U.S. Summary Comments on Draft Final Report of Aircraft Accident
Turkish Airlines flight 1951, Boeing 737-800, TC-JGE
February 25, 2009, Amsterdam Schiphol Airport (EHAM)

INTRODUCTION

This letter and attachments relate to the investigation of the crash of Turkish Airlines flight 1951, a Boeing 737-800, which occurred on February 25, 2009, while on approach to runway 18R at Amsterdam Schiphol Airport (EHAM), Amsterdam, Netherlands. In accordance with Annex 13 to the Convention on International Civil Aviation, as the State of Design and Manufacture of the 737 airplane, a U.S. Accredited Representative and advisers[1] participated in the Dutch Safety Board (DSB) investigation. On December 21, 2009, the U.S. Accredited Representative received the DSB's draft final report. The U.S. investigative team's comments are submitted to the DSB pursuant to section 6.3 of Annex 13 to the Convention.

SUMMARY

In response to the accident notification, the U.S. Accredited Representative and advisors traveled to the Netherlands to assist with the DSB investigation. The U.S. team assisted with all aspects of the on-scene investigation including: flight crew operations, cockpit voice recorder, flight data recorder, powerplants, airplane structures, airplane systems, and survivability. The team participated in follow-on activities involving airworthiness issues and airplane performance and engineering simulation. The airworthiness investigation included extensive examination and testing of the radar altimeter systems, autothrottle systems, and FDR and historical data analysis. The airplane performance analysis was conducted to support a simulation of the accident approach using the Boeing engineering simulator (M-Cab) that combined the FDR and CVR data with the B737 aerodynamic data.

The draft report states that the captain's radio altimeter incorrectly indicated -8 during the approach, which during the final approach caused the autothrottle system to go into retard mode and commanded the throttles to idle. Post-accident examination and testing of the radio altimeter by the investigative team could not determine the cause of the radio altimeter system fault but did confirm that such a failure can result in observed behavior of the autothrottle. The U.S. team agrees with the DSB that modifications to the B737NG autothrottle system should be mandated, and a proposed recommendation is included at the end of this summary.

The radio altimeter failure and subsequent retard of the throttles was a significant factor in the accident. However, this accident resulted from multiple operational and system failures, and the draft DSB report does not adequately consider several factors that are essential to understanding how the accident occurred and ways to prevent its recurrence. This omission diminishes the effectiveness of the report, and does not adequately characterize the scope of the investigation, as

[1] Advisers to the U.S. Accredited Representative included representatives from the National Transportation Safety Board, Federal Aviation Administration, Boeing Commercial Airplanes, Honeywell, and CFM International.

the issues identified expand beyond the B737NG community, such as, airspeed awareness and approach-to-stall recovery training.

In addition, the U.S. team notes that the draft report does not align with the Annex 13 format recommended in ICAO Doc 9756, Manual of Aircraft Accident and Incident Investigation, Part IV, Reporting. The DSB's choice to deviate from established formatting conventions may also minimize the safety impact of the lessons learned from this accident.

The remainder of this letter describes the U.S. team's analysis of the available evidence and primary areas of technical concern with the DSB draft final report. The attachments to this letter provide specific comments, corrections and suggestions on the draft final report along with additional data that supports the analysis.

The U.S. team believes that the significant contributors to the accident included: (1) an unexpected change to the autothrottle mode caused by a faulty radio altimeter; (2) a poorly managed, non-stabilized approach that resulted in a high crew workload during a critical phase of flight; (3) the crew's subsequent failure to detect and respond to the decreasing airspeed and impending onset of the stick shaker during the final approach despite numerous indications; (4) the crew's failure to abort the unstabilized approach and initiate a go-around; and (5) after stick shaker onset, the captain's delayed thrust increase that then resulted in a fully developed aerodynamic stall and ground impact.

The U.S. team believes the following points are not properly developed, not properly emphasized, or are incorrectly analyzed in the draft final report:

1) the decision to continue the unstable approach contributed to inadequate monitoring of the approach as the airspeed decayed towards stick shaker
2) the airplane was easily recoverable if the crew had applied normal approach-to-stall recovery techniques when the stick shaker activated
3) the accident airplane had been operating with known, but unreported system failures
4) the radio altimeter system meets FAA certification criteria
5) the survival factors aspects of the accident are not adequately addressed

1) The decision to continue the unstable approach contributed to inadequate monitoring of the approach as the airspeed decayed towards stick shaker.

The accident occurred during the final approach to runway 18R at EHAM. FDR data indicates that the captain's radio altimeter was malfunctioning throughout the flight, which caused the autothrottle system to inappropriately transition to the "landing retard" mode and commanded the throttles to idle during the final approach. The airplane had been decelerating during the initial approach and as the airplane descended through about 760 feet the airspeed reached the selected approach reference speed (Vref) of 144 knots. Over the next 23 seconds, the airspeed decreased to 109 knots and the stickshaker activated.

Neither pilot detected the slowing airspeed in advance of the stick shaker. Both pilots should have been monitoring their primary flight display during the approach (the first officer as pilot flying and the captain providing backup as pilot monitoring). Furthermore, the safety pilot had the responsibility to provide additional backup and monitoring. Cues of slowing airspeed included:

- throttles in the idle position from top of descent to stickshaker (about 100 seconds)
- large number of trim wheel revolutions with associated aural feedback
- airspeed green trend vector bar pointing 10 knots down
- "amber band" low speed approaching the current airspeed
- box around the airspeed turned amber at 126 knots and flashed for 10 seconds
- red dashed "barber pole" stall warning indication approaching the current airspeed
- magenta MCP airspeed target box moving up away from the current airspeed
- airplane pitch attitude approaching the yellow pitch limit indication

Simulator observations demonstrated these cues were available to the pilots and, if heeded, allowed adequate time for the pilots to initiate corrective action. Possible reasons for the pilots' failure to recognize and respond to these cues were evaluated, including stabilized approach criteria, workload and monitoring, cockpit tone, and crew background.

<u>Stabilized Approach</u>

As the DSB draft report concludes, the accident flight did not meet the Turkish Airlines' stable approach criteria when it descended through 1,000 feet above ground level (AGL): the airplane was not in the landing configuration (flaps 15); the sink rate was greater than 1,000 feet per minute (1,300 fpm); and the landing checklist was not completed (started at 800 feet). Although the draft report makes this conclusion, the U.S. team is concerned that this issue is not emphasized on the basis that the airplane's energy was being managed well at 1000 feet. It is important to reinforce that being stabilized at 1000 feet not only ensures correct configuration and energy state at touchdown, but also is required so that pilots can fully monitor all aspects of the final approach. This is important since, as in this accident, the pilots must monitor the flight instruments as well as transition to flying visually as they break out of the clouds (600-800 feet AGL during the accident flight). This entire flight crew's ability to monitor the flight instruments, and detect decreasing airspeed in a timely manner, was affected by their performance of the landing checklists below 1000 feet in IMC – a time when the pilots' attention should be focused on the instruments and monitoring the approach.

A root cause analysis of this area should involve a detailed examination through interviews and manual reviews of the operator's safety department, training department, line operations, and management structure. The report indicates that the DSB conducted a review of Turkish Airlines' flight safety department and concludes that it "does not operate satisfactorily". It states that the airline does not monitor the flight data for stabilized approaches and flight mode annunciation changes. Monitoring flight data is only a way to ensure that procedures are being followed and is not, by itself, a training device.

There are several questions that should be answered regarding stabilized approaches, including: What stabilized approach training is provided to pilots? Is there a "no fault" go-around policy? How many go-arounds are executed each year? What crew resource management training is provided? These questions are pertinent because a stabilized approach allows the flight crew to concentrate on their primary tasks of monitoring airspeed and flight path with a minimum of distractions during the final approach.

The U.S. team recognizes that an in-depth operational factors investigation can be very difficult but nevertheless it is extremely integral and relevant in this accident. Even if additional information cannot be added regarding specific information, the team would encourage the DSB to include more information in the final report emphasizing the need for a stabilized approach. Specifically, that the purpose for having stabilized approach criteria is to provide pilots a quantitative means to determine whether they should or should not continue the approach, rather than relying on their judgment about whether it is possible to complete the approach. It also should be concluded that this flight crew should have initiated a go-around when they realized that they did not meet the stabilized approach criteria.

