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

November 8, 1996

HUMAN PERFORMANCE GROUP
GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION

FOURTH 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 (retired)

Captain Benjamin A. Berman
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 Kayten, Ph.D.
Federal Aviation Administration

Chuck DeJohn, D.O.
Federal Aviation Administration

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 the documentation of the Human Performance Group, Group Chairman's Factual Report of Investigation, Third Addendum, dated October 27, 1995.

1. Pilot interviews related to rudder-input incidents.

The Human Performance Group conducted group telephone interviews of two B-737 captains who experienced emergencies involving unexpected rudder input during the landing phase, as a result of the medical incapacitation of the first officer. Attachment 1 to this report provides a summary of the interview of Captain Gary Higby, while Attachment 2 summarizes the interview of Captain Don Widman. Attachment 3 consists of a company report by Captain Widman three days after his incident, and Attachment 4 is a description of the incident by Captain Widman that was published by Flying Magazine.

2. Pilot interviews related to wake turbulence incident.

Malcolm Brenner and Chuck Leonard conducted telephone interviews of the two B-737 pilots involved in a wake turbulence incident while landing behind a B-727 airplane that occurred on February 9, 1996. Attachments 5 and 6 summarize the interviews.

3. Speech analysis

The NTSB Speech Laboratory conducted a speech analysis on the audio tape of the cockpit voice recorder (CVR) to obtain further human performance information. This work is summarized in a separate report, under preparation.

4. Pilot leg measurement.

According to a family representative, the first officer's pant leg inseam measurement was 36-37 inches.

5. Leg length limitations in the seat design.

Attachment 7 is a statement by the Boeing Commercial Airplane Company concerning pilot leg length limitations in the use of the B-737 pilot seat.

6. Expanded statement by pathological expert.

Attachment 8 is an expanded statement by David W. Hause, M.D., whose expert opinion was cited in the Second Addendum Report.

7. ASRS statement.

Attachment 9 is a statement by Vincent J. Mellone, ASRS Operations Manager, concerning data information in the ASRS Structured Callback Report completed for this investigation (and included in the public docket).

8. Interviews related to the San Pedro Sula incident.

Attachment 10 summarizes interviews conducted by NTSB staff in connection with the rudder incident experienced by a Continental Airlines B-737 on April 12, 1994, near San Pedro Sula, Honduras.

9. Statement by the Interstate Aviation Committee

Attachment 11 is a statement by the Interstate Aviation Committee (MAC), Moscow, Russia, the government agency responsible for investigating aviation accidents in the Commonwealth of Independent States. The statement was prepared at the request of the Human Performance Group to summarize the experiences and observations of this agency with accidents involving uncommanded roll events. Attachment 12 is an English translation of this statement prepared under contract to the NTSB.

Malcolm Brenner, Ph.D.
Senior Human Performance Investigator

[redacted]

LIST OF ATTACHMENTS

1. Summary of Captain Higby interview.
2. Summary of Captain Widman interview.
3. Company report by Captain Widman.
4. Flying Magazine article by Captain Widman.
5. Summary of Captain Ellis interview.
6. Summary of Captain Schmidt interview.
7. Boeing statement on pilot stature certification criteria.
8. Statement by Dr. Hause.
9. Statement by Mr. Mellone.
10. Summary of San Pedro Sula interviews.
11. Statement of the Interstate Aviation Committee (in Russian).
12. Statement of the Interstate Aviation Committee (in English translation).

ATTACHMENT 1

WITNESS INTERVIEW
Captain Gary Higby
Southwest Airlines

The Human Performance group participated in a telephone interview of Captain Higby on January 17, 1996. He was the pilot of a B-737 passenger flight that experienced a control emergency situation while attempting to land.

Captain Higby was captain of a B-737-300 passenger flight landing at Oakland International Airport (OAK) at 2300, on March 29, 1994. Weather was 500 feet overcast, five mile visibility in fog, and wind of about ten knots. It was the first officer's leg. The autopilot was engaged in control wheel steering, flaps were set at 30 degrees, airspeed was 135 to 140 knots, and the airplane was at 1500 feet AGL, when "the first officer let out a blood curdling scream." Captain Higby yelled "What's wrong?" and glanced at him. The first officer was looking outside at the fog. His eyes were extremely large, and his back was arched so the captain thought he might have been shocked by the circuit breakers. The first officer screamed a second time, his back went rigid, and he clutched at the control column. Captain Higby thought it was a brain seizure. The captain, who had his feet positioned close to the rudder pedals, noticed the beginning of a right roll and felt the left rudder pedal hit his ankle. He put his feet on the rudder pedals and noticed a displacement of at least 5 to 6 inches.

The captain, who was 5'8" tall and weighed 175 pounds, was physically smaller than the first officer (who was about 5'11" tall and weighted about 200 pounds). The captain disconnected the autopilot, applied opposite aileron, and physically fought the first officer for control of the rudder pedals. With difficulty, he was able to neutralize these controls. Recalling military experience in mid-flight refueling, the captain increased thrust in the right engine and used differential engine thrust to help him maintain neutral rudder position. He signaled for a flight attendant. She entered the cockpit, unlatched the seat belt of the first officer (who was still rigid), and the pressure came off the rudder pedals. The captain recovered at about 900 feet AGL. Although he had disconnected the autopilot early in the recovery, he had been too busy to activate the button a second time to silence the autopilot disconnect warning.

Later, Captain Higby learned that the first officer suffered a seizure. He had been hallucinating and had no recall of the incident.

Captain Higby stated that he was startled at the beginning of the incident, and estimated that startle delayed his action by no more than two to three seconds. He responded instinctively to right the airplane and did not verbalize his actions. This was partly because the first officer was impaired and would not understand his verbalization, and partly because verbalization would slow down an immediate response. He was concerned with avoiding hills near the airport and regaining control but was not concerned about airspace violation.

Captain Higby had 21,500 flight hours at the time of the incident, with 15,500 hours in B-737 (Models 200, 200, and 500). He experienced unusual attitude training as a combat pilot in the U.S. Air Force, and flew aerobatics in general aviation airplanes. He experienced a previous emergency, seven years before, when a general aviation airplane intruded on the runway as his transport flight was landing. The first officer was flying, and he took control and averted a collision.

ATTACHMENT 2

WITNESS INTERVIEW
Captain Don Widman

The Human Performance group conducted a telephone interview of Captain Widman on January 16, 1996. He was the pilot of a B-737 passenger flight that experienced a control emergency during a landing approach.

Captain Widman's experience occurred on June 11, 1980. It was described in a company operations report on June 16, 1980, included as Attachment 3, and in an article published in Flying magazine in January, 1996, included as Attachment 4. The interview elaborated some of the information in these documents.

The incident involved a B-737-200 airplane, on final approach to Cheyenne, Wyoming, in daylight, visual conditions with the first officer hand flying the approach. Winds were reported as light and variable, but the pilots observed that dust was blowing southbound to the north of the airport and northbound from the south of the airport. Anticipating wind shear conditions, they elected to fly the approach at 145 knots, 10 knots above the bug speed. Flap setting was probably 30 degrees.

At about 800 feet AGL, the captain observed an increase in airspeed. At 500-600 feet AGL, the airspeed had climbed to 160 knots and the captain stated that "we are too damned fast." The first officer did not respond. The captain called for a go-around, reached for the throttles, and, about this time, the nose of the airplane slewed left. The captain glanced at the first officer and observed that the first officer was not moving and appeared to be dead. There was an unnatural blue-purple color in his complexion and his hands were hanging limp.

