this accident.

The Safety Board recognizes that there are unresolved technical, operational, and human factors issues that will need to be carefully evaluated and addressed in connection with the design and implementation of a low-airspeed alert system.[12] The Board encourages the FAA to consult with representatives from the National Aeronautics and Space Administration (NASA) and other aviation industry specialists in resolving and addressing these issues. Despite these unresolved issues, the Safety Board concludes that the development of and requirement for the installation of low-airspeed alert systems could substantially reduce the number of accidents and incidents involving flight crew failure to maintain airspeed. Therefore, the Safety Board believes that the FAA should convene a panel of aircraft design, aviation operations, and aviation human factors specialists, including representatives from NASA, to determine whether a requirement for the installation of low-airspeed alert systems in airplanes engaged in commercial operations under 14 CFR Parts 121 and 135 would be feasible, and submit a report of the panel's findings. The Safety Board further recommends that if the requested panel determines that a requirement for the installation of low-airspeed alert systems in airplanes engaged in commercial operations under 14 CFR Parts 121 and 135 is feasible, the FAA should establish requirements for low-airspeed alert systems, based on the findings of this panel.

**Recommendations**

As a result of the investigation of the October 25, 2002, Aviation Charter, Inc., accident, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Conduct en route inspections and observe ground training, flight training, and proficiency checks at all 14 *Code of Federal Regulations* Part 135 on-demand charter operations as is done at Part 121 operations and Part 135 commuter operations to ensure the adequacy, quality, and standardization of pilot training and flight operations. (A-03-51)
>
> Require that 14 *Code of Federal Regulations* (CFR) Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement a Federal Aviation Administration-approved crew resource management training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O. (A-03-52)

[12] Some of the issues that should be addressed include the following: defining the target speed at which the alert system would activate, effectively integrating such a system with other aircraft systems, preventing nuisance alarms and flight crew over-reliance on such a system (see, for example, A.R. Pritchett, "Reviewing the Role of Cockpit Alerting Systems," *Human Factors and Aerospace Safety* Vol. 1, No. 1 [2001]: 5-38), differentiating such an alert from other kinds of cockpit alerts and warnings, and developing flight crew procedures on and training for the use of such systems.

Convene a panel of aircraft design, aviation operations, and aviation human factors specialists, including representatives from the National Aeronautics and Space Administration, to determine whether a requirement for the installation of low-airspeed alert systems in airplanes engaged in commercial operations under 14 *Code of Federal Regulations* Parts 121 and 135 would be feasible, and submit a report of the panel's findings. (A-03-53)

If the panel requested in Safety Recommendation A-03-53 determines that a requirement for the installation of low-airspeed alert systems in airplanes engaged in commercial operations under 14 *Code of Federal Regulations* Parts 121 and 135 is feasible, establish requirements for low-airspeed alert systems, based on the findings of this panel. (A-03-54)

Chairman ENGLEMAN, Vice Chairman ROSENKER, and Members CARMODY, GOGLIA, and HEALING concurred with these recommendations.

*Original Signed*

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Chairman