Airspeed Monitoring During the Final Approach

About 900 feet above ground level (AGL) at an airspeed of about 158 knots, the captain called for flaps 40 and the flaps began to transition to full extension. Two seconds later, the first officer called for the speed to be set and the autothrottle selected speed was adjusted to 141 knots and, after several seconds, advanced back to 144 knots. Five seconds later, about 800 feet AGL at an airspeed of about 153 knots, the captain stated that the landing checklist was not complete. The speed brake lever was then lifted by one of the pilots, however, both the “speed brake armed” and “speed brake do not arm” lights illuminated and the captain stated speed brake. The speed brake handle was then cycled twice over the next 4 seconds and both lights illuminated each time it was set to the arm position. The pilots’ statements and the repeated operation of the handle suggest that the captain recognized that the light configuration was an abnormal condition; however, no discussion referencing the abnormal procedure in the quick reference handbook followed. While this occurred, airspeed decreased from 150 to 142 knots (below the 144 knot Vref speed) indicating that the three pilots were likely distracted from monitoring the airspeed by this abnormal indication.

Both the captain and the first officer continued the landing checklist in a command-response manner as the airplane descended through about 600 feet AGL. Based on the weather reported in the area at the time of the accident, it is likely that visual contact with the runway environment or the ground occurred about this time. After the captain called 500 feet, the first officer called for the landing lights. Airspeed was 115 knots and the box around the airspeed display turned amber and started flashing and remained flashing until 1 second before the start of stickshaker. Following the 500 foot call, the captain asked that the cabin crew be warned and then the safety pilot made a public address (PA) announcement. Three seconds later, about 460 feet AGL and at an airspeed of about 109 knots, the stickshaker activated. The pilots’ activities conducting the landing checklist (including the safety pilots PA) and attempts to identify the runway environment as the aircraft began to descend below the reported ceilings likely distracted the pilots.

It is concluded that the entire flight crew’s abilities to monitor the flight instruments, and detect slowing airspeed in a timely manner, were affected by their performing the landing checklists below 1000 feet AGL in IMC – a time when crew attention should be focused on the instruments and monitoring the approach[2].

<u>Cockpit Tone (Crew Communication)</u>

It was the captain's responsibility to set the tone in the cockpit, and to manage communications and workload in a manner promoting adherence to standard operating procedures. This is especially true given that the first officer was new and operating under line flying under supervision (LIFUS) rules; therefore, the captain had a responsibility to not only provide oversight, but also to provide guidance and instruction to the first officer on normal line flying operations. However, the data show that the captain did not ensure that checklists, callouts, and adherence to normal operating procedures were maintained nor did he initiate appropriate discussion or non-normal situation management when system failures were identified.

The U.S. team examined the available data to determine why an experienced captain did not manage the cockpit environment effectively. In his role to provide instruction and guidance, the captain may have allowed the first officer to make procedural mistakes (not calling for checklists, late configuration changes, etc.) intending to discuss these errors during a debrief after the completion of the flight. Or, in his role as an examiner, he may have allowed the errors for evaluation purposes because the first officer was approaching his twentieth flight progress check. Regardless of the intent, the captain's failure to effectively manage the flight under these conditions showed poor judgment and an inappropriate instructor-student relationship.[3] The conduct of any revenue flight outside of standard operating procedures compromises safety.

This communication pattern led to breakdowns in checklist usage, standard callouts and recognition of non-normal situations. There is no evidence that the FO, as the pilot flying, initiated the Descent, Approach (at 10,000 feet), and Landing checklists as required by company procedures. The draft report does describe that an approach briefing was completed; however, it does not indicate if this was in conjunction with the descent checklist (since it is the last item on the checklist). In addition, as previously stated, the landing checklist was not initiated until below 1,000 feet AGL.

Similarly, the pilots did not make verbal callouts consistent with normally accepted procedures during the approach. Specifically, there were no callouts by either pilot as the airplane approached the selected altitude during the flight level changes, when the glideslope became active after they were cleared for the approach, or when changes occurred on the flight mode annunciator. The purpose for making callouts is to assist with maintaining situational awareness, monitoring of the flight data, and capturing errors before they are made. If the pilots had verbalized that the glideslope was active, before the localizer was captured, it may have

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[2] The U.S. team notes that the lack of emphasis on this aspect in this report is inconsistent with previously published DSB reports given that previous DSB reports dealing with airplane stall accidents on a wide range of aircraft types have consistently commented on the pilot's responsibility to monitor airspeed.

[3] It is possible that the performance demonstrated by the captain on the accident flight was characteristic. However, the investigation did not obtain sufficient data from which to determine whether it was. For example, interviews with other crewmembers and evaluation of the operator's normal practices on the line were not presented in the draft report nor provided to the U.S. Accredited Representative.

reinforced that they were close to landing and possibly triggered them to initiate the landing checklist and slow the airplane for the approach (FDR data indicate that the airplane was at flaps 1, 195 knots, and about 8.5 nm from the threshold).

The pilots also exhibited poor recognition and response to several non-normal indications during the approach. This was exhibited first when the landing gear configuration warning sounded several times as the airplane was descending through FL100. During this abnormal warning, the captain acknowledged the radio altimeter was not reliable but did not discuss the potential effects on the aircraft automatic flight systems or on the approach and did not raise awareness to the first officer that the left radio altimeter was not reliable and should not be referenced during the approach. The safety pilot reiterated the radio altimeter failure later in the approach after the airplane had captured the glideslope. Again, the captain acknowledged but did not discuss the airplane's reduced system capability.

Another example of poor recognition of and response to non-normal situations occurred when the first officer attempted to arm the autopilot for the approach. After the flight was cleared for the approach, the first officer attempted to engage the second autopilot to conduct a dual channel approach. However, he selected approach mode button and left autopilot button in the wrong order. As a result, the right (active) autopilot disconnected and the autopilot disconnect warning sounded. Three seconds later, the right autopilot was reengaged followed by the approach mode button; however, there was no discussion between the pilots as to why the disconnect occurred. More importantly, there was no discussion about proceeding with a single channel approach instead of dual channel approach, despite the persistence of the amber "SINGLE CH" indication on the primary flight display.

This error was significant, because had the autopilot been properly engaged in dual channel mode, the left radio altimeter fault would have resulted in a dual channel autopilot disconnect and aural warning, thereby providing the crew yet another indication that their automatic flight systems were not operating properly and should not have been relied on.

The final instance of poor recognition of and response to non-normal situations occurred as the airplane descended through 800 feet AGL when the pilots attempted to arm the speed brake handle for landing. Although evidence indicates that the captain understood this was not correct, there was no active discussion of the fault, nor did he mention the non-normal procedure associated with the "speed brake do not arm" light that is contained in the quick reference handbook. More importantly, normally accepted procedures require a go-around if a system failure is observed during the final approach where resolution would distract from normal monitoring duties. Ultimately, the flight crew accepted this and other abnormal conditions and continued with the approach without understanding its effect on the landing.

<u>Background of the Flight Crew</u>

Another important aspect to understanding a flight crew's performance during an accident is to understand their training histories and recent duty and sleep activities. The DSB draft report does not contain, nor was the U.S. team provided, a significant amount of information regarding the pilots' training history or company procedures. The draft report only addresses two areas: the lack of approach to stall training requirements and the inconsistent practices within the

Turkish Airlines pilot community regarding mode annunciator callouts. However, the team does not believe these areas are sufficiently developed or emphasized in the conclusions consistent with their role in safe operating practices.

Other questions regarding training that were asked by the U.S. team during the investigation but were not answered include: What techniques are taught during approach to stall training (e.g. hand position)? What are the policies and procedures regarding use of the autothrottle (e.g. guarding of the throttle on approach)? What are the policies and procedures regarding altitude changes and approach callouts? Is there specific training for captains on conducting line training? What are the policies and procedures regarding operation of the speed brake handle and lights prior to landing? What are the policies and procedures for autopilot approach procedures?

The draft report also does not contain any information regarding the pilots' duty and sleep periods prior to the accident flight. Typically, investigations attempt to define the pilot histories for the previous 72-hours prior to the accident. This information assists in understanding any possible role of fatigue had on the pilots' performance during the accident. In this accident, some of the pilots' performance errors could be consistent with the known effects of fatigue. Therefore, fatigue effects should be considered in the investigation, since the pilots' performance breakdowns during the accident flight are uncharacteristic of normal air carrier operations.

2) The airplane was easily recoverable if the crew had applied normal approach-to-stall recovery techniques when the stick shaker activated.

When the stickshaker activated, the first officer appropriately applied forward pressure on the control column and started to advance the thrust levers. The captain then declared he had control of the airplane and the first officer released the column and thrust levers. It can also be concluded that the captain placed both hands on the control wheel because the thrust levers subsequently retarded to idle because the autothrottle was still engaged. The thrust levers were not increased to full until 9 seconds after the start of stickshaker. In addition, the autopilot remained engaged for 6 seconds.

The U.S. team agrees with the DSB that the captain was surprised by the stickshaker activation. His actions were not consistent with trained procedures or an established habit pattern. As noted in the draft report, JAR OPS-1 only requires approach to stall training for a pilot's initial type rating and not for recurrent training and that Turkish Airlines training curriculum follows this guideline. The U.S. team agrees with the DSB conclusion that the JAR OPS-1 requirements are inadequate. In addition, due to several other recent accidents involving stickshaker activation with the autopilot engaged, the U.S. team would encourage expanding the recommendation to include "scenario based stall training".

To understand and evaluate the operational factors and airplane performance aspects of the accident, the investigation team conducted a simulator study using the Boeing Multi-Purpose Engineering Cab Simulator (M-Cab), which is a 6-degree of freedom motion engineering simulator. A summary of the findings and data collected during the simulator runs is provided in attachment 2 to this letter.

The M-Cab simulation showed that the airplane was easily recoverable if normal stall recovery techniques were initiated within a few seconds of stick shaker activation. In the simulation, thrust application was delayed for three seconds to provide for startle/recognition time. In each recovery, the stick forces were low, even if retrimming was delayed. In addition, several runs were conducted using a single-channel autopilot engaged and full thrust applied at stickshaker. Although the initial descent was arrested, the autopilot did not have enough authority to counter the full thrust and full nose-up stabilizer trim and pilot intervention was necessary. Reducing the thrust or having the pilot disconnect the autopilot allowed the recovery to successfully continue.

Airplane performance data show that, once an airplane exceeds the critical angle of attack where maximum lift is being generated the wing will stall and lift will significantly decrease. Based on data for the accident flight, this occurred between 4 and 6 seconds after stick shaker activation (between the time of autothrottle disengagement and autopilot disengagement). After this point, the accident airplane would have had insufficient altitude to recover given its altitude. However, the time window prior to the onset of full stall was more than adequate to allow the execution of the appropriate control inputs.

3) The accident airplane had been operating with known, but unreported, system failures.

The DSB draft report includes a section titled, “History of radio altimeter failures”; however, there is no discussion of the FDR data recovered from the accident airplane. The accident FDR contains the nine previous flights before the accident flight. In each flight, there is evidence that the captain’s radio altimeter had malfunctioned. More importantly, there were two flights that experienced inappropriate autothrottle retard events similar to the accident flight. On one of these events, the flight crew allowed the airspeed to decrease below their selected speed by about 20 knots before recovering. None of the radio altimeter failures or two autothrottle retard events were included in the airplane maintenance log by the flight crews. Had these events been written up by the pilots, the subsequent flights would have been required to operate under the Dispatch Deviations Guide which states that the corresponding autopilot and autothrottle may not be used for the approach and landing phase of flight.

In addition, although the draft report states that there were similar radio altimeter failures on 148 flights out of the 1,143 flights stored on the quick access recorder, it does not document that most of these malfunctions were also not recorded in the airplane log book by the flight crews. Although the report states that flight crews were not informed of the radio altimeter maintenance problems, it does not mention that maintenance crews were also not informed of the radio altimeter flight problems, nor does it expand on what effect these shortcomings had on the accident. The U.S. team believes that this data supports the DSB conclusion that the Turkish Airlines safety management system did not operate satisfactorily and that the maintenance practices at the airline did not promote identification of in-service deficiencies.

4) The radio altimeter system meets FAA certification criteria.

The U.S. team does not agree with the DSB conclusion that the radio altimeter system does not meet FAA federal aviation regulations (FAR). The draft report suggests that the radio altimeter was providing erroneous data but not failed. This is incorrect because the radio altimeter system was in a failed state because it was providing erroneous data.

The U.S. team believes that the DSB is misinterpreting the certification regulations. For the purposes of determining compliance with FAR 25.1301, proper function of a radio altimeter system is described in Advisory Circular (AC) 25-7A, Sec. 170 (e) (5). The 737NG's radio altimeter system meets the criteria set forth in that section, within the reliability requirements established by FAR 25.1309(b), even considering the known in-service issues discussed in the DSB draft report. In addition, the intent of FAR 25.1431 is to prohibit adverse interactions between communications and navigation systems (e.g., RF emissions or naturally emitted electrical "noise"). Although malfunction of the radio altimeter system may adversely influence the operation of the autothrottle, it is not correct to interpret FAR 25.1431 as prohibiting the type of effect observed in the accident, given the other indications and airmanship responsibilities discussed below.

In looking at FAR 25.1309, it is important to look at the entire regulation as well as AC 25.1309-1A. FAR 25.1309(c) states that the equipment must provide warning to the crew when unsafe system operation is detected so that they may take appropriate action. Expanding on this, the AC states that these warnings or indications may either be natural (inherent) or designed into a system and should be timely, rousing, obvious, clear, and unambiguous in time to allow the crew to take appropriate corrective action. It also states that corrective procedures should be provided in the flight manual—unless they are accepted as normal airmanship. In addition, AC 25-7A requires that, crews have adequate time to take corrective action that might be necessary as a result of failure conditions being evaluated under FAR 25.1309.

Taking these regulations and advisory material into account, the following conclusions can be made: 1) failure of the radio altimeter was identified by the flight crew; 2) the effect of the failed radio altimeter caused the autothrottle system to command the thrust levers to idle; 3) there were inherent timely, obvious, clear, and unambiguous system and performance indications to the flight crew of this state, primarily the loss of airspeed and attendant non-normal indications and throttle position; 4) indications were provided at a point where the airplane's capability and the crew's ability still remained sufficient for appropriate corrective crew action to have taken place; 5) there was no impact on the ability of the crew to operate the airplane since the crew could advance the throttles (even without disconnecting the autothrottle); and 6) the corrective actions required by the crew would be considered normal airmanship (i.e. part of standard pilot skills tests) since airspeed monitoring is required for normal flight.

The U.S. team also disagrees with the statement in section 5.12.1 that the radio altimeter was certified based on zero errors. Rather, the radio altimeter was originally certified that no single faults within the computer would result in erroneous radio altitude indications. The original analysis conducted for certification did not take into account that faults in the antennas and cables could result in erroneous radio altitude readings. As a result, the original analysis did overestimate the reliability of the radio altimeter system. However, analysis of the system reliability subsequent to the accident show that the rate of erroneous readings from the radio altimeter system remains less than the rate required by the regulations, when the antenna and cable faults are taken into account.

Therefore, the U.S. team believes that the radio altimeter system complies with all certification requirements. However, the team agrees with the DSB that modifications to the B737NG autothrottle system should be pursued to enhance safety and have included a recommendation at the end of this summary.

5) The survival factors aspects of the accident are not adequately addressed.

During the on-scene investigation phase of the accident, substantial data was collected regarding seat damage, floorboard deformation, overhead bins and passenger service units (PSU). While there is some discussion in the draft report regarding survival factors, it lacks detailed analysis of the data related to the design standards and safety implications for the cabin interior. This data is extremely valuable to the international aviation community, since it is a rare occurrence that the data is preserved enough to be documented in such detail. Often, aircraft accidents involve fire damage and/or impact damage that limit the amount of cabin interior data collection available. However, this accident did not display either of these limiting factors for data collection. This is especially significant given the impact sequence and relatively few fatalities.

Since the DSB report will not be including detailed analysis of the data collected pertaining to seats (crew and passenger), seat tracks, seat belts, overhead bins, and PSUs, the U.S. team would encourage the DSB make this data available to the industry so that a full analysis could be completed. This would include a more detailed database of the passenger injuries and autopsy results since the information provided by the Injury Severity Score (ISS) does not provide sufficient detail. As an example, the report states that there were numerous spinal column injuries, which could include a number of related injuries like compression, fractures, strains, etc. Additional details of the passenger injuries would be invaluable in relating the cabin damage to the specific injuries suffered by the passengers.

PROPOSED RECOMMENDATIONS

To the International Civil Aviation Organization (ICAO), European Aviation Safety Agency (EASA), U.S. Federal Aviation Administration (FAA), and Turkish Director General of Civil Aviation (DGCA):

1. Require operators and training centers to develop and conduct training that incorporates approach to stall training that is unexpected and involves autopilot and/or autothrottle disengagement.

To the ICAO, EASA, and Turkish DGCA:

2. Modify recurrent training requirements to include approach to stall training that is unexpected and involves autopilot and/or autothrottle disengagement.

To the U.S. FAA, EASA, and Turkish DGAC:

3. Require modification and installation of the Boeing 737NG autothrottle systems to include a radio altimeter comparator function
4. Require operators to install a low-airspeed alert system that provide pilots with redundant aural and visual warnings of an impending hazardous low-speed condition.

To the Boeing Company:

5. Conduct further engineering assessment of the Boeing 737NG RA systems to improve reliability
6. Review and modify approach to stall recovery procedures

To the IVW:

7. Require Air Traffic Control in the Netherlands to modify intercept procedures to comply with ICAO requirements
8. Inform controllers of stabilized approach criteria and how it relates to accident prevention

To Turkish DGCA:

9. Review guidance to LIFUS instructors on prioritizing airplane safety over the duties of training
10. Review reporting at Turkish Airlines to ensure flight crews are reporting all faults, failures, malfunctions and defects.