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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

HUMAN PERFORMANCE GROUP CHAIRMAN'S FACTUAL REPORT SECOND ADDENDUM

(27 PAGES)

By: Malcolm Brenner

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY (AS-50)
Washington, D.C. 20594

October 5, 1995

HUMAN PERFORMANCE GROUP
GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION

SECOND ADDENDUM

A. ACCIDENT: DCA-94-MA-076

Location: Aliquippa, Pennsylvania
Date: September 8, 1994
Time: 1904 Eastern Daylight Time
Airplane: Boeing 737-300, N513AU

B. HUMAN PERFORMANCE GROUP

Chairman: Malcolm Brenner, Ph.D.
National Transportation Safety Board

Members: Captain Charles F. Leonard
National Transportation Safety Board

Captain Robert L. Sumwalt
Air Line Pilots Association -- USAir

R. Curtis Graeber, Ph.D.
Boeing Commercial Airplane Group

Captain Mike Carriker
Boeing Commercial Airplane Group

Captain Paul Sturpe
USAir

Peter J. Lambrou, M.D.
USAir

Phyllis Kayton, Ph.D.
Federal Aviation Administration

Chuck DeJohn, D.O.
Federal Aviation Administration

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C. SUMMARY

On September 8, 1994, at 1904 Eastern Daylight time USAir flight 427, a Boeing 737-300, N513AU, crashed while maneuvering to land at Pittsburgh International Airport (PIT), Pittsburgh, Pennsylvania. The airplane was being operated on an instrument flight rules (IFR) flight plan under the provisions of Title 14, Code of Federal Regulation (CFR), Part 121, on a regularly scheduled flight from Chicago-O'Hare International Airport, Chicago, Illinois, to Pittsburgh. The airplane was destroyed by impact forces and fire near Aliquippa, Pennsylvania. All 132 persons on board the airplane were fatally injured.

D. DETAILS OF INVESTIGATION

This report continues work reported earlier in the Human Performance Group Factual Report dated October 31, 1994 and the Addendum dated December 14, 1994. [At the time of the earlier reports, the Human Performance Group operated as a Sub-Group of the Operations Group. Thereafter, it became a separate Group, and this change is reflected in the title of the present report when compared to the earlier ones.]

Additional information was obtained relevant to the actions of the pilots in the final moments of the flight, the backgrounds of the pilots, and related areas.

1. Seat positions of the pilots

Identifiable sections of the seat tracks for both the captain and first officer were obtained from the wreckage and were examined by the Structures Group. No determination could be made of the actual seat position for either pilot.

2. Rudder pedal damage pattern

According to the NTSB Metallurgist's Factual Report, damage to the rudder pedal structures, as observed in the wreckage, included a shearing of the shafts for the left rudder pedals used by both pilots. There was no such shearing of the shafts for the right pedals.

The Human Performance Group met in June, 1995, with David Hause, M.D., Deputy Medical Examiner, Office of the Armed Forces Medical Examiner of the Armed Forces Institute of Pathology (AFIP), to determine whether this damage pattern provided information on pilot rudder use. Based on a review of the

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metallurgical and other available evidence, Dr. Hause provided the following opinion:

The symmetrical pattern of rudder pedal fractures suggests a similar extension of the legs of both crewmembers, probably with both left legs extended and in contact with the rudder pedals, at the time of impact.

3. Position of traffic relative to the pilots

As the emergency sequence began, the first officer was speaking aloud to indicate that he had visually acquired the Jetstream that had been called as traffic. NTSB/Boeing calculations determined that, at the time of the comment, the viewing angle to the Jetstream would have been about 37 degrees to the right and 17 degrees below the standard airplane eye reference point. Cockpit visibility analysis indicated that the Jetstream should have been visible through the forward lower quadrant of the first officer's #2 window if the first officer's eyes were at the design position.

4. Disorientation/Vestibular effects

An expert on disorientation/vestibular effects, Dr. Malcolm Cohen of the NASA-Ames Research Center, was asked to provide an opinion on the likelihood that disorientation/vestibular effects acted as a factor in the pilots' actions during the upset sequence. Dr. Cohen examined relevant information from the investigation. In conjunction with the Human Performance Group, he underwent repeated simulations of the upset sequence on the NASA Vertical Motion Simulator (VMS) that used large physical motions to produce a high fidelity reconstruction of the acceleration forces in the upset sequence. Dr. Cohen experienced the simulations in a variety of formats, including an initial one in which he was exposed to motion cues only and no visual cues. A letter summarizing Dr. Cohen's conclusions is included as Attachment 1.