Captain Widman stated that he responded instinctively to keep the airplane flying, thinking that the medical incapacitation of the first officer had somehow brought on the control problem. He advanced the throttles and input right aileron, nearly full input. It was not sufficient to correct the roll, but he was able to maintain a coordinated 45 degree turn and establish "coordinated" flight. The resulting climbing turn continued through a 270 degree change in direction and a climb to 1500 feet AGL as the captain cleaned up the airplane configuration. Though the flight attendants were shaken by the initial, momentary wildness of the ride, the climb-out itself was smooth and coordinated. The aircraft was never near stalling speed.

As soon as the airplane was in a go-around configuration, about 30-60 seconds into the incident, the captain summoned a flight attendant to get oxygen to the first officer. The flight attendant notified the captain that the first officer's leg was rigid and locked straight on the left rudder pedal. The first officer had suffered a seizure, and the rudder pedal was at full input. The flight attendant moved the first officer's leg off the rudder, and the captain regained control of the airplane.

Captain Widman said that he was startled at the beginning of the incident. He flew reflexively, and his motor responses were sharp and unaffected. However, his ability to analyze was hurt. He said that he had two problems and his mind was overloaded: he had an airplane out of control, and he had a first officer who appeared to be dead or dying. It blocked out other concerns, and he was surprised he did not realize that the rudder was in. Captain Widman said that he did not know what was causing the airplane to slew. He did not have a specific memory of trying to use the rudder, but said it seemed logical that he would have tried. He had reached the limit of what he could concentrate on. He did not verbalize his actions.

Captain Widman had about 25,000 flight hours at the time of the incident, with 3,500 hours in the B-737. He was a captain since 1964. He received unusual attitude training in the Air Force, which he felt helped him in the incident, and had no aerobatic experience since that time. He had experienced several engine failures during his career, but not at points that he considered emergencies. The captain was an active member of the pilot union. He was age 53 at the time, 6'0" tall and about 190 pounds. The first officer, age 41, was 5'9" or 5'10" tall and stocky.

Captain Widman decided to write an article for Flying magazine after the Colorado Springs accident. The article was accepted for publication in July, 1994, two months prior to the Pittsburgh accident.

ATTACHMENT 3

Company report by Captain Widman

FRONTIER AIRLINES

Frontier Airlines, Inc.
8250 Smith Road
Denver, Colorado 80207
Telephone (303) 398-5151

June 16, 1980

Captain W. S. Norris
Regional Director Flight Operations
FRONTIER AIRLINES, INC.
8250 Smith Road
Denver, Colorado 80207

Dear Captain Norris:

The following report covers the critical portion of Flight #326 as it approached the Cheyenne, Wyoming airport on June 11th, 1980.

The crew consisted of myself as Captain, First Officer [redacted] Flight Attendants Gene Schroeder, Diane Brunson and Wendy Winters.

With First Officer [redacted] at the controls, we were on final approach to runway 26, the weather was VFR, wind variable at 6 knots, landing clearance had been received, the aircraft was in landing configuration and stable down to 500 feet above the ground. From that point a build up in airspeed began, I emphasized this in my calls, we seemed to be encountering a bit of turbulence at that time leading me to believe that we were also encountering some wind shear, and I still did not anticipate anything other than a routine landing. At what was probably about 300' AGL the following happened more or less at once:

The nose of the aircraft slewed to the left, I got on the controls and glanced at the First Officer and realized that he was incapacitated and apparently unconscious. I added full power and began a climb and missed approach. The aircraft was still wallowing around and I was having a problem getting the controls into a coordinated flight situation. The aircraft flew best in a climbing left turn. In the meantime, I had gotten the aircraft into a go around configuration and rang for a Flight Attendant. Gene Schroeder responded immediately and I directed that he get 100% oxygen to [redacted] By this time the cause of the flight control problem became apparent when I realized that [redacted] left foot was holding left rudder. I told F/A Schroeder to get [redacted] foot off that pedal and restrain it from further interference.

We now called a second Flight Attendant to assist with the oxygen and the third attendant to assist with details relating to hand restraint as I best recall.

Meanwhile, the Tower had been advised that the co-pilot had developed a physical problem that required an ambulance. I had momentarily considered having the Attendants try to get the First Officer out of his seat but dismissed this without discussion as impractical under the circumstances, deciding instead to land as soon as possible. Tower cleared me to land on runway 8, we were by then south-west of the City. I believe Brunson and Winter assisted Schroeder in getting seated on the jumpseat, and they returned to the cabin while Schroeder continued to assist the First Officer as we landed.

The First Officer began to return to consciousness while taxiing in and upon parking I left the cockpit so that prompt medical attention could be given.

My gratitude for the composed and competent assistance of the Flight Attendants under difficult and trying circumstances cannot be overstated. Without their help the outcome probably would have been considerably different.

Yours truly,

[redacted]

Don Widman
Captain - B-737

DW/dt

cc: R. J. Orr

ATTACHMENT 4

Flying Magazine article by Captain Widman

I LEARNED ABOUT FLYING FROM THAT

NIGHTMARE ON FINAL

NO. 667
BY DONALD WIDMAN

It was one of those moments of anxiety which on rare occasions punctuate the hour upon hour of fortunate boredom.

From our vantage point six miles east of the airport and 1,500 feet above the ground, the visible dust in the vicinity of the airport was blowing in opposite directions. Consequently we viewed the report of "light and variable" wind with skepticism.

Another wind check confirmed the reported wind and the controller added, "You're cleared to land, Runway 26." Due to the obviously capricious wind and its potential for mischief, we added 10 knots to our calculated no-wind approach speed.

The first officer was at the controls, the Boeing 737-200 was in landing configuration, and our indicated airspeed included the additional 10 knots as we approached the outer marker. Though the skies were clear of clouds and visibility was unlimited, we tuned in the ILS as a backup for the visual approach. As we crossed the outer marker, all was well. We were aligned with the centerline of the runway, our rate of descent normal; there was nothing to indicate what was about to happen.

At a thousand feet I began the procedural calls of altitude, airspeed and sink rate. As we left 800 feet, I noted and called attention to an increase in the indicated airspeed. From the planned plus-10 it quickly became a plus-15, then 20, and stabilized at plus-25 as we approached 500 feet. The rate of descent had increased accordingly and we were less than 30 seconds from touchdown.

At this point I was concerned but not yet alarmed; this appeared to be a classic, though a bit extreme, wind shear, from which we could expect to emerge with the excess airspeed dropping off as rapidly as it had built up.

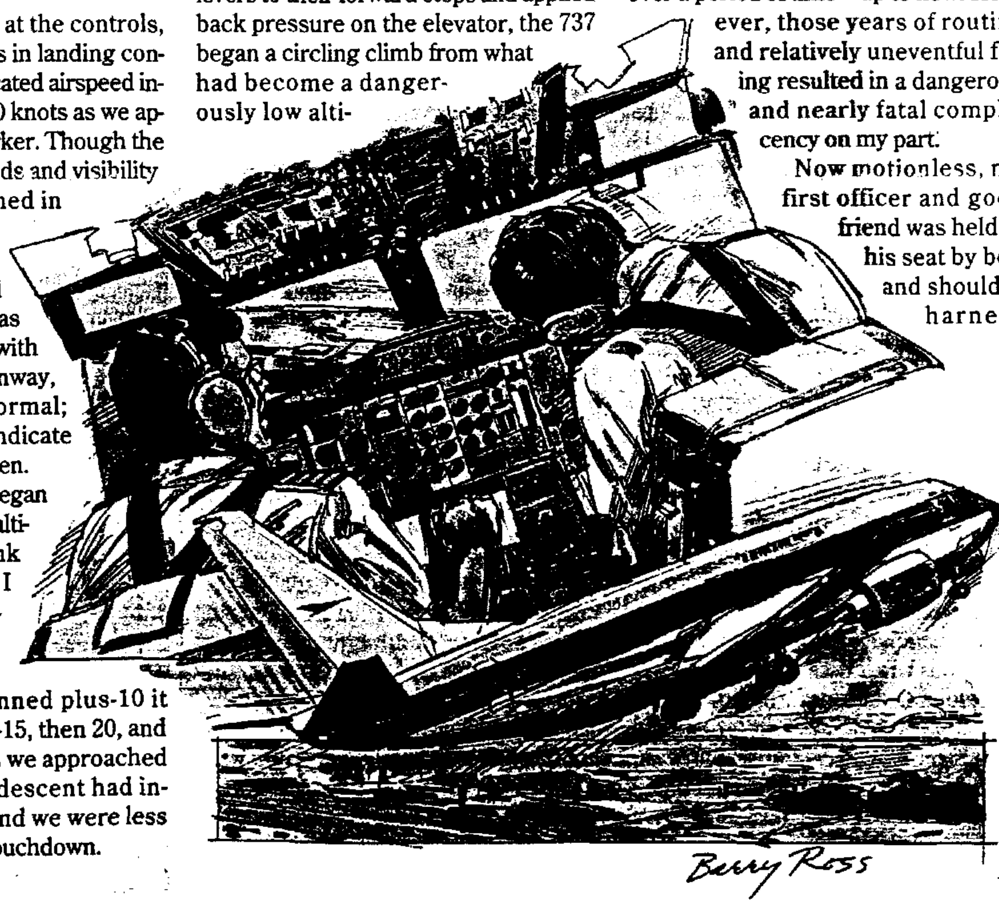
When the excess airspeed did not drop off, I expected the first officer to react by reducing power; he did nothing, and I shouted, "We're too fast!" Incredibly, the aircraft was still on the glide path and aligned with the runway. The thought that he was no longer flying the aircraft did not enter my mind.

When he did not respond to my emphatic warning, I reached for the power levers, intending to initiate a missed approach, and as I gripped them I glanced to my right, wondering why he had done nothing to correct a now-critical situation. Just as I touched the power levers, the aircraft suddenly "slewed" to the left in a wild, still descending, uncoordinated turn. As I pushed the power levers to their forward stops and applied back pressure on the elevator, the 737 began a circling climb from what had become a dangerously low altitude. Later, one of the flight attendants who was seated in the rear of the airplane where the aircraft's motion was most violent, knowing only that something was drastically wrong, described her thoughts as, "This is it, we've had it and we're going to crash."

My questioning glance at the first officer was frightening—he was obviously unconscious; that he was no longer alive appeared to be a very real possibility.

We had flown together, he as first officer and I as captain, hundred of hours and thousands upon thousands of miles. During the course of a 15-year period we frequently flew the same monthly schedules. We knew each other's likes and dislikes, moods, idiosyncrasies and jokes. We trusted each other's skill and judgment. Together we had experienced the usual mechanical problems ranging from minor to major, in short, the "normal" events an airline flight crew would experience over a period of time—up to now. However, those years of routine and relatively uneventful flying resulted in a dangerous and nearly fatal complacency on my part.

Now motionless, my first officer and good friend was held in his seat by belt and shoulder harness



in a nearly out-of-control airplane. While I stared at his contorted body, one simple question burned through my mind: "My God, what happened?"

For some unknown reason I was unable to "roll" out of the left turn; the turn could, however, be coordinated by use of the ailerons. A 45 degree angle-of-bank turn was a simulator training maneuver, not something to be done in a "real" airplane 200 feet off the ground—unless one had to.

With maximum power now set, I repositioned the flaps to a "go-around" setting and retracted the landing gear. That extra airspeed which moments before had been a liability suddenly became an asset of immeasurable value by enabling us to begin this wild and unplanned maneuver with our airspeed well above stalling speed.

Though we were continuing the steep turn, we were gaining altitude, and I had a moment to think about the plight of the first officer. I signaled for a flight attendant to come to the cockpit and the attendant seated in the forward part of the cabin responded immediately, asking, "What's wrong?" Nodding toward the first officer, I said, "Get the oxygen mask on him."

In the process of following that brief instruction, the flight attendant, who was a licensed pilot, discovered the cause of the still-uncontrollable turn when he realized—and told me—that the first officer's stiffened left leg was holding full left rudder. I didn't need to tell him to forget the oxygen and take care of the "control" problem. Supercharged as he was, he flexed the first officer's leg at the knee, thus freeing the rudder. This allowed us to recover from the turn that by now had progressed through some 270 degrees. We were level at 1,500 feet and the aircraft was once again under control.

A second flight attendant was called and she assumed the duty of making certain the first officer continued to breathe an uninterrupted flow of 100 percent oxygen.

In a matter of moments, the first officer appeared to be regaining consciousness to the extent that we needed the third flight attendant to assist by keeping the FO's hands clear of switches and controls. (Incidentally, and incredibly, five people *can* get in the cockpit of a Boeing 737—all at one time.)

Until we could fly straight and level we had not advised the tower of our predicament, and no one in the tower had asked questions. Tower personnel observing our unusual missed approach were probably as perplexed, but not as alarmed, as our 72 passengers must have been. Fortunately, no other aircraft were in the pattern.

With the aircraft and my voice once again under control, I advised the tower of the onboard medical problem and requested that emergency medical assistance stand by to await our arrival. I also requested and received landing clearance. Our passengers were then advised that the copilot had suddenly become ill, thus the missed approach. They were assured (if such was possible) that he was now much improved and that we would soon be landing.

As we turned final for the second time, two of the flight attendants returned to stations in the cabin. The remaining attendant belted himself into the center jump seat. From this position he was able to assist by reading the checklists (particularly important, I believe, when operating under such unusual circumstances) and by monitoring the now-recovering first officer; we landed without further complications.

As we parked at the terminal, waiting paramedics boarded the aircraft to assist the first officer, who was soon able to walk to the waiting ambulance. In the hospital it was determined that his seizure had been triggered by a chemical imbalance. With proper treatment he regained full health.

We eventually completed our delayed trip with the help of a reserve first officer. Arriving at our layover stop for a much-needed rest I found that sleep did not come easily. During the time that I was awake that night and on many subsequent nights I reviewed the known factors which contributed to the safe outcome of a situation that was, for a brief moment in time and space, touch and go.

Without the flight attendants' skilled and calm assistance in the crowded cockpit the outcome would have been unpredictable at best. Until they could lend support, the aircraft was literally out of control.

Another factor was our skepticism about the reported wind that was in such contrast with our observations of the actual wind in the vicinity of the airport. As a consequence of this doubt, we planned a higher airspeed on the approach and allowed the airspeed to increase even further due to what was probably a "phantom" wind shear. I will always believe that because of the additional airspeed we were able to keep the aircraft from stalling, rolling over and plunging that short distance to earth when the sudden and unexpected full application of the left rudder took effect.

Following this incident, someone unknown to me sent an article entitled "Pilot Incapacitation in Flight" published in *The Cockpit* (United Airlines, May 1980). A summary of facts gleaned from that article quoting various sources follows:

During a seven-year period prior to 1980, there were 17 instances of pilot deaths in the cockpit. Five of these deaths led to accidents that resulted in 148 fatalities. Of those five, four deaths occurred during the approach phase of flight. Two-thirds of the 17 pilots who died were under the age of 50. (The first officer in this story was 40.)

When total incapacitation, ranging from unconsciousness to death, occurs, the pilot simply ceases to function. A second and more dangerous form of incapacitation is subtle or partial incapacitation, in which the pilot flying remains conscious but with reduced analytical capacity. The subtle type is more dangerous because it happens more frequently and is more difficult to detect.

Between March 30, 1983, and January 8, 1993, National Transportation Safety Board records reveal 36 instances of crew incapacitations on Part 135 and Part 121 air carrier operations.

Pilots should realize that a crew member's incapacitation is always a possibility, and as with any aircraft emergency it must be dealt with in three phases: 1) recognizing the problem, 2) maintaining or regaining control of the aircraft, and 3) solving the problem.

In the personal experience described in this article, earlier recognition would have lessened the impact of the illness by allowing me to take control of the aircraft at a higher altitude and before the seizure resulted in full application of the rudder. Several days after the incident, my first officer stated that he remembered nothing of my calls about the high airspeed; he probably suffered a partial incapacitation before the total incapacitation occurred.

And last but not least—always expect the unexpected. □

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ATTACHMENT 5

WITNESS INTERVIEW
Captain Steve Ellis
United Airlines

Malcolm Brenner and Chuck Leonard conducted a telephone interview of Captain Ellis on February 16, 1996. He was the pilot of a B-737-200 passenger flight that experienced a wake turbulence encounter behind a B-727 airplane on February 9, 1996. Additional participants in the telephone interview were Bill Yantiss, United Airlines Safety Office, and Marilyn Pearson and Pete Delo, ALPA-United Pilot's Association.

This was the second leg of an initial operating experience (IOE) training flight, with check pilot Robert Schmidt conducting training from the right seat. Captain Ellis had about three flight hours in this model aircraft as captain, 2000-3000 hours as first officer in the B-737 Model 300, and about 14,000 total flight hours.

This incident occurred at 0830 hours, in daylight conditions, surface winds 300/08, with greater than 10 miles visibility and a clear horizon. The airplane was on approach to Chicago's O'Hare Airport (ORD) and was established on the glide path three miles behind a B-727, according to TCAS. Airspeed was 180 kts, flaps position was 2 degrees, the airplane was manually flown, and altitude was about 3000 feet MSL.

The incident began with a "lateral burble" that Captain Ellis recognized as a typical wake turbulence entry. The airplane began rolling hard to the left. Captain Ellis counteracted the roll with what he thought to be full aileron and rudder input but the airplane did not roll back to a level attitude. The aileron wheel was vertical and the rudder pedal was not quite against the stop. Aileron and rudder were input at the same time. The rolling motion stopped, the airplane shuddered (not buffet), but it remained hanging in a left bank as it continued descending. Captain Ellis felt that the controls stopped the rolling motion but that little authority remained to return the airplane to a level attitude. The maximum bank was about 20-25 degrees. Captain Ellis was concerned that the wake turbulence might be strong enough to cause the airplane to go inverted and was very conscious of the need to maintain a level pitch attitude.

The airplane "snapped" right for a moment, then returned into the vortex induced left bank. Captain Ellis advanced the power to just above the go-around setting and called for a go-around. The airplane sped up immediately and escaped the wake turbulence, breaking out the top at above 200 knots airspeed.

Captain Ellis had flown into wake turbulence many times before, and he recognized this as a wake turbulence encounter. He was confident that there was no yaw damper problem or other airplane malfunction. The airplane was responding properly. He did not know why there were two periods to the encounter. Other wake turbulence encounters were not nearly so violent as this one and did not last as long. There was extremely strong shuddering, although not like stall buffet. Once, as a first officer, he had observed a similar incident handled by the captain.

Captain Ellis had undergone unusual attitude training as a helicopter pilot in the military and as a candidate for an instructor rating. He recently completed the Advanced Maneuvers training at United Airlines, and was very conscious of this training while the event was happening. The training stressed aggressive use of all controls, especially rudder, and awareness of pitch attitude if the airplane rolled over. It was important to keep the pitch attitude level.

ATTACHMENT 6

WITNESS INTERVIEW
Captain Robert Schmidt
United Airlines

Malcolm Brenner and Chuck Leonard conducted a telephone interview of Captain Schmidt on February 16, 1996. He was giving IOE training to Captain Ellis from the right seat of the B-737 flight that experienced, on February 9, 1996, a wake turbulence encounter behind a B-727 airplane. Captain Schmidt was interviewed independently of Captain Ellis. Additional participants in the telephone interview were Bill Yantiss, United Airlines Safety Office, and Marilyn Pearson and Pete Delo, ALPA-United Pilot's Association.

Captain Schmidt said he was looking inside the cockpit when the incident began. The flaps were at two degrees, the airspeed was 180 kts., and the airplane was three miles behind a B-727 as measured on the TCAS. He felt like they were entering wake turbulence and the airplane began to roll. He observed that Captain Ellis put in the correct aileron and rudder commands, but the airplane rolled to a 25 degree bank and held in this position. With regard to aileron use, the captain's top hand was at an 11 o'clock position where a 12:30 o'clock position represents full use.

Captain Schmidt has 11,000 hours total flight time, of which 3000 hours were in the B-737-200. He said he had never previously encountered a wake turbulence experience like this where the airplane would not come out of the encounter. He had experienced wake turbulence frequently in military formation flying in the C-130, but said you could feel the burble and control the encounter with primary controls. He had encountered wake turbulence rarely in civilian flying, usually flying perpendicular to it and feeling a "short burp." He had never before seen an airplane just hang there, with the control surfaces able to stop the roll but nothing more. He believed the aircraft glide path was the same as the vortices. With go-around thrust added (still flaps at 2), the nose rose enough to fly out of the descending vortices, causing the aircraft to accelerate to 210 knots, thus regaining normal flight control response. They were able to complete the landing safely.

Captain Schmidt said that it never occurred to him that there might be anything wrong with the airplane, because the initial burble and the roll were familiar wake turbulence experiences, and Captain Ellis did not complain about the controls.

ATTACHMENT 7

Boeing statement on pilot stature certification criteria

Boeing Commercial Airplane Group
P.O. Box 3707
Seattle, WA 98124-2207

April 18, 1996
B-B600-15612-ASI

Mr. Malcolm Brenner, AS-50
National Transportation Safety Board
490 L'Enfant Plaza S. W.
Washington, D.C. 20594

BOEING

Subject: Pilot Stature Certification Criteria - USAir 737-300 Accident near Pittsburgh N513AU, September 8, 1994

Reference: Human Performance Group Meeting, January 16-17, 1996

Dear Mr. Brenner:

Mr. Curt Graeber advises that during the reference meeting you requested a statement from Boeing addressing: "pilot height design limits for the B-737 seat." The seat installation and motion used on all USAir Model 737-300 airplanes was first certified for a pilot stature range of 5 feet 2 inches to 6 feet 0 inches, but was later certified for a pilot stature range of 5 feet 2 inches to 6 feet 3 inches. These pilot stature ranges do not necessarily designate the persons who may be accommodated in the 737-300 cockpit. The ranges are intended to designate design references only, not pilot stature limits.

If you have any questions, please contact me.

Very truly yours,

[redacted]

for John W. Purvis
Director, Air Safety Investigation
Org. B-B600, M/S 14-HM
Telex 32-9430, STA DIR PURVIS
[redacted]

cc: Tom Haueter, NTSB, AS-10

DEPARTMENT OF DEFENSE
ARMED FORCES INSTITUTE OF PATHOLOGY
WASHINGTON, DC 20306-6000

REPLY TO
ATTENTION OF

Office of the Armed Forces Medical Examiner 22 January 1996

Malcolm Brenner, Ph.D.
Senior Human Performance Investigator
National Transportation Safety Board
Washington, DC 20594

Dear Dr. Brenner,

Pursuant to our discussions, below is my elaboration of the opinions I offered to the Human Performance Group concerning considerations of possible control inputs by crew of USAir flight 427.

With the information from the metallurgical analysis that both the pilot's and co-pilot's left rudder pedals were fractured in a similar pattern, I infer the possibility that both flight officers were symmetrically applying pressure to their respective left rudder pedals at the time of ground impact. The metal fracture implies such a strong pressure that I find the most likely body position to do this would be with the majority of the body weight concentrated on the left foot, that is: with the left knee locked. This sort of positioning sometimes produces characteristic "control injuries" (which would probably be mid-foot fractures, telescoping/collapsing fractures of leg bones, and/or hip fractures). Unfortunately, in this case, the extent of body disruption from the crash, the quantity of remains recovered, and incomplete re-association of recovered remains, did not yield these body parts of the flight crew for examination. This makes this scenario a "possible explanation" rather than an opinion with quantifiable probability.

Sincerely yours,

[redacted]

DAVID W. HAUSE
LTC, MC, USA
Deputy Medical Examiner

ATTACHMENT 9

Statement by Mr. Mellone

Battelle

ASRS Office
625 Ellis Street
Suite 305
Mountain View, California 94043
Telephone (415) 969-3969

December 1, 1995

Mr. Malcolm Brenner
Human Performance Division
National Transportation Safety Board
AS-50
690 L'Enfant Plaza, S.W.
Washington, DC 20594-2000

Dear Mr. Brenner:

This is in response to the inquiries from Mr. Michael Carriker, Boeing Commercial Airplane Group, in behalf of the NTSB Human Performance Group, concerning data information in the Multi-Engine Turbojet Uncommanded Upsets Structured Callback Summary:

- **Multi-Engine Turbojet Loss of Control Factors Data Chart**
  Although, the overall number of loss of control incidents between 1987 and May 1995 totaled 556 incidents, we displayed a breakdown of factors referenced in a total of 297 incidents on this chart. We selected the top 10 factors by number of incidents per factor. Beyond the top 10 factors, there were numerous other factors that were referenced in loss of control incidents, but were smaller numbers in frequency. As an example, factors such as hydraulic system, structural condition, overcontrol, wing load, distraction, fatigue, etc., were referenced in lesser frequencies.

- **ASRS Reports With Reporter Narratives**
  In order to identify loss of control factors such as wake turbulence, aircraft icing, flaps, etc., that are depicted in the above mentioned chart, it was necessary to screen the pilot's narratives in the 556 loss of control incidents. By searching the ASRS database and limiting our interrogation to multi-engine turbojet loss of control incidents, we were able to determine the top 10 factors.

- **Upsets Summary Acronyms**
  Explanatory information enclosed.

Sincerely,

[redacted]

Vincent J. Mellone
ASRS Operations Manager

VJM/smf

Enclosures

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, CA 94035-1000

Reply to Attn of: FL:262-1

MEMORANDUM FOR: Recipients of Aviation Safety Reporting System Data

SUBJECT: Data Derived from ASRS Reports

The attached material is furnished pursuant to a request for data from the NASA Aviation Safety Reporting System (ASRS). Recipients of this material are reminded of the following points which must be considered when evaluating these data.

ASRS reports are submitted voluntarily. The existence in the ASRS database of reports concerning a specific topic cannot, therefore, be used to infer the prevalence of that problem within the national aviation system.

Reports submitted to ASRS may be amplified by further contact with the individual who submitted them, but the information provided by the reporter is not investigated further. Such information may or may not be correct in any or all respects. At best, it represents the perception of a specific individual who may or may not understand all of the factors involved in a given issue or event.

After preliminary processing, all ASRS reports are deidentified. There is no way to identify the individual who submitted a report. All ASRS records systems are designed to prevent any possibility of identifying individuals submitting, or other names, in ASRS reports. There is, therefore, no way to verify information submitted in an ASRS report after it has been deidentified.

The National Aeronautics and Space Administration and its ASRS contractor, Battelle Memorial Institute, specifically disclaim any responsibility for any interpretation which may be made by others of any material or data furnished by NASA in response to queries of the ASRS database and related materials.

[redacted]

William Reynard, Director
Aviation Safety Reporting System

CAVEAT REGARDING STATISTICAL USE OF ASRS INFORMATION

Certain caveats apply to the use of ASRS statistical data. All ASRS reports are voluntarily submitted, and thus cannot be considered a measured random sample of the full population of like events. For example, we receive several thousand altitude deviation reports each year. This number may comprise over half of all the altitude deviations which occur, or it may be just a small fraction of total occurrences. We have no way of knowing which.

Moreover, not all pilots, controllers, air carriers, or other participants in the aviation system, are equally aware of the ASRS or equally willing to report to us. Thus, the data reflect **reporting biases**. These biases, which are not fully known or measurable, distort ASRS statistics. A safety problem such as near midair collisions (NMACs) may appear to be more highly concentrated in area "A" than area "B" simply because the airmen who operate in area "A" are more supportive of the ASRS program and more inclined to report to us should an NMAC occur.

Only one thing can be known for sure from ASRS statistics–they represent the **lower measure** of the true number of such events which are occurring. For example, if ASRS receives 300 reports of track deviations in 1993 (this number is purely hypothetical), then it can be known with certainty that at least 300 such events have occurred in 1993.

Because of these statistical limitations, we believe that the **real power** of ASRS lies in the **report narratives**. Here pilots, controllers, and others, tell us about aviation safety incidents and situations in detail. They explain what happened, and more importantly, **why** it happened. Using report narratives effectively requires an extra measure of study, the knowledge derived is well worth the added effort.

For a text on the strengths and limitations of incident data, the process of using incidents for human factors evaluations, statistical analysis methods and other sources of incident data, see:

Chappell, S.L. (1994). Using voluntary incident reports for human factors evaluations. In N. Johnston, N. McDonald & R. Fuller (Eds.), Aviation Psychology in Practice. Aldershot, England: Ashgate.

Flight Conditions - the weather environment at the time of the occurrence or situation in terms of the conventional definition for flight conditions. Codes used are: VMC–visual meteorological conditions; IMC–instrument meteorological conditions; MXD–mixed flight conditions (both VMC and IMC); MVI–marginal VFR; SVF–special VFR.

Reference Facility ID (or LOC ID) - the standard three-letter (or letter-number combination) location identifier associated with an airport or navigational facility as referenced in the FAA Order 7350.5Z series entitled "Location Identifiers."

Facility Identifier - the standard three-letter (or letter-number combination) location identifier associated with an ATC facility as referenced in the FAA Order 7350.5Z series entitled "Location Identifiers."

Aircraft Type - the aircraft type involved in the incident differentiated by arbitrary gross takeoff weight ranges (military aircraft type are differentiated by function). Codes used re:

SMA	-	small aircraft (less than 5,000 lbs)
SMT	-	small transport (5001 - 14,500 lbs)
LTT	-	light transport (14,501 - 30,000 lbs)
MDT	-	medium transport (30,001 - 60,000 lbs)
MLG	-	medium large transport (60,001 - 150,000 lbs)
LRG	-	large transport (150,001 - 300,000 lbs)
HVT	-	large transport (over 300,000 lbs)
WDB	-	wide-body (over 300,000 lbs)
ULT	-	ultralight (including hang gliders)
SPN	-	sailplane/glider
SPC	-	special purpose
FGT	-	fighter
BMB	-	bomber
MLT	-	military transport
MTR	-	military trainer

Anomaly (Descriptions, Detector, Resolution, Consequences) - short summary of a standard chain of sub-events within a reported incident.

Situation Report Subjects - description(s) of a static hazard which creates a safety problem.

ANOMALY DEFINITIONS

ACFT EQUIPMENT PROBLEM/CRITICAL - Aircraft equipment problem that is vital to the safety of the flight.

ACFT EQUIPMENT PROBLEM/LESS SEVERE - Not qualifying as a critical aircraft equipment problem.

ALT DEVIATION - A departure from or failure to attain or failure to maintain an ATC assigned altitude. It does not include an injudicious or illegal altitude in VFR flight where no altitude has been assigned by ATC or specified in pertinent charts.

ALT DEV/OVERSHOOT - An aircraft climbs or descends through the assigned altitude.

ALT DEV/UNDERSHOOT ON CLB OR DES - An aircraft fails to reach an assigned altitude during climb or descent.

ALT DEV/EXCURSION FROM ASSIGNED - An aircraft departs from level flight at an assigned altitude.

ALT DEV/XING RESTRICTION NOT MET - Charted or assigned altitude crossing restriction is not met.

ALT-HDG RULE DEVIATION - Cruise flight contrary to the altitudes specified in FAR 91.159.

CONFLICT/NMAC (NEAR MIDAIR COLLISION) - A conflict is defined as the existence of a perceived separation anomaly such that the pilot(s) of one or both aircraft take evasive action; or are advised by ATC to take evasive action; or experience doubt about assurance of continuing separation from the viewpoint of one or more of the pilots or controllers involved. A near midair collision is when the flight crew reports, either directly or as quoted by the controller, that the reported miss distance is less than 500 feet.

CONFLICT/AIRBORNE LESS SEVERE - A conflict not qualifying as a NMAC.

CONFLICT/GROUND CRITICAL - A ground occurrence that involves (1) two or more aircraft, at least one of which is on the ground at the time of the occurrence, or (2) one or more aircraft conflicting with a ground vehicle. The flight crew reports, either directly or as quoted by a controller, that they took evasive action to avoid a collision (emergency action go-around, veering on runway or taxiway, takeoff abort, or emergency braking), and the balance of the report, including the narrative is judged consistent with a critical occurrence.

CONFLICT/GROUND LESS SEVERE - A ground conflict not qualifying as critical.

CONTROLLED FLT TOWARD TERRAIN - Flying at an altitude that would, if continued, result in contact with terrain.

ERRONEOUS PENETRATION OF OR EXIT FROM AIRSPACE - Self-explanatory.

IN-FLT ENCOUNTER/OTHER - In-flight encounter (e.g., bird strikes, weather balloons).

IN-FLT ENCOUNTER/WX - In-flight encounter with weather (e.g., wind shear, turbulence, clouds, high winds, storms).

LESS THAN LEGAL SEPARATION - Less than standard separation between two airborne aircraft (as standard separation is defined for the airspace involved).

LOSS OF ACFT CONTROL - Self-explanatory.

NON-ADHERENCE LEGAL RQMT/CLNC - Non-adherence to an ATC clearance.

NON-ADHERENCE LEGAL RQMT/FAR - Non-adherence to a Federal Aviation Regulation.

NON-ADHERENCE LEGAL RQMT/PUBLISHED PROC - Non-adherence to approach procedure, standard instrument departure, STAR, profile descent, or operational procedure as described in the AIM or ATC facility handbook.

NON-ADHERENCE LEGAL RQMT/OTHER - Non-adherence to SOPs for aircraft, company SOPs, etc.

RWY OR TXWY EXCURSION - An aircraft exits the runway or taxiway pavement.

RWY TRANSGRESS/OTHER - The erroneous or improper occupation of a runway or its immediate environs by an aircraft or other vehicle so as to pose a potential collision hazard to other aircraft using the runway, even if no such other aircraft were actually present.

RWY TRANSGRESS/UNAUTH LNDG - A runway transgression specifically involving landing without a landing clearance or landing on the wrong runway.

SPEED DEVIATION - Aircraft speed contrary to FARs or controller instruction.

TRACK OR HDG DEVIATION - Self-explanatory.

UNCTRL ARPT TRAFFIC PATTERN DEVIATION - Failure to fly the prescribed rectangular pattern or failure to enter on a 45 degree angle to the downwind leg.

VFR IN IMC - Flight conducted under Visual Flight Rules (VFR) into Instrument Meteorological Conditions (IMC) when not on an instrument flight plan and/or when not qualified to fly under Instrument Flight Rules (IFR).

Your printout from the ASRS includes information on the following categories. Please note–each entry in a category is separated by a semicolon (e.g., two SMAs in one incident would be coded as "SMA;SMA;" in the Aircraft Type category.

Accession Number - a unique, sequential number assigned to each report.

Date of Occurrence - the date of the occurrence/situation in the form of a year and a month; e.g., 9304 represents April 1993.

Reported by - role of the person who reported the occurrence/situation. Codes used are: FLC–flight crew; PLT–pilot; CRM–crew member; CTLR–Air Traffic Controller; PAX–passenger; OBS–observer; AFC (or AIR)–Air Force; NVY–Navy; UNK–unknown.

Persons Functions - description of a person's function at the time of the occurrence. Codes used are:

FLC	PIC	-	Pilot in command as determined by official designation, prior consensus, or actually controlling the aircraft			
	CAPT	-	Captain role in a multi-person flight crew			
	FO	-	First Officer/Copilot role in a multi-person flight crew			
	SO	-	Second Officer/Flight Engineer role in a multi-person flight crew			
	OTH	-	Additional crew member (e.g., navigator) in a multi-person flight crew			
	CKP	-	Check pilot (essential flight crew member occupying a crew position/role)			
	ISTR	-	Legally qualified flight instructor who is giving instruction at the time of the occurrence/situation			
	PLT	-	Pilot in a single-person crew			
	TRNEE	-	*Flight crew member in training.*			
TWR	LC	-	Local controller	COORD	-	Coordinator position
	GC	-	Ground controller	CD	-	Clearance delivery
	FD	-	Flight data position	SUPVR	-	Supervisor
	OTH	-	Other	TRNEE	-	Trainee
TRACON	AC	-	Approach controller	COORD	-	Coordinator position
	DC	-	Departure controller	SUPVR	-	Supervisor
	RHO	-	Radar hand-off position	OTH	-	Other
	FD	-	Flight data position	TRNEE	-	Trainee
ARTCC	M	-	Manual controller	COORD	-	Coordinator position
	R	-	Radar controller	SUPVR	-	Supervisor
	H	-	Hand-off position	OTH	-	Other
	D	-	Assistant or data man	TRNEE	-	Trainee
MIL	PAR	-	Precision approach radar	OTH	-	Other
	RSU	-	Runway supervisory unit			
MISC	FSS	-	Flt service station specialist	DISP	-	Dispatcher
	ACI	-	Air carrier inspector	CENR	-	Company enroute check personnel
	UNI	-	Unicom operator			
	FBO	-	Fixed base operator/employee	TADV	-	Tower advisory
	CAB	-	Cabin attendant	AMGR	-	Airport manager
	VD	-	Vehicle driver	OBS	-	Observer
	PAX	-	Passenger	SUPVR	-	Supervisor
	CGP	-	Company ground personnel	OTH	-	Other

ATTACHMENT 10

Summary of San Pedro Sula interviews

SAN PEDRO SULA INCIDENT
FACTUAL INFORMATION
B. A. Berman

1. Interview Summary—Captain Ray Miller (Continental Airlines)

Interviewed March 29, 1996 over the telephone by B. Berman, M. Brenner, and T. Haueter.

Miller was the captain of the flight involved in the San Pedro Sula incident on April 11, 1994. He provided the following information:

The event began with a lateral disturbance: a "left-right bang" that felt like a jet wake. In ¼ second, the airplane reached about 20 degrees of left roll, then rolled right to wings level. After this initial yaw event, the aileron controls were "locked." He disconnected the autopilot. He was "putting in a great deal of force leveling the aircraft" prior to disconnecting the autopilot.

Next, he "turned the aircraft loose to see what it wanted to do." First it "just sat there;" then, it "wanted to roll to the right." He continued to apply force to the aileron control. He said that he could not move the control wheel laterally; he felt like he was applying force against mechanical stops. Additional force resulted in "ratcheting" of the control wheel that moved these stops and allowed more wheel travel. He had to use "arm strength to the left" and "put his shoulder into it" to maintain control of the airplane.

Next, he closed the throttles. He gave control to the first officer for a while.

He fought the locked ailerons for control all the way to landing. There was no yaw after the first excursion. After the first excursion, his control problem was one of pilot induced oscillation due to hitting a "dead spot" related to the mechanical stops in the aileron control system. After he ratcheted them back with force, these stops were about at the 1 index to the right and 4 index to the left (which he described as about 50 percent of wheel throw). The rudder pedals were centered with no pressure.

He thinks that the rudder PCU of the incident airplane had been subject to an AD requiring it to be removed, cleaned, and sealed. This PCU was removed from an airplane about 1-1/2 years prior to the incident. A new employee of Continental "sealed it" because it "looked clean."

He thinks that the aileron control problems occurred because the autopilot went into a test mode as he was turning it off. He believes that this test mode would lock the aileron controls.

2. Interview Summary—First Officer Gerald B. Emory (Continental Airlines)

Interviewed April 26, 1996 over the telephone by B. Berman.

Emory was the first officer on the flight involved in the San Pedro Sula incident. He provided the following information:

He had flown about 6-8 monthly pairings with Captain Ray Miller in the preceding 3-4 years.

When the incident began, he was sitting sideways talking to a flight attendant who was in the cockpit. Captain Miller was facing forward. The right wing dropped, about 30 degrees by his perception. It "snapped" very rapidly from level flight to this attitude. He looked back at the right wing to see if any wing panels had departed the airplane. When he looked back, the airplane was in a stable right bank and was maintaining altitude. He believes that the control wheel (yoke) was level. The autopilot was still engaged.

Miller turned off the autopilot with the yoke button. The autopilot disengaged normally. After that, "everything was fine." He knew that Miller was very uncomfortable, but he was comfortable because Miller had the airplane under control.

He never took the control wheel or felt the control pressures. He is unable to specify the wheel inputs Miller was introducing. Miller didn't complain of control problems while the airplane was descending. Miller was "pretty excited," "really working the controls," and "worried about the pressures," though, as the descent occurred.

The autopilot disconnect normally turns the autopilot all the way off, rather than leaving the autopilot in control wheel steering mode. He did not see specifically whether the autopilot "snapped all the way down to off" rather than into the CWS position.

3. <u>Review of CVR</u>

The San Pedro Sula CVR includes a "wailer" sound similar to the autopilot disconnect tone at about the time that the incident begins. The sound ends about 1 second after it starts.

4. <u>Interview Summary: Larry Hirni, Boeing autopilot systems engineer</u>

Interviewed on April 26, 1996 over the telephone by B. Berman. Mr. Hirni provided the following information:

Autopilot disconnect pulls a stop out from the engage lever and the lever falls all the way down; it "could not" stick in the control wheel steering (CWS) mode. For the autopilot to remain engaged without the lever being down, failures of 2 independent switches would be required. The pilot would have felt autopilot pitch inputs as well as roll inputs, if the autopilot had remained engaged.

The disconnect horn would not sound unless the engage lever fell all the way to disconnect.

The autopilot is not capable of trimming the ailerons.

The CWS mode would amplify the pilot's input and require less force, rather than more, to achieve a given roll rate.

If the crew tried to overpower an engaged autopilot, it would drop to CWS mode with no horn and no force to overpower.

With autopilot engaged or in CWS, a pilot's control input demand can be faster than the autopilot actuator can move if the pilot moves the wheel faster than the autopilot servo can respond. In this case, the pilot would be working against the servo. But when the servo/actuator caught up, the force would go away. The wheel would have to move more than 60 degrees per second to create this situation.

There is a force limiter in the autopilot at 17 degrees wheel deflection (flaps up condition).

For the "byte" test mode to be engaged, the airplane must be at less than 60 knots, with weight on the squat switches, and byte test mode selected on the FMCS test screen. When engaged, the autopilot sends a display to the screen. It is not trying to drive the servos. The output to the roll servo is held at zero. But if the autopilot is engaged, it couples to the servo. With the wheel held in the centered position, a pilot attempting to move the control wheel would have to overpower the autopilot. This would require "normal autopilot overpowering force." Also, a small error in the servo loop could cause the wheel to drift one way or the other.

Boeing has never had an autopilot drop into the byte test mode while an aircraft was in flight.

It is possible that a failure of a switch in the mode control panel could have actuated a 28V solenoid and driven the control wheel without normal autopilot actuation. These switches are connected to ground to protect against a failure like this.

The autopilot has a "Command" position which, if overridden by control wheel input, would provide CWS during the control input and then hold the roll attitude that existed at the time the control input ceased.

ATTACHMENT 11

Statement of the Interstate Aviation Committee
(in Russian)

МЕЖГОСУДАРСТВЕННЫЙ
АВИАЦИОННЫЙ КОМИТЕТ

INTERSTATE
AVIATION COMMITTEE

117292, Москва,
ул. Кржижановского, д. 7, корп. 1
Тел.: 125-14-52, факс: 129-61-44

0200200

14.03.96 N 05-569

Заместителю директора
Управления безопасности
полетов

г-ну Р.Шлиду

Уважаемый г-н Шлид!

Передаю Вам некоторые результаты исследований по опыту расследований типичных авиапроисшествий, связанных с неадекватными действиями пилотов при неожиданных для них эволюциях самолета. В исследованиях принимали участие высококвалифицированные специалисты в области летного труда и психологии летной деятельности.

Когда летчик тяжелого самолета (транспортного, пассажирского или бомбардировщика) ***неожиданно*** оказывается в эволюции, характеризующейся большим углом крена (из-за спутного следа, отказа автопилота, взрыва вне самолета и тому подобное), то в его понимании процесса полета возникает т.н. “психологическая сшибка” (stupor), порождаемая различием в ожидаемом (прогнозируемом) и фактическим положением самолета в пространстве. В течение 3…4 секунд сознание пытается осмыслить причину “непонятного” положения самолета и какие бы то ни было действия летчика отсутствуют.

Потеря этих 3…4 секунд влечет за собой неконтролируемое увеличение угла крена и изменение угла тангажа и к моменту готовности пилота к работе самолет приобретает значительный угол крена (30…40°) и, как правило, опускание носа по тангажу. Рефлекторная реакция летчика тяжелого самолета всегда направлена на парирование доминирующей опасности - снижение с разгоном скорости, запас по которой чаще всего мал, что провоцирует взятие колонки штурвала “на себя” с созданием нормальной перегрузки. При этом условия полета (день или ночь) не играют существенной роли, так как вне облаков пилоты при размытой линии естественного горизонта, что характерно

B4972

для высот более 2000 м (7000 футов), более привычны к приборному, чем к визуальному полету, и поэтому могут при восстановлении пространственной ориентировки обращаться к показаниям авиагоризонта.

Сочетание большого угла крена и положительной перегрузки - идеальные условия для ввода в спираль, выход из которой если и возможен, то достаточно сложен.

Такова внешняя картина явления. Причины нам видятся в следующем.

При непосредственном (без автоматики, вручную) управлении самолетом у пилота с опытом вырабатываются навыки управления, когда обеспечено сенсомоторное управление на уровне рефлекторной деятельности при минимальных запаздываниях реакции. При этом пилот как бы управляет своим телом (и, следовательно, самолетом) в пространстве, ориентируясь на естественный горизонт (в визуальном полете на небольшой высоте) или тождественные ему ориентиры, либо на систему показаний приборов, которая создает в его сознании так называемый "образ полета".

При этом важную роль играют телесные ощущения, которые создаются сочетанием усилий на органах управления и ответная реакция самолета, выраженная в угловых и линейных ускорениях (акселерационное восприятие движения самолета).

Система автоматического управления, работа с которой имеет операторский характер, как бы "отчуждает" летчика от непосредственного управления самолетом, что снижает или даже исключает его восприятие самолета на уровне пропреоцептивных ощущений. Теперь при переходе к ручному (непосредственному) управлению при прочих равных условиях (своевременное привлечение внимания к объекту - например, к авиагоризонту) необходимо некоторое время адаптации к ощущению, утраченному в течение длительного автоматизированного полета.

Вторая причина состоит в длительности формирования "образа полета" при существующих формах индикации угла крена по типу "вид с самолета на землю", когда на приборе индицируется подвижная линия приборного горизонта при неподвижном (относительно пилота и самолета) силуете самолета.

Исследованиями на большой статистике установлено, что при данном виде индикации имеет место значительное число ошибочных первичных реакций летчика по выводу самолета из крена (до 9%) и большое запаздывание в восприятии показаний (до 33% случаев более 3 сек) в то время как при индикации типа "вид с земли на самолет" соответствующие показатели равны 1,4 % и 98% случаев менее 1 сек. (Данные заимствованы из отчетов Летно-исследовательского Института им.М.М.Громова, Научно-исследовательского испытательного Института авиакосмической медицины и Научно-испытательного Института им. В.П.Чкалова , 1978…1984 г).

Характерно, что при потере пространственной ориентировки пилотами самолета Ил-18, где применялся авиагоризонт с типом индикации "вид с земли на самолет", в трех известных случаях пилоты восстанавливали пространственную ориентировку и выводили самолет с последующей посадкой (23.12.65 г. Магадан, 11.12.69 г. Свердловск, 21.01.71 г. Ростов-на-Дону). В этих случаях вывод самолетов характеризовался следующими параметрами:

23.12.65

Ил-18 N° 75688. Ночь, полет при включенном автопилоте выше облаков. За 43 сек самолет потерял высоту с 8000 до 4000 метров, вертикальная скорость была достигнута 170 м/сек, скорость по прибору возросла с 470 до 730 км/час, максимальный угол крена был 90°, перегрузка при выводе 3,25 (максимально допустимая эксплуатационная 2,5). При выводе самолет был значительно деформирован. Причина - случайное отключение автопилота экипажем.

10.12.69.

Ил-18 N° 75699. Ночь, полет при включенном автопилоте выше облаков. За 18 сек самолет потерял высоту с 8400 до 7000 метров, вертикальная скорость была достигнута 95 м/сек, максимальный угол крена был 70°, перегрузка при выводе 2,5. Скорость увеличилась с 440 до 600 км/час.

21.01.71.

Ил-18 N° 75727. Полет при включенном автопилоте. За 44 сек самолет потерял высоту с 7800 до 5000 метров, вертикальная скорость была достигнута 130 м/сек, скорость по прибору возросла с 500 до 680 км.час, максимальный угол крена был 90°, перегрузка при выводе 2,7 (максимально допустимая эксплуатационная 2,5). При выводе самолет был значительно деформирован. Причина - отказ автопилота или его случайное отключение экипажем.

По нашему мнению, этими причинами (отвлечение от непосредственного, сенсомоторного управления и недостаточная наглядность авиагоризонтов) в значительной степени объясняются те случаи, когда пилоты тяжелых самолетов, непреднамеренно попавшие в эволюцию с большими углами крена, не могут своевременно выправить положение.

Одним из факторов катастрофы А-310 под Междуреченском (22.03.94 г) была потеря пространственной ориентировки пилотов, а также их неумение адекватно управлять самолетом в сложном пространственном положении. Как известно, командиром был опытный пилот (общий налет 9675 час, в качестве командира 5595 час, на самолете А-310 в качестве командира 895 час), который не находился на своем рабочем месте. Второй пилот (пилот 1 класса, общий налет 5855 час, на самолете А-310 в качестве второго пилота 440 час) вмешался в управление при угле крена 63°, однако в дальнейшем штурвал был взят "на себя", а сопутствующее (скорее всего, непроизвольное) отклонение педали привели к переходу самолета в штопор.

Есть основания предварительно предполагать, что в катастрофе под Хабаровском также имело место нечеткое представление пилотов относительно угла крена самолета (командир - пилот 1-го класса с общим налетом 12225 час, из них на Ту-154 - 5016 часов, в том числе командиром 3974 часов) вмешался в управление при угле крена около 80°, но безуспешно.

В обоих случаях пилоты имели высшую квалификацию линейных пилотов гражданской авиации и упрекнуть их в недостатке мастерства нет никаких оснований.

Проведенный в 1973 г анализ материалов по выводу самолета Ил-18 из глубоких кренов, выполненный ГосНии ГА, ОКБ "Ильюшин", Летно-исследовательским институтом авиапромышленности и ЦАГИ показал, что при попадании самолета в сложное пространственное положение с большим креном необходимо в первую очередь выводить самолет из крена, а затем из снижения, поскольку взятие штурвала "на себя" до вывода из крена переводит самолет в крутую спираль с опусканием носа и увеличением вертикальной скорости снижения. Попытки вывода самолета из создавшегося спиралеобразного движения только с помощью взятия штурвала "на себя" оказываются неэффективными и связаны с опасными последствиями, т.к. самолет в конечном итоге может выйти за границы допустимых ограничений.

В случае несвоевременного вмешательства в управление, особенно при запаздывании с выводом самолета из крена, если режим работы двигателей остается неизменным и соответствует исходному режиму полета на эшелоне, рост крена сопровождается энергичным нарастанием скорости, предельные значения числа M и $V_{пр}$ достигаются достаточно быстро (через 20…25 сек), что может привести к созданию на борту сложной ситуации.

Радикальной профилактикой могли бы быть следующие мероприятия:

1.-тренировки пилотов в выводе из сложного пространственного положения на тренажерах при неожиданном попадании в него;

2.-периодические провозки на маневренных самолетах с элементами пилотажа;

3.-периодическое (в течение длительного полета) ручное управление полетом для сокращения времени дезадаптации к пилотированию и восстановления "чувства машины";

4.-дополнительные исследования ***Норм летной годности*** в части требований к форме индикации приборного горизонта, особенностей деятельности пилота при применении высокоавтоматизированных систем автоматического управления полетом.

Эти мероприятия нуждаются в дополнительных исследованиях. Мы располагаем научным и методическим "заделом" для их проведения, намерены их проводить в ближайшем будущем и предлагаем обсудить перспективу проведения совместных исследований. Если Вас интересуют данные по каким-нибудь другим конкретным происшествиям, мы готовы их Вам сообщить.

Заместитель Председателя Комитета
[redacted] Р.Теймуразов

Заместитель Председателя Комиссии
по расследованию авиационных происшествий
[redacted] В.Кофман

Заместитель Начальника Научно-технического Центра
летчик-испытатель
[redacted] В.Овчаров

ATTACHMENT 12

Statement of the Interstate Aviation Committee
(in English translation)

INTERSTATE
AVIATION COMMISSION

117292 Moscow
Ul. Krzhizhanovskogo, Bldg. 7, Korpus 1
Tel.: 125-14-52, fax: 129-51-44

To: Deputy Director
Office of Aviation Safety

0200200

Mr. Ron Schