National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: June 1, 2000

In reply refer to: A-00-41 through -45

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On February 9, 1998, a Boeing 727, registration No. N845AA, operating as American Airlines flight 1340, crashed short of the runway while on a coupled instrument landing system (ILS) category II approach to runway 14R at Chicago O'Hare International Airport (ORD). The approach was normal until the airplane passed through 200 feet above ground level (agl), where the airplane started a pitch oscillation that grew in time. The airplane descended below the ILS glide slope, then climbed above it, and finally descended below it again, impacting the ground 300 feet short of the runway threshold. Upon impact, the airplane slid over the threshold and then off the right side of the runway, where it came to rest. The airplane was extensively damaged, and 22 passengers and 1 flight attendant sustained minor injuries.

Flight 1340 was a regularly scheduled passenger flight from Kansas City, Missouri, to Chicago, Illinois. At the time of the approach, the ceiling was overcast at 100 feet, with visibility at 1/2 mile in freezing fog; the temperature and dew point were 28° F. The runway visual range (RVR) on runway 14R was 1,400 feet, variable to 1,800 feet. The surface wind was about 4 knots from the south. The weather minimums for the ILS category II approach to O'Hare runway 14R are a decision height of 110 feet radio altitude and an RVR of 1,200 feet. Thus, the ceiling and visibility were close to the category II minimums at the time of the accident.

A primary concern during the Safety Board's continuing investigation of the accident has been to determine the reasons for the pitch oscillations during the approach. Investigators are considering several possibilities, including flight control inputs by the autopilot. Test results indicate the existence of an autopilot system anomaly that, under certain conditions, can produce undesirable pitch oscillations in the 727.

Airplane damage precluded functional checks of the autopilot equipment while it remained onboard the airplane, so Safety Board investigators removed the Sperry Aerospace SP-150[1] autopilot components and bench tested them at the Honeywell, Inc.,[2] facility in Seattle,

[1] Boeing 727s may also be equipped with an older model autopilot, the Sperry SP-50. Although the autopilot installed on the accident airplane was an SP-150, this letter also addresses issues regarding the SP-50 autopilot.

[2] Honeywell, Inc., purchased Sperry Aerospace in 1986.

Washington. In addition, investigators installed and ground tested the navigational and autopilot equipment from N845AA in another 727 at the American Airlines facility in Tulsa, Oklahoma. Although the bench and airplane tests were satisfactory, the investigators discovered that a 1983 service bulletin (SB) issued by Sperry, to change the sensitivity schedule of the autopilot while in approach mode, had not been completed on the autopilot system installed in the accident airplane. Investigators explored the consequences of not changing the sensitivity schedule in a study that was performed using the 727 engineering simulator at the Boeing Company in Renton, Washington. The purpose of the simulator study was twofold: (1) to determine the stabilizer and elevator movements required to reproduce the motions of the accident airplane; and (2) to evaluate the autopilot performance during a coupled ILS approach using different autopilot sensitivity schedules, in conditions similar to those of the accident flight.

The engineering simulator uses mathematical models of the airplane aerodynamics, mass properties, and propulsion and flight control systems, together with models of Earth's gravity and atmosphere, to compute the trajectory and orientation of the airplane and its response to engine and flight control inputs. The simulator also contains mathematical models of the airplane's autopilot systems, which duplicate actual autopilot commands. The simulation incorporates these commands into its flight control models to compute control surface deflections and the resulting airplane motion.

The investigators were able to estimate the stabilizer and elevator movements during the accident scenario using information from the 727 engineering simulator and trim-in-motion sounds from the accident airplane's cockpit voice recorder. In addition, the simulator study showed that the autopilot sensitivity schedule has a significant effect on the autopilot performance during a coupled ILS approach.

The ILS provides electronic signals to guide the pilot (and autopilot) in flying the airplane to the runway. The localizer course[3] is usually aligned with the runway, and the localizer signal provides electronic angular horizontal displacement information to receivers on the airplane. Likewise, the glide slope is usually a 3° flight path to a point about 1,000 feet down the runway from the approach end. The glide slope signal provides electronic angular vertical displacement from the design flight path angle. The electronic signals are processed on the airplane; instruments indicate whether the airplane is on the localizer and glide slope, or indicate how much, and in which direction, the airplane has deviated from them. The information provided to the pilot via displays on the instrument panel, or directly to the autopilot, indicate whether the airplane should continue on course, or fly up, down, left, or right to get back on course.

Needle deflections on the instruments show how far the airplane has deviated from the localizer or glide slope. The amount of displacement is commonly expressed in "dots." For example, 1 dot of needle displacement indicates that the airplane is about 0.32° offset from the 3° glide slope. At the runway threshold, a 1-dot fly down position would indicate that the airplane was about 6 feet above the glide slope. At the outer marker, typically about 5 miles from the

[3] The path over the ground to the approach end of the runway.

runway, a 1-dot fly down would indicate that the airplane is about 200 feet above the glide slope even though the angular displacement would be the same for both cases.

If the airplane was at the outer marker, the autopilot would have to provide a certain level of elevator input to move the airplane from a 1-dot fly down position to being “on” the glide slope. However, at the runway threshold, the autopilot would have to provide for much less elevator correction for the same 1-dot indication because the actual vertical distance to be corrected is much less.

Because glide slope deviations close to the runway require smaller pitch corrections than those required far from the runway, the autopilot sensitivity has to be reduced as the airplane nears the runway. This process is called autopilot desensitization. The appropriate sensitivity depends on distance from the runway, but if the ILS does not provide distance measuring equipment (DME) information, there is no way to directly measure this distance. Therefore, to properly set, or schedule, the sensitivity, the distance from the runway must be estimated based on other, measurable parameters. One method of estimating distance from the runway is to continually use radio altitude and the geometrical relationship between altitude and distance for a glide slope of about 3°. As the radio altitude decreases, the airplane is assumed to be closer to the runway, and the autopilot sensitivity is reduced appropriately. This method will be in error when the terrain preceding the threshold has significant peaks or valleys, or if the glide slope differs significantly from the 3° or other angle assumed by the method. However, the method is not affected by the ground speed of the airplane.

Another way to estimate the distance from the threshold is to measure the time elapsed since passing a point of known distance from the runway, and then to calculate the distance traveled from that point by multiplying the measured time by an assumed ground speed. This time-based method was used by the Sperry SP-150 autopilot installed on the accident airplane (N845AA). The SP-150 is capable of scheduling the sensitivity based on radio altitude; however, the system on N845AA was set up to start desensitizing over a period of 150 seconds after passing through a radio altitude of 1,500 feet. During the 150 seconds, the autopilot sensitivity (or gain) would be reduced from a value of 1.0 to a value of 0.22. Upon receiving the middle marker signal on the ILS approach, the gain would further reduce to a value of about 0.055 over 30 seconds. If the middle marker signal is received before the gain reaches a value of 0.22, the gain will start to decrease at twice the original rate until reaching 0.22, and then it will continue to decrease to 0.055 over 30 seconds.

A characteristic of the time-based method of desensitizing the autopilot is that the gain will be scheduled properly only if the distance from the runway at 1,500 feet radio altitude is consistent with a 3° glide slope, and if the actual ground speed is relatively close to the ground speed the autopilot designers assumed when selecting the time period required for desensitization. If the ground speed is higher than the ground speed assumed in the autopilot design, the airplane will approach the runway before the desensitization period expires and the sensitivity will be higher than that intended by the design. If the ground speed is lower than the design ground speed, the autopilot will be desensitized when the airplane is still far from the runway and the sensitivity will be lower than that intended by the design.

The 150-second desensitization period used by the Sperry SP-50 and SP-150 autopilots was optimized for the approach airspeeds corresponding to a 40º flap setting. However, in the early 1980s, operators started landing the 727 at 30° flap settings and correspondingly higher airspeeds in order to improve the maneuverability of the airplane during the approach. American Airlines flight 1340 had 30° flap settings when it crashed during its approach. In November 1982 and February 1983, Sperry issued two SBs that described autopilot modifications to account for these new, higher approach airspeeds. The first, SB 21-1132-121 (issued November 23, 1982), advised operators to modify the vertical path couplers in SP-50 autopilots; the second, SB 21-1132-122 (issued February 7, 1983), contained identical language to advise operators to modify the pitch control channels in SP-150 autopilots:

> SP-150 gain programming as a function of time is too slow for the faster approach speeds used today. This modification produces a faster gain reduction for glide slope signals. Accomplishment of this modification is optional based on individual operator or industry experience.

The modifications described in the SBs reduce the time required for autopilot desensitization from 150 seconds to 105 seconds. Compliance with these SBs is optional, and SB 21-1132-122, which was applicable to N845AA, was not accomplished.

During the Safety Board investigation, an American Airlines captain described a pitch event experienced by another 727. In November 1997, that airplane was making a coupled ILS category II approach to runway 14R at Chicago O'Hare when, at about 250 feet, the crew felt a bump and the airplane pitched up in response to being slightly below the glide slope. The airplane climbed through the glide slope, and then pitched down severely to recapture the glide slope. The captain called for a go-around, and believing that there had been an infringement on the ILS critical area, came back for another approach. When the same bump was felt again, the captain executed an auto go-around and diverted to the alternate. This 727 also had a time-based autopilot with a 150-second desensitization period.

In the simulator study at Boeing, investigators compared the performance of autopilots with 150-second and 105-second desensitization periods by using the simulator to compute, for each system, autopilot commands and the resulting airplane response while on a coupled ILS approach at conditions similar to the 1998 accident flight. To exercise the autopilot and provide it with the task of returning to and maintaining the glide slope, investigators used a variety of methods to disturb the airplane from the glide slope centerline.[4] The simulator results show that at the approach speeds of the accident flight, the autopilot with the 150-second desensitization period responds to the disturbances by commanding oscillatory pitch changes that grow in time and result in significant deviations from the desired flight path. The altitude response computed by the simulator in these cases is very similar to that recorded by the accident airplane's digital flight data recorder.

[4] The methods included initially trimming to glide slope angles other than 3° or inducing turbulence or vertical wind gusts.

Although the Safety Board's investigation of the flight 1340 accident has not been completed, the 150-second desensitization schedule is considered a likely factor in the destabilized approach of the accident flight and in the reported pitch event that occurred in 1997. The Board is concerned that other 727s equipped with unmodified SP-50 and SP-150 autopilots could experience, in conditions similar to those of the accident flight, undesirable and potentially dangerous pitch changes during coupled ILS category II approaches. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should require operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to perform the modifications described in SB 21-1132-121 (for the SP-50 autopilots) and SB 21-1132-122 (for the SP-150 autopilots) if these 727 aircraft are used for coupled ILS category II approaches at flap settings less than 40°.

Simulator tests show that at the approach speed used on the accident flight, the autopilot can also command divergent oscillatory pitch changes with the 105-second desensitization period, although these diverged slowly and were always substantially less in magnitude than those resulting from the 150-second period. The resulting altitude deviations with the 105-second period were also substantially less than those resulting from the 150-second period. Nonetheless, the oscillations generated with the 105-second period occurred at an altitude just above the ILS decision height (at about 200 feet agl), and could alarm or distract pilots and destabilize the approach if encountered on an actual flight.

The Safety Board's investigation indicates that under the conditions of the accident flight, the performance of the Sperry autopilot with a 105-second desensitization schedule on coupled ILS approaches is superior to that of the autopilot with a 150-second desensitization schedule. However, even the autopilot with the 105-second desensitization period may exhibit unsatisfactory performance if it is not operated within the limitations of its design. The performance of the autopilot was not tested at approach speeds lower or higher than those of the accident flight; however, the characteristics of the time-based desensitization design and the simulator results suggest that if the approach speed were to increase, the 105-second period autopilot could be too sensitive near the runway, possibly resulting in the pitch oscillations and altitude deviations seen with the 150-second period autopilot at the original approach speed. At approach airspeeds less than that used on the accident flight (such as would be used at a full 40° flap deflection), the performance of the 150-second period autopilot could be superior to that of the 105-second period autopilot. These characteristics indicate that the appropriate desensitization period for the autopilot depends on the approach airspeed, which in turn depends on the flap setting used for the approach, among other factors (such as airplane gross weight and reported wind conditions).

The certification basis of the 727 equipped with Sperry autopilots is contained in Part 4b of the Civil Air Regulations (CAR), which date from 1953. Amendment 6 to Part 4b states in paragraph 4b.612(d) that

> The automatic pilot system shall be of such design and so adjusted that, within the range of adjustment available to the human pilot, it cannot produce hazardous loads on the airplane or create hazardous deviations in the flight path under any conditions of flight appropriate to its use either during normal operation or in the event of malfunctioning, assuming that corrective action is initiated within a reasonable period of time.

The divergent pitch oscillations near the ground that can result from Sperry 150 autopilot commands under conditions similar to the accident flight constitute hazardous deviations in the flight path. The Safety Board believes that the autopilot performance in such circumstances does not conform to the requirements of paragraph 4b.612(d). Further, the FAA-approved airplane flight manual for the 727 does not define operating limitations on coupled approaches with Sperry autopilots that would restrict their use to conditions for which the autopilots were designed and under which their performance is confirmed to be satisfactory and safe. Therefore, the Safety Board believes that FAA should develop sets of operating limitations for Sperry Aerospace SP-50 and SP-150 autopilots on coupled ILS approaches that are appropriate for the desensitization schedule used by these autopilots so that every possible desensitization schedule has a corresponding set of operating limitations. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. The Safety Board also believes that the FAA should advise all operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled ILS approaches at airspeeds that are not consistent with the desensitization schedule of the autopilots, and notify the operators that the FAA has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the autopilot design.

The Safety Board is further concerned that all autopilots currently utilizing time-based desensitization schedules on coupled ILS approaches may exhibit unsatisfactory performance when used with slower or faster approach speeds or other factors that were not envisioned during the original certification process. Therefore, the Safety Board believes that the FAA should review the certification of all autopilot systems that use time-based desensitization schedules and develop operating limitations, as necessary, for the use of these autopilots on coupled ILS approaches. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. The Safety Board further believes that the FAA should advise all operators of aircraft equipped with autopilot systems that use time-based desensitization schedules to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled ILS approaches at airspeeds that are not consistent with the autopilot desensitization schedule, and notify the operators that the FAA has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the design of the autopilot.

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

> Require operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to perform the modifications described in Sperry Service Bulletin (SB) 21-1132-121 (for SP-50 autopilots) and SB 21-1132-122 (for SP-150 autopilots) if these 727 aircraft are used for coupled instrument landing system category II approaches at flap settings less than 40°. (A-00-41)

> Develop sets of operating limitations for Sperry Aerospace SP-50 and SP-150 autopilots on coupled instrument landing system approaches that are appropriate for the desensitization schedules used by these autopilots so that every possible desensitization schedule has a corresponding set of operating limitations. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. (A-00-42)

> Advise all operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled instrument landing system approaches at airspeeds that are not consistent with the desensitization schedule of the autopilots, and notify the operators that the Federal Aviation Administration has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the autopilot design. (A-00-43)

> Review the certification of all autopilot systems that use time-based desensitization schedules and develop operating limitations, as necessary, for the use of these autopilots on coupled instrument landing system approaches. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. (A-00-44)

Advise all operators of aircraft equipped with autopilot systems that use time-based desensitization schedules to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled instrument landing approaches at airspeeds that are not consistent with the autopilot desensitization schedule, and notify the operators that the Federal Aviation Administration has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the design of the autopilot. (A-00-45)

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA and BLACK concurred in these recommendations.

By: Jim Hall
Chairman

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On February 9, 1998, a Boeing 727, registration No. N845AA, operating as American Airlines flight 1340, crashed short of the runway while on a coupled instrument landing system (ILS) category II approach to runway 14R at Chicago O'Hare International Airport (ORD). The approach was normal until the airplane passed through 200 feet above ground level (agl), where the airplane started a pitch oscillation that grew in time. The airplane descended below the ILS glide slope, then climbed above it, and finally descended below it again, impacting the ground 300 feet short of the runway threshold. Upon impact, the airplane slid over the threshold and then off the right side of the runway, where it came to rest. The airplane was extensively damaged, and 22 passengers and 1 flight attendant sustained minor injuries.

Flight 1340 was a regularly scheduled passenger flight from Kansas City, Missouri, to Chicago, Illinois. At the time of the approach, the ceiling was overcast at 100 feet, with visibility at 1/2 mile in freezing fog; the temperature and dew point were 28° F. The runway visual range (RVR) on runway 14R was 1,400 feet, variable to 1,800 feet. The surface wind was about 4 knots from the south. The weather minimums for the ILS category II approach to O'Hare runway 14R are a decision height of 110 feet radio altitude and an RVR of 1,200 feet. Thus, the ceiling and visibility were close to the category II minimums at the time of the accident.

A primary concern during the Safety Board's continuing investigation of the accident has been to determine the reasons for the pitch oscillations during the approach. Investigators are considering several possibilities, including flight control inputs by the autopilot. Test results indicate the existence of an autopilot system anomaly that, under certain conditions, can produce undesirable pitch oscillations in the 727.

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Washington. In addition, investigators installed and ground tested the navigational and autopilot equipment from N845AA in another 727 at the American Airlines facility in Tulsa, Oklahoma. Although the bench and airplane tests were satisfactory, the investigators discovered that a 1983 service bulletin (SB) issued by Sperry, to change the sensitivity schedule of the autopilot while in approach mode, had not been completed on the autopilot system installed in the accident airplane. Investigators explored the consequences of not changing the sensitivity schedule in a study that was performed using the 727 engineering simulator at the Boeing Company in Renton, Washington. The purpose of the simulator study was twofold: (1) to determine the stabilizer and elevator movements required to reproduce the motions of the accident airplane; and (2) to evaluate the autopilot performance during a coupled ILS approach using different autopilot sensitivity schedules, in conditions similar to those of the accident flight.

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A characteristic of the time-based method of desensitizing the autopilot is that the gain will be scheduled properly only if the distance from the runway at 1,500 feet radio altitude is consistent with a 3° glide slope, and if the actual ground speed is relatively close to the ground speed the autopilot designers assumed when selecting the time period required for desensitization. If the ground speed is higher than the ground speed assumed in the autopilot design, the airplane will approach the runway before the desensitization period expires and the sensitivity will be higher than that intended by the design. If the ground speed is lower than the design ground speed, the autopilot will be desensitized when the airplane is still far from the runway and the sensitivity will be lower than that intended by the design.

The 150-second desensitization period used by the Sperry SP-50 and SP-150 autopilots was optimized for the approach airspeeds corresponding to a 40º flap setting. However, in the early 1980s, operators started landing the 727 at 30° flap settings and correspondingly higher airspeeds in order to improve the maneuverability of the airplane during the approach. American Airlines flight 1340 had 30° flap settings when it crashed during its approach. In November 1982 and February 1983, Sperry issued two SBs that described autopilot modifications to account for these new, higher approach airspeeds. The first, SB 21-1132-121 (issued November 23, 1982), advised operators to modify the vertical path couplers in SP-50 autopilots; the second, SB 21-1132-122 (issued February 7, 1983), contained identical language to advise operators to modify the pitch control channels in SP-150 autopilots:

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Although the Safety Board's investigation of the flight 1340 accident has not been completed, the 150-second desensitization schedule is considered a likely factor in the destabilized approach of the accident flight and in the reported pitch event that occurred in 1997. The Board is concerned that other 727s equipped with unmodified SP-50 and SP-150 autopilots could experience, in conditions similar to those of the accident flight, undesirable and potentially dangerous pitch changes during coupled ILS category II approaches. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should require operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to perform the modifications described in SB 21-1132-121 (for the SP-50 autopilots) and SB 21-1132-122 (for the SP-150 autopilots) if these 727 aircraft are used for coupled ILS category II approaches at flap settings less than 40°.

Simulator tests show that at the approach speed used on the accident flight, the autopilot can also command divergent oscillatory pitch changes with the 105-second desensitization period, although these diverged slowly and were always substantially less in magnitude than those resulting from the 150-second period. The resulting altitude deviations with the 105-second period were also substantially less than those resulting from the 150-second period. Nonetheless, the oscillations generated with the 105-second period occurred at an altitude just above the ILS decision height (at about 200 feet agl), and could alarm or distract pilots and destabilize the approach if encountered on an actual flight.

The Safety Board's investigation indicates that under the conditions of the accident flight, the performance of the Sperry autopilot with a 105-second desensitization schedule on coupled ILS approaches is superior to that of the autopilot with a 150-second desensitization schedule. However, even the autopilot with the 105-second desensitization period may exhibit unsatisfactory performance if it is not operated within the limitations of its design. The performance of the autopilot was not tested at approach speeds lower or higher than those of the accident flight; however, the characteristics of the time-based desensitization design and the simulator results suggest that if the approach speed were to increase, the 105-second period autopilot could be too sensitive near the runway, possibly resulting in the pitch oscillations and altitude deviations seen with the 150-second period autopilot at the original approach speed. At approach airspeeds less than that used on the accident flight (such as would be used at a full 40° flap deflection), the performance of the 150-second period autopilot could be superior to that of the 105-second period autopilot. These characteristics indicate that the appropriate desensitization period for the autopilot depends on the approach airspeed, which in turn depends on the flap setting used for the approach, among other factors (such as airplane gross weight and reported wind conditions).

The certification basis of the 727 equipped with Sperry autopilots is contained in Part 4b of the Civil Air Regulations (CAR), which date from 1953. Amendment 6 to Part 4b states in paragraph 4b.612(d) that

> The automatic pilot system shall be of such design and so adjusted that, within the range of adjustment available to the human pilot, it cannot produce hazardous loads on the airplane or create hazardous deviations in the flight path under any conditions of flight appropriate to its use either during normal operation or in the event of malfunctioning, assuming that corrective action is initiated within a reasonable period of time.

The divergent pitch oscillations near the ground that can result from Sperry 150 autopilot commands under conditions similar to the accident flight constitute hazardous deviations in the flight path. The Safety Board believes that the autopilot performance in such circumstances does not conform to the requirements of paragraph 4b.612(d). Further, the FAA-approved airplane flight manual for the 727 does not define operating limitations on coupled approaches with Sperry autopilots that would restrict their use to conditions for which the autopilots were designed and under which their performance is confirmed to be satisfactory and safe. Therefore, the Safety Board believes that FAA should develop sets of operating limitations for Sperry Aerospace SP-50 and SP-150 autopilots on coupled ILS approaches that are appropriate for the desensitization schedule used by these autopilots so that every possible desensitization schedule has a corresponding set of operating limitations. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. The Safety Board also believes that the FAA should advise all operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled ILS approaches at airspeeds that are not consistent with the desensitization schedule of the autopilots, and notify the operators that the FAA has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the autopilot design.

The Safety Board is further concerned that all autopilots currently utilizing time-based desensitization schedules on coupled ILS approaches may exhibit unsatisfactory performance when used with slower or faster approach speeds or other factors that were not envisioned during the original certification process. Therefore, the Safety Board believes that the FAA should review the certification of all autopilot systems that use time-based desensitization schedules and develop operating limitations, as necessary, for the use of these autopilots on coupled ILS approaches. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. The Safety Board further believes that the FAA should advise all operators of aircraft equipped with autopilot systems that use time-based desensitization schedules to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled ILS approaches at airspeeds that are not consistent with the autopilot desensitization schedule, and notify the operators that the FAA has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the design of the autopilot.

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

> Require operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to perform the modifications described in Sperry Service Bulletin (SB) 21-1132-121 (for SP-50 autopilots) and SB 21-1132-122 (for SP-150 autopilots) if these 727 aircraft are used for coupled instrument landing system category II approaches at flap settings less than 40°. (A-00-41)

> Develop sets of operating limitations for Sperry Aerospace SP-50 and SP-150 autopilots on coupled instrument landing system approaches that are appropriate for the desensitization schedules used by these autopilots so that every possible desensitization schedule has a corresponding set of operating limitations. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. (A-00-42)

> Advise all operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled instrument landing system approaches at airspeeds that are not consistent with the desensitization schedule of the autopilots, and notify the operators that the Federal Aviation Administration has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the autopilot design. (A-00-43)

> Review the certification of all autopilot systems that use time-based desensitization schedules and develop operating limitations, as necessary, for the use of these autopilots on coupled instrument landing system approaches. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. (A-00-44)

Advise all operators of aircraft equipped with autopilot systems that use time-based desensitization schedules to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled instrument landing approaches at airspeeds that are not consistent with the autopilot desensitization schedule, and notify the operators that the Federal Aviation Administration has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the design of the autopilot. (A-00-45)

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA and BLACK concurred in these recommendations.

[Original Signed]

By: Jim Hall
Chairman