5. Microphone signatures on the cockpit voice recording (CVR)

The NTSB Speech Laboratory examined microphone signatures on the CVR indicating air-to-ground radio transmissions during the emergency period. Microphones can be keyed inadvertently during emergencies because a microphone switch is located on each control wheel. Inadvertent activation can be a secondary indicator that a pilot was holding the control wheel.

The senior audio technician of the Speech Laboratory examined in May, 1995, the "hot microphone" channels of the CVR for microphone signatures. They were identified by transient amplitude spikes produced when the microphone biasing relay closed, and by the presence or absence of a sidetone on the channel.

In the case of the captain, there was a single microphone signature on his channel during the upset period. The microphone went on at 1903:15.0 and off at 1903:16.5, corresponding to a radio transmission by the captain.

In the case of the first officer, there were multiple microphone signatures on his channel, as follows:

On	Off	
1903:09.4	1903:09.5	
1903:09.7	1903:11.6	
1903:11.8	1903:12.3	
1903.13.7	1903:15.2	
1903:16.7	1903:20.7	
1903:20.9	1903:21.7	
1903:21.7	1903:22.8	[end of the recording]

6. Medical claims history

A review was completed by group members (Malcolm Brenner, Ph.D.; Peter J. Lambrou, M.D.; Chuck DeJohn, D.O.) of the medical records of the company-sponsored insurance carrier. During the five years prior to the accident, the first officer submitted no medical claims. During the same period, the claims submitted by the captain indicated no significant illnesses or hospitalizations, with the exception of the back surgery as described in the Human Performance Factual Report. The investigation revealed no evidence of any active or pre-existing medical conditions that would have affected the performance of the flightcrew.

Group members conducted a telephone interview with the captain's allergist. The doctor reported that the captain received regular allergy shots for environmental allergens. He stated that the captain's clinical symptoms, consisting of sneezing, runny nose, and post-nasal drip, were mild and responded well to treatment. The captain's last allergy shot was administered in August, 1994, and his treatment was current at the time of the accident.

7. U.S. Air Force (USAF) flight records for the captain

According to a representative, contacted by the NTSB in May, 1995, all USAF flight records prior to September 3, 1975, had been destroyed. Flight records covering the period September 3, 1975 to March 15, 1979 were obtained for Captain Germano.

According to the records, the captain underwent pilot training as a member of the Air National Guard (ANG). He completed undergraduate pilot training in December 1973, and returned to his ANG unit. The only airplane that he flew during this time was the O-2, which he began flying in February 1974. This was the military version of the Cessna 337 and was used for forward air controller missions. It was not an aerobatic airplane.

His records showed the following flight hours as of the last entry:

* Total flight time....893.6 hours
* PIC " " ....535.2 "
* Co-pilot " " ....132.2 "
* Student " " ....226.2 "

There were no evaluations, check rides, incidents, or accidents indicated on this record. No comments of any type were noted.

8. Braniff Airways, Inc., company records for Captain Germano

Records for Captain Germano's tenure at Braniff Airways, Inc., were provided to the NTSB by Dalfort Aviation, Dallas, Tx, which is the custodian of the Braniff Airways records. The records represented all those that the company was able to locate in their archives.

The information provided pertained to Captain Germano's new-hire status with the airline, including his initial assignment as a DC-8 flight engineer. Also, attendance sheets for the ground school and recurrent training were included. One sheet showed the captain's employment date as October 17, 1977, and a RIF (reduction-in-force) date of December 1, 1980. The captain, who was hired by USAir on February 4, 1981, submitted a resignation letter to Braniff on February, 4, 1982. In the remarks section, following the notation of his resignation, was entered the comment: Rehire: yes.

The records contained no evaluations or comments concerning check rides or other performance criteria.

9. Pilot log records for First Officer Emmett

The wife of First Officer Emmett, according to a family representative, was not aware of any aerobatic experience by her husband. To her knowledge, he never owned an aerobatic airplane, never participated in aerobatic activities, and never performed cropdusting.

The first officer's logbooks, provided by the family in response to a request from the NTSB, covered the period from June 6, 1970, until February 2, 1988. They included his initial flight training and ended when his total flight time was 1336 hours. The logbooks included no airline flying by the first officer (who was hired by Piedmont Airlines in February, 1987). The logbooks were notable for the detailed documentation of the flights, including descriptions in the remarks section of the maneuvers performed on each flight.

According to the logbook entries, the first officer had flown 41 different makes/models of aircraft. All were civilian, general aviation airplanes of which one, the PT-17 (Stearman), was an aerobatic-capable airplane. He logged 9.3 hours in the PT-17, but, in the remarks section of the logbook, made no reference to performing aerobatic maneuvers on these flights. There was no record of any cropdusting flying by the first officer.

