LTR 2524

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 31, 1994

In reply refer to: A-94-164 through -166

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On April 26, 1994, China Airlines flight 140, an Airbus A-300-600R, registration B-1816, crashed while on approach to the Nagoya/Komaki Airport, Nagoya, Japan. The airplane was destroyed. Of 271 persons on board the airplane, only 7 survived the accident.

The accident is being investigated by the Aircraft Accident Investigation Commission (JAAIC) of Japan. The Government of France, as the state of manufacture sent an Accredited Representative from the Bureau Enquetes-Accidents (BEA). The BEA Accredited Representative was accompanied to the accident scene by BEA technical specialists, representatives from the Direction Generale de L'Aviation Civile (DGAC) of France, and representatives from the Airbus Industries. The French investigative team worked closely with the JAAIC investigators and provided considerable technical knowledge on the airplane and its systems. DGAC was the authority in charge of certification of the A300. The Safety Board did not send a U.S. accredited representative to the accident scene. However, a representative from Pratt & Whitney, the manufacturer of the engines, was designated as the Safety Board's technical advisor and assisted the JAAIC in the investigation. The JAAIC shared the pertinent details of the investigation, including data from the cockpit voice recorder (CVR) and the flight data recorder (FDR), with the Safety Board's staff and the Pratt & Whitney representative. The data show that there were no failures of the airplane's engines, flight control systems, or structure; weather was not a factor; and the airplane was operating within the allowed weight and center of gravity limits.

The final report on this accident will be issued by the JAAIC, in accordance with Annex 13 to the Convention on International Civil Aviation. Additionally, the DGAC, as the certification authority, has informed the Safety Board that it is developing an airworthiness directive (AD) as a result of this accident. The issuance of an AD by the certification authority would require compliance by all operators of the A300. However, after reviewing the accident data, the Safety Board has concerns regarding the A300 autopilot system that it believes the Federal Aviation Administration (FAA) should address as soon as possible.

Examination of the FDR and CVR data indicate that the first officer was manually flying the airplane during the approach with the autopilot (AP) off. It is likely that the flight director (FD) and the autothrottle system (ATS) were engaged during the approach. The airplane was stabilized on the localizer and glideslope (G/S) with a power setting of 1.1 engine pressure ratio (EPR), until reaching 1,071 feet when the fuel flow values indicated the start of a power increase. Five seconds later, the airplane leveled off at about 1,030 feet as the EPR values reached 1.2. At this point in the flight, the CVR recorded the captain stating, "You have triggered the GO LEVER, retard a little and disengage." The Safety Board believes that this statement indicates that the first officer had inadvertently selected the autothrottle system to the "go-around" mode.

According to FDR data, the engine power initially began to increase and then decrease, indicating that the first officer retarded the throttle levers and likely disengaged the ATS. Disengaging the ATS would not have canceled the go-around (G/A) command. The airplane's altitude remained steady, not changing more than 4 feet, for the next 16 seconds. Nine seconds after leveling at 1,030 feet, the AP 1 and 2 Command Modes (CMD) were engaged. It is the Safety Board's understanding that under these circumstances, that is in the landing configuration and G/A mode having been selected, the AP would have engaged in the G/A mode, irrespective of the status of the ATS. Thus, once engaged, the AP will command the airplane to the G/A profile unless the pilot acts to select a different AP mode on the mode control panel. Approximately 3 seconds after the AP CMD was engaged, the trimmable horizontal stabilizer (THS) began moving in the airplane nose-up (ANU) direction from a previously steady value of 5.27°. This was coincident with the application of airplane nose-down (AND) elevator. At the end of the period of level flight, the G/S deviation values increased to full-scale deflection (high), the power was reduced to 1.03 EPR, and a descent resumed.

The THS moved continuously for 18 seconds in the ANU direction as the elevator angle increased in the AND direction, until the THS reached full travel (12.8°). The descent was continuous as the airplane approached the G/S, and the elevator angles remained at between 9 and 10° AND. The AP CMD mode remained engaged for 12 seconds after the THS reached full ANU travel.

As the airplane reached a point about one dot above the G/S, the CVR indicates that the captain called for the ATS to be engaged, and the call was followed by an increase in engine noise. The FDR data also recorded increasing engine thrust values followed by increased AND elevator angles that moved to full travel as the pitch attitude began to increase and the airplane began to climb. The CVR recorded the captain taking control and requesting the GO LEVER. The THS began to move in the nose-down direction as the pitch attitude reached 25°, EPR values increased to 1.6, and elevators remained at full travel AND. The slats and flaps began to transition "UP" as the pitch attitude reached 40° and the airspeed decreased to 115 knots. The maximum pitch attitude (52° ANU) was reached as the CVR recorded the sound of the stall warning, at which time the airspeed had decreased to 78 knots, and the THS had decreased to 7.38°. The airplane entered an aerodynamic stall at approximately 1,800 feet above ground level (agl), and the pilots were unable to regain control prior to striking the ground short of the runway.

Examination of the FDR data indicates that by manually overriding the autopilot commands, the flightcrew was able to maneuver the airplane to a position near the glideslope. However, when the captain decided to abort the landing and advanced the power levers, even with full AND elevator deflections, the combination of the thrust moment of the engines and the full ANU deflection of the THS resulted in a net ANU pitching moment.

The CVR transcript indicates that the flightcrew did not understand why the airplane was not responding to the control inputs, and, apparently, they did not realize that the autopilot was trimming ANU. The Safety Board notes that certain features of the A-300 AP/FD might have contributed to the crew's confusion. During manual flight, use of the pitch trim switches on the control wheel results in an audible "whooler" sound. The autotrim movement of the THS during AP engagement has no associated audible signal. In addition, the A-300 is not equipped with an out-of-trim warning light. Also, in most FD modes, activation of the pitch trim switches disengages the AP. However, in the "land" or "go-around" modes, the pitch trim switches neither disengage the AP nor move the THS.

Examination of the A-300 pilots' operating manual indicates that above 1,500 feet agl, a force on the control column of about 33 pounds will result in the disengagement of the autopilot. When the airplane is below 1,500 feet agl and in the land or go-around FD modes, the autopilot cannot be disengaged by a force on the control column; and, if the force is counter to the autopilot, the force will result in the THS moving in a direction opposite to the commands to the elevator. Pilots may not be aware of the trim movement with the autopilot in the land or go-around modes, since the movement of the THS manual trim wheel in the cockpit is essentially silent, and the pilots' trim switches on the control wheels are deactivated. The pilots' operating manual for the airplane provides that, except during the glideslope and localizer capture phase of the land mode, when a "Supervisory Override Function" permits the pilots to assert control movements to assist the AP in making a smooth capture, pilots should not attempt to override the autopilot. The manual further states that the airplane should either be operated in the manual mode or autopilot mode and that pilots should be aware when the autopilot is on and controlling the airplane.

The Safety Board has been informed of a previous occurrence of an A-310 autopilot trimming problem during a landing approach. On February 11, 1991, Interflugen flight V103, an Airbus A-310, experienced an upset while on final approach to Moscow, Russia. The flightcrew apparently did not realize that they were resisting the autopilot, which, in turn, was commanding the THS opposite to their elevator commands. The airplane experienced three severe pitch ups, and the airspeed dropped to a near stall at the peak of each maneuver. The airplane climbed above 1,500 feet agl on the first pitch up, thereby disengaging the autopilot. However, the crew was unaware of the THS position and encountered two additional pitch-up maneuvers before control was regained. Additionally, the Safety Board has been informed of a similar event that involved an A-300, operated by Eastern Airlines, while on approach to Atlanta in 1987. The Safety Board is attempting to confirm this report.

On June 24, 1993, Airbus Industries issued Service Bulletin (SB) A300-22-6021 providing for a modification to the flight control computer to change the software control laws for the A-300-600. This modification provides for the disengagement of the autopilot when a force of about 33 pounds is applied to the control column in the land or go-around modes above 400 feet agl. Below this altitude, the autopilot cannot be disengaged by a force on the control column. The manufacturer provides that below 400 feet, only slight inputs on the control column would be needed to refine the approach. Additionally, if a pilot tried to fight the

autopilot's inputs, the control forces should not become very high prior to landing. However, the Safety Board is concerned that the possibility still exists for a pilot-induced "runaway trim" situation at low altitude and that sufficient time would be available for the stabilizer to reach maximum up or down trim prior to the airplane landing. Such a situation could result in a stall or the airplane landing in a nose-down attitude.

The A-300 models affected by the SB are the B4-601, B4-603, B4-605R, B4-622, B4-622R, and C4-620. Airbus has stated that "due to significant differences in aircraft performance, go-around autopilot pitch control laws and autopilot interface (trim audible whooler signal, trim control, and autopilot logic)," a specific modification is not necessary for these older models. The Safety Board has been informed that a similar SB has been issued for the A-310. The Safety Board is uncertain whether a similar problem can exist on these other airplanes and believes that the FAA should examine the control laws and warning systems on all Airbus A-300 and A-310 models.

The Safety Board has determined that the autopilot systems used on airplanes produced by the Boeing Commercial Airplane Company and Douglas Aircraft Company will disconnect through several means, such as: a difference between pilot- and autopilot-commanded elevator positions; a pitch or roll force on the control column; cutout switches to interrupt the electrical stabilizer trim command when the control column is deflected a certain amount in a direction opposite to the horizontal stabilizer trim motion; activation of the stabilizer trim switch; or manual trimming of the stabilizer. Additionally, further protection is often provided by such means as a master caution warning light, engine indication and crew alerting system (EICAS) message, stabilizer motion warning horn, the visual and aural indication of the trim control wheel in motion, and inhibited autopilot nose-up trim in the go-around mode. It is noted that the disconnect and warning systems are fully functional, regardless of altitude, and with or without the autopilot in the land or go-around modes.

The Safety Board believes that the autopilot disconnect systems in the Airbus A-300 and A-310 are significantly different than the disconnect systems provided in other large transport-category airplanes. Additionally, the lack of a stabilizer-in-motion warning appears to be unique to the Airbus A-300 and A-310. The accident in Nagoya and the incident in Moscow indicate that pilots may not be aware that under some circumstances the autopilot will work against them if they try to manually control the airplane. Additionally, the A-300 and A-310 do not have the

autopilot disconnect safety features to alert pilots that the THS is moving to oppose their control command. It is probable that the accident in Nagoya would have been prevented if the autopilot had disconnected as the pilot pushed forward on the control column or if an alert had been provided that the THS was in motion.

The Safety Board believes that an airplane's systems should be designed with redundancy and fail-safe features so that one failure, omission, or lag in pilot reaction time does not result in the loss of an airplane. The Safety Board believes that the A-300 and A-310 series airplanes should be equipped so that the autopilot will disconnect if the pilot applies a specific input to the flight controls or trim system, regardless of the altitude or operating mode of the autopilot system, and that a perceptual alert is provided to the pilots that the THS is in motion.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require operators of the Airbus A-300 and A-310 series airplanes to provide immediate and recurrent training to flightcrews on the hazard of attempting to counter autopilot commands by manual control forces when the airplane is being flown with the autopilot engaged in the land or go-around mode. (Class II, Priority Action) (A-94-164)
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> Review the logic of the Airbus A-300 and A-310 series automatic flight control systems and require modification as necessary so that the autopilot will disconnect if the pilot applies a specified input to the flight controls or trim system, regardless of the altitude or operating mode of the autopilot. (Class II, Priority Action) (A-94-165)
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> Require modification of Airbus A-300 and A-310 series autopilot systems to ensure that the systems provide a sufficient perceptual alert when the trimmable horizontal stabilizer is in motion, irrespective of the source of the trim command. (Class II, Priority Action) (A-94-166)

Acting Chairman HALL, and Members LAUBER, HAMMERSCHMIDT, and VOGT concurred in these recommendations.

By: Jim Hall
Acting Chairman