10. Recommended operational procedures.

The Human Performance Group prepared written questions concerning recommended operational procedures related to the upset situation. These questions were answered by the USAir Standards/Training Department and by the Boeing Commercial Airplane Group. Their answers are included as Attachments 2 and 3 respectively.

11. Interview of preceding B-727 pilot

A group member (Ca[t. Charles F. Leonard) conducted a telephone interview in May, 1995, with the captain of Delta Airlines Flight 1083, a Boeing 727 airplane that was sequenced immediately ahead of the accident airplane in the landing pattern at PIT. The captain stated, without hesitation, that the horizon was clearly defined on the evening of the accident. There was no restriction to visibility.

12. Interview of Southwest Airlines crew involved in upset

The Human Performance Group conducted telephone interviews in May, 1995, with the captain and first officer of a Southwest Airlines B-737 flight involved in an uncommanded roll incident on March 29, 1995. The incident is documented in material collected by the Performance Group. The crewmembers provided the following information:

Both pilots had their feet on the floor prior to the incident, but almost immediately put their feet on the pedals when the incident began. The captain thought the pedals were centered. The first officer thought the pedals were not centered but could not say which way they were displaced.

Both pilots perceived that this was a wake turbulence encounter. The captain thought that the plane would roll "on its back" if left unchecked; the first officer thought the roll rate was three to five degrees per second up to fifteen degrees bank angle. It was approximately three seconds until the autopilot was disconnected. The first officer thought he added "right rudder" to correct a left yaw. The captain added "1/4 left rudder" with no effect.

The pilots checked the yaw damper indicator, disconnected the yaw damper, and the incident ended. They had received the latest yaw damper emergency procedure.

13. Written responses of crew involved in Richmond incident.

The Human Performance Group prepared written questions for the captain and first officer of a USAir B-737 flight involved in a roll incident on July 25, 1995. The incident is documented in the material collected by the Performance Group. The questions were developed to elicit an elaboration of the available information, and the answers provided by the pilots are included as Attachment 4 [in preparation].

14. Interview of the eyewitness who reported smoke.

Two group members (Malcolm Brenner, Ph.D.; Captain Charles F. Leonard) conducted a telephone interview in June, 1995, of Fred Piccirilli, an eyewitness to the accident who reported seeing smoke from the airplane prior to impact. Mr. Piccirilli was previously interviewed in person on September 12, 1994 by a team that included Human Performance Group members (Malcolm Brenner, Ph.D.; Capt. Robert Sumwalt, Peter J. Lambrou, M.D.). A signed statement by Mr. Piccirilli, prepared on September 9,

1994, is included in the Witness Group Chairman's Factual Report.

Information provided by Mr. Piccirilli in the telephone interview was nearly identical to that from the earlier group interview, and provided some elaboration on information provided in the signed statement concerning smoke observation, as follows:

The smoke was observed just forward of the right wing, about 3/4 of the way back from the service door to the wing, and became visible as the airplane was nosed over toward impact with the underside facing toward him. The smoke was orangish-reddish-brownish in color. It was streaming out, but not with enough force to go into the engines. He did not observe fire. The smoke remained in the air after the impact and dissipated slowly, getting lighter and lighter with time and not dispersing with wind action.

15. ASRS upsets incidents callback project

The Human Performance Group asked the NASA-Ames Research Center Aviation Safety Reporting System (ASRS) to conduct a structured callback telephone survey of pilots who voluntarily reported uncommanded in-flight upsets involving large, civilian jet aircraft during the time period August 15, 1995 to November 15, 1995. The structured callback consisted of a detailed telephone interview concerning the nature of the upset, the weather conditions, the actions of the aircraft, the aerobatic training and experience of the pilots, the responses of the pilots to the upset, recommendations to prevent such upsets, and other related factors. Pilot reports were solicited through the description of the callback project in pilot and aviation industry trade journals.

Further information on this activity will be provided after the November 15, 1995, closing deadline.

16. SHEL model.

A member of the group (Capt. Robert Sumwalt) led an effort to develop a SHEL model related to this accident, as presented in the International Civil Aviation Organization (ICAO Human Factors Digest 7, Investigation of human factors in accidents and incidents, Circular 240-AN/144, ICAO, Montreal, Canada, 1993). To help focus human performance activities in the investigation, A working SHEL model was prepared and used by the group. It is anticipated that a final SHEL model will be provided as an output of the group at the end of the investigation.

17. Conclusion by the Human Performance Group

On June 6, 1995, all members of the group reached the following conclusion regarding the applicability of available data on the airplane's final movements to pilot input on those movements:

There is no way we can conclude for certain that the crew did or did not put in rudder input.

Malcolm Brenner, Ph.D.
Senior Human Performance Investigator

B Stark
10/5/93

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LIST OF ATTACHMENTS

1. Letter from Dr. Malcolm Cohen concerning vestibular/disorientation issues.

2. Letter from USAir on recommended operations procedures.

3. Letter from the Boeing Commercial Airplane Group on recommended operations procedures.

4. Answers provided by the crew in the Richmond in the Richmond roll incident to written questions.

ATTACHMENT 1.

Letter from Dr. Malcolm Cohen concerning vestibular/disorientation issues.

National Aeronautics and
Space Administration
Ames Research Center
Moffett Field, CA 94035-1000

Reply to Attn of

SLR: 239-11

SEP 21 1995

Malcolm Brenner, Ph.D.
National Transportation Safety Board
409 L'Enfant Plaza East, SW
Washington, DC 20594

Dear Dr. Brenner:

Thank you for the opportunity to participate in the NTSB review of the crash near Pittsburgh of USAIR Flight #427 (Accident DCA-94-076). I appreciate your interest in my research on intersensory interactions and their role in human spatial orientation, as well as the opportunity to work with you in this investigation. As you know, I have been conducting research in this general area for several years, and I have enclosed a reprint of a book chapter that summarizes some of my earlier work (see enclosure).

On the basis of my review of the circumstances leading up to the accident, the cockpit data recordings of various flight parameters, the transcript of the pilots' comments preceding the crash, and on my participation in the Vertical Motion Simulator reconstruction of the accident at NASA-Ames Research Center on July 11, 1995, I am fairly confident that pilot disorientation was not a major causal factor in the crash.

In my opinion, the accident situation did not provide any obvious evidence of factors that are normally associated with disorientation due to abnormal vestibular stimulation. These factors typically include degraded out-of-the-cockpit vision (e.g., night or instrument flight conditions) that is coupled with changes in linear or angular accelerations, which are either sudden, violent, and supra-threshold, or subtle, gradual, and sub-threshold. It is also possible that, under degraded visual conditions, false or inaccurate instrument readings could lead to disorientation.

(12)

In contrast, this accident occurred during clear, daytime, visual flight conditions, where there would be ample opportunity for visual information to override any vestibularly-induced disorientation. The motion of the aircraft, from the initial encounter with the turbulence to the point where it probably was out of control and no longer recoverable, did not display obvious evidence of the types of acceleration that would be conducive to disorientation. Rather, except for the initial upset from the turbulence, the motions of the aircraft appeared to have been relatively gradual, supra-threshold, and nearly continuous. Under these circumstances, I believe that the pilots probably would have experienced little difficulty in maintaining an accurate perception of their orientation, even during any brief periods when they may have lost sight of the visual horizon due to the pitch down attitude of the airplane. In addition, perturbations of the flight path generally appear to have been followed by verbal comments from the pilots, indicating that they were fully aware of their trajectory, and that they were not able to change it. On balance, there does not appear to be any compelling evidence to conclude that the pilots were disorientated, nor is there evidence to believe that they applied incorrect control inputs in an attempt to overcome their disorientation, and thereby caused the accident.

Whether the control inputs were appropriate, or inappropriate, it is most unlikely that they were caused by pilot disorientation. Thus, although I cannot completely exclude the remote possibility, it does not appear at all likely that pilot disorientation due to abnormal vestibular stimulation provided a major contribution to this accident.

I would be most pleased to cooperate with you in the future, should the NTSB again wish to avail itself of my services.

Sincerely,

[redacted]

Malcolm M. Cohen, Ph.D.

Enclosure:

Cohen, M. M.
Visual-Proprioceptive Interactions (Chapter 6). In: R. D. Walk & H. L. Pick, Jr. (Eds.) *Intersensory Perception and Sensory Integration*, New York: Plenum Publishing Co., pages 175-215, 1981.

ATTACHMENT 2.

Letter from USAir on recommended operations procedures.

QUESTIONS FOR USAIR STANDARDS/TRAINING

QUESTION : What are the recommended procedures for where the pilots rest their feet during routine flight? For when a pilot places his feet on the rudder controls during descent?

RESPONSE: There is no recommended procedure for where the pilots should rest their feet during routine flight. USAir requirements for rudder pedal usage, include, but are not limited to the following phases of flight; Takeoff, Approach, and Landing. Additionally, the rudder pedals are to be utilized at any time aircraft yaw correction is required.

QUESTION; What is the recommended procedure for how the rudder is us ed during normal approaches and landings?

RESPONSE: The rudder is used to align the longitudinal axis paralell to the desired track.

QUESTION: What is the recommended procedure in the event of wake turbulence encounter? Would pilots normally hand-fly, or use autopilot in response to wake turbulence? At what point would hand-flying be appropriate?

RESPONSE: To maintain desired aircraft flight by use of appropriate control surfaces ie. roll control surfaces moved by rotating either control wheel, pitch control surfaces moved by elevator displacement, and yaw control surfaces moved by rudder pedal deflection.
If the autopilot is engaged prior to wake encounter, the autopilot would be normally left on, provided appropriate corrections are being made. Conversely, hand-flying would be appropriate when appropriate and/or adequate corrections are not being made.

QUESTION: What is recommended procedure for recovery from excessive/severe roll? What is proper rudder input, power setting, and control column position?

RESPONSE: Opposing roll control activated thru control wheel rotational movement, adverse yaw correction thru rudder input. Correct rudder pedal displacement to counteract adverse yaw, power used to maintain existing airspeed, and counter adverse roll by rotating control wheel to maintain desired aircraft attitude.

QUESTION: What is the recommended response to stickshaker activation? Stickshaker activation in a dive?

RESPONSE: Initially, verification of the the warning's validity needs to be made. If a stall condition exists, the wings will be rolled level, application of full power, and the nose will be lowered slightly. If in response to a windshear encounter, after rotation to the proper pitch attitude and power application has occured, the stick shaker would be respected as the upper limit of pitch. If the stick shaker was in response to a dive, no specific procedure is recommended.

QUESTION; What is the recommended transfer of control procedure in the above situations when the first officer is the flying pilot?

RESPONSE: Flight Operations Manual states that transfer of control will be initiated by the controlling pilot, and then acknowledged and verified by the receiving pilot.

Post-it® Fax Note 7671	Date 5-18-95	# of pages ▶ 1
To Malcom Brenner	From George Snyder	
Co./Dept. NTSB	Co. [illegible]	
Phone #	Phone # [redacted]	
Fax #	Fax #	

ATTACHMENT 3.

Letter from the Boeing Commercial Airplane Group on recommended operations procedures.

P.O. Box 3707
Seattle, WA 98124-2207

August 14, 1995
BXK01-15322-ASI

Malcolm Brenner
AS-50
National Transportation Safety Board
490 L'Enfant Plaza SW
Washington DC 20594

BOEING

Subject: USAir 737-300 N513AU Accident Near Pittsburgh, September 8, 1994

Dear Mr. Brenner:

Following are responses to questions provided in the attached draft inquiry from a USAir/Boeing/FAA working group:

1. What are the recommended procedures for where pilots rest their feet during routine flight? For when a pilot places his feet on the rudder controls during descent?

In Boeing Operations Manuals there is information in the introduction which states:

> This manual is written under the assumption the user has had previous multi-engine jet aircraft experience and is familiar with basic jet aircraft systems and basic pilot technique common to aircraft of this type. Therefore, the Operations Manual does not contain basic flight information considered to be prerequisite training.

Although this is in reference to the Operations Manual, we use similar baseline criteria for the purpose of training. We feel that for a student currently entering transition training today, feet and hand placement are compulsory training concepts learned early in basic flight training. Since these are basic to airplane operation, these points are not specifically revisited in Boeing training nor do we publish any written guidance on this subject.

Pilots are expected to have feet and hands placed to ensure the desired flight path is maintained in any stage or phase of flight.

2. What is the recommended procedure for how the rudder is used during normal approaches and landings?

As stated in the response to the first question, this is considered one of the very basic aspects of flying for which Boeing does not provide specific training or instruction. Boeing must, and does, make some general assumptions regarding competence and qualifications for entry-level students transitioning to transport category airplanes and our training programs are based on these assumptions.

In Boeing airplanes, use of rudder for coordinating normal flight maneuvers is not necessary. As in any airplane, rudder is used for an engine failure condition, in performing proper crosswind landing techniques and for directional control after landing.

BOEING

3. What is the recommended procedure in the event of wake turbulence encounter? Would pilots normally hand-fly or use autopilot in response to wake turbulence? At what point would hand-flying be appropriate?

Similar to the responses to the previous questions, we expect that flight crews have learned through past training and experience how to maintain the desired flight path during foreseeable flight conditions, which include wake turbulence encounters.

Upon encountering wake turbulence, we would expect the flight crew to use flight controls to maintain, or correct to, the desired flight path. We do not advocate engaging an autopilot if wake turbulence is encountered during manual flight. If already on autopilot, if the autopilot system performance is unacceptable, the flight crew should disconnect and fly manually.

4. What is recommended procedure for recovery from excessive/severe roll? What is proper rudder input, power setting, control column position?

We assume and expect that flight crews have previously received training on how to avoid and recover from excessive or severe roll conditions. As this training is considered prerequisite to airplane operations, Boeing does not provide written guidance or a published procedure for these conditions.

The Boeing Instrument Training Manual discusses the basics of the control, performance, and navigation instruments on the flight deck and states, "When any indication, other than those desired, is observed on the performance instruments, a change of airplane attitude and or power is required." The manual goes on to discuss basic bank, thrust and pitch control and rules of thumb to use in effecting changes in these parameters. The amount of control input in these parameters is dependent on the magnitude of the roll.

5. What is the recommended response to stickshaker activation? Stickshaker activation in a dive?

We assume and expect that pilots have received training on the manner in which an airplane can stall, the flight conditions and external events that can contribute to a stall, and the correct manner in which to respond to these conditions.

The stall warning is considered to be any warning readily identifiable to the pilot, either artificial (stick shaker) or initial buffet. Recovery from an approach to stall will be initiated at the earliest recognizable stall warning, initial buffet or stick shaker. Information regarding the approach to stall recovery is provided in the enclosed Boeing 737 Flight Crew Training Manual pages and the procedure from the Boeing 737 Operations Manual.

BOEING

6. What is the recommended transfer of control procedure in the above situations when the first officer is the flying pilot?

We do not recommend procedures for operators or establish training for pilots that identify the conditions, circumstances or occasions when transfer of control is, or is not, appropriate. Operators generally establish such procedures in their airline operations and training programs.

We do not advise transfer of control during recovery maneuvers, however, the captain has command authority on the flight deck to establish the most efficient and safe recovery method and would be expected to take control from the first officer if he deems this the safest course of action. We would expect the flight crew to communicate and use established cockpit resource management principles to identify and effect coordinated, safe and efficient conduct during recovery maneuvers.

If The Boeing Company can be of further assistance do not hesitate to contact me.

Very truly yours,

FLIGHT TEST

[redacted]

J.W. Purvis, Director
Air Safety Investigation
BXK01, M/S 14-HM
[redacted]

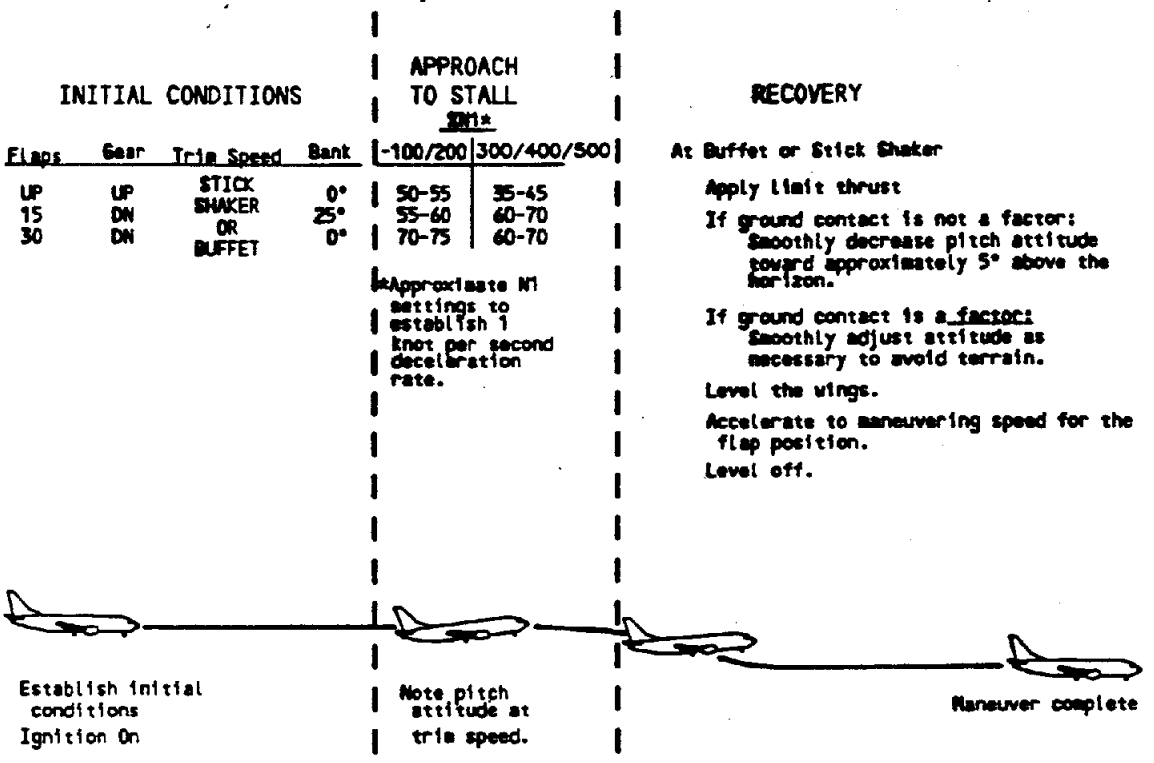

Figure 2-17 APPROACH TO STALL RECOVERY

APPROACH TO STALL RECOVERY

Objective

These maneuvers are performed to familiarize the student with stall warning and the correct recovery technique. The instructor pilot should set the initial conditions.

Airspeed Cursor

The Command Cursor should be set to the maneuvering speed for the flap setting prior to starting these maneuvers.

Entry

Set the thrust and decelerate, keeping the airplane in trim. For flaps down stall practice, extend the flaps on the normal flap extension speed schedule. Maintain approximately level flight during the entry so that an appropriate deceleration rate will occur. Note the pitch attitude as airspeed reaches the maneuvering speed.

Recovery

All recoveries from approaches to stall are performed as if an actual stall has occurred.

Landing Gear

If the entry has been made with the landing gear extended, do not raise it until after the recovery has been effected and a positive rate of climb has been established.

Flaps

Less altitude is lost and the recovery is simplified by not changing flap position. Retracting the flaps from the landing position is not recommended, especially when near the ground, as a greater altitude loss will result during the recovery. Flap extension above 20,000 feet is not permitted.

Ground Contact Not a Factor

At the first indication of stall, buffet or stick-shaker, advance the thrust levers to limit thrust, smoothly decrease pitch attitude toward approximately 5 degrees above the horizon, then level the wings. Be prepared to begin trimming immediately as thrust and airspeed increase.

As the airplane accelerates, continue to adjust pitch attitude as required to minimize altitude loss and return to maneuvering speed. At high altitudes (above 20,000 feet), pitch attitudes less than 5 degrees may be necessary to achieve acceptable acceleration, and an altitude loss of up to approximately 1500 feet may be expected.

Accelerate to maneuvering speed and stop the rate of descent.

Ground Contact a Factor

At the first indication of stall warning, buffet or stick-shaker, immediately and simultaneously advance the thrust levers to limit thrust and smoothly reduce pitch attitude slightly (approximately 1 to 2 degrees) to silence the stick shaker. If in a turn, slowly and smoothly roll wings level avoiding excessive aileron inputs. As airspeed increases, readjust pitch attitude upward to minimize terrain closure, avoiding steady stick shaker.

Avoid large, abrupt control inputs which may induce a secondary stall during the recovery. Ensure that pitch attitude changes are consistent with the rate of change of airspeed and vertical speed, and ensure that thrust is adequate while ground contact is a threat. Be prepared to begin trimming immediately as thrust and airspeed increase.

When terrain contact is no longer a threat, accelerate to normal maneuvering speed for the flap setting and return to the desired altitude.

Autopilot Engaged

If an approach to stall is encountered with the autopilot engaged, and sufficient altitude is available, apply thrust and allow the airplane to return to normal speed. At high altitude, it may be necessary to initiate a shallow descent to regain maneuvering speed. If autopilot response is not acceptable, or if terrain is at all a consideration, such as during approach, the autopilot should be disengaged.

APPROACH TO STALL RECOVERY

The following is immediately accomplished at the first indication of stall, buffet or stick shaker.

PILOT FLYING	PILOT NOT FLYING
Advance the thrust levers to maximum thrust, smoothly adjust pitch attitude* to avoid ground contact or obstacles. Level the wings (do not change flap or landing gear configuration).	Assure maximum thrust. Monitor altitude and airspeed. Call out any trend toward terrain contact.
When ground contact is no longer a factor, adjust pitch attitude to accelerate the airplane while minimizing altitude loss. Return to the speed appropriate for the configuration.	

*NOTE: At high altitudes it may be necessary to decrease pitch attitude below the horizon to achieve acceleration.

ATTACHMENT 4.

Answers provided by the crew in the Richmond roll incident to written questions.

Questions for USAir 299 Flight Crew - Roll Incident, Richmond VA

1. What was your understanding at the time as to the cause of the roll event?
   - At the time of the event, how many degrees did you believe the airplane rolled initially?

2. During the uncommanded roll, the airplane was rolling for approximately 30 seconds and rolled past 0 degrees for 8 seconds.
   - What did you think the airplane should have done?
   - What was the key point that made the roll "uncommanded"?

3. During the event did you discuss what you thought was happening (i.e. diagnose the event) and/or what you should do to correct the situation?
   - If so, who decided what should be done?

4. Who was flying the airplane at the start of the event?
   - Did the same individual continue flying and continue to be the only pilot actively controlling the airplane?
   - If "No", who took control when or were both pilots attempting to control the airplane?

5. Have you ever experienced a similar event?
   - If so, in what type airplane? (Please describe the previous event and how you responded.
   - How have you been trained to respond to such events?

6. About 20 seconds before autopilot disconnect, CWS Roll became active for a little over 2 seconds. Did somebody drive it in and out of CWS Roll (and if yes, why) or did it occur on its own?

7. What bank angle was selected during the period 4365-4420. (This would be the period of time aircraft was turning left, from 360 degrees to about 220 degrees)

8. The FDR shows LNAV engaged at 4385, then disengaged at 4395. (This is the period of time when aircraft is coming thru heading of about 330 degrees in its turn from 360 degrees to 225 degrees)
   -Did you as a crew select LNAV at 4385, then deselect it at 4395?
   -If so, why?
   -How did you deselect? (i.e. by selecting HDG mode, or by deselecting LNAV, etc)

9. LNAV was re-engaged at about 4425 (heading approximately-225 degrees). During the time LNAV was not engaged (4395-4425) was there any update to the FMC i.e. was active way point reselected or changed?

10. Can you explain "checked the speedbrake for spoiler float"?
    -How did you do it?
    -What did you look for?

11. Do you remember whether you put in right aileron trim?
    -If so, who put it in? Why?
    -Can you tell us when you added right aileron trim?
    -Was it before or after the rudder was deflected to the left?

12. It is stated in your report that "to reduce the control forces to keep wings level, aileron electric (?) trim switching...approximately 2.4 sec. Aileron trim was noted to be 3.5 degrees (do you mean units?) right and the trim did not work in flight."
    -How did you determine aileron trim position?
    -How did you determine that aileron trim was not working?

13. Question deleted per Mike Carriker.

14. The FDR indicates that the rudder remained deflected to the left for approximately the last 2.5 minutes of the flight.
    -Were you aware that this was the case?
    -Did this rudder deflection result from a crew input? If so:
    - Why did you put in left rudder?
    - Did you realize at the time that you continued to apply left rudder until landing?
    - Why did you continue to apply left rudder after the initial input?
    - When do you believe it is appropriate to use rudder when flying (i.e., when in the air) the 737?

15. Was the autopilot disconnected by the disconnect switch (on the wheel) or by the paddle switch?

16. Were there any noticeable differences in forces when trying to move the wheel clockwise vs. counterclockwise (i.e., were the forces symmetrical)?

17. Were there any noticeable differences between the left and right rudder forces during the incident?

18. Did the rudder pedals appear not to be centered during the incident? If so, by how much and toward which direction?

19. Were there any visual differences between the left and right roll rates when the wheel was used?

20. How did the crew overcome high wheel forces (e.g., both pilots holding the wheel to the left or right)?

21. Do you have any comments regarding cross-control inputs?

22. Was either crew aware of any recent uncommanded roll incidents on the 737? If so, how do you think this knowledge may have influenced your assessment of the situation?

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ANSWERS TO QUESTIONS FOR USAIR FLIGHT 299 CREW

1. We didn't know because we did not have time to analyze the event.

   a. Approximately 25 degrees to 30 degrees.

2. The aircraft should have continued to maintain the left bank.

   a. When the aircraft rolled to the right.

3. Yes, briefly.

   a. The Captain.

4. The Captain.

   a. Yes, except for briefly when the First Officer was directed to take control to verify the wheel control position and pressure that the Captain was experiencing.

   b. At no time did both pilots control the aircraft.

5. No.

   Procedure is disconnect autopilot and yaw damper off.

6. No, it occurred on its own.

7. 30 degrees.

8. At 4385 the Captain engaged LNAV but the crew did not deselect LNAV at 4395.

9. No.

10. a. Pulled speed brake out of detent.

    b. A decreased roll rate.

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To MALCOLM BRENNER	From PAUL STURPE
Co. NTSB	Co. USAIR
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ANSWERS TO QUESTIONS FOR USAIR FLIGHT 299 CREW

11. Neither crew member applied right aileron trim.

12. After landing we noticed the control wheel position was 3.5 units to the right. In flight the application of left aileron trim did not affect or change control pressures.

13. Deleted.

14. Yes, crew applied left rudder as necessary throughout the approach and landing to maintain directional control of the aircraft.

15. Disconnect switch on the wheel.

16. Clockwise required little or no pressure; counterclockwise required normal aileron pressure to overcome the right roll tendency.

17. No.

18. Rudder pedals were centered until crew input left rudder to maintain directional control of the aircraft.

19. No.

20. There were no high wheel forces.

21. No.

22. Yes, our knowledge of Flight 427 and subsequent uncommanded roll incidents, would make it impossible not to have that knowledge influence our assessment of the situation in order to insure that a safe landing was achieved.

10/5/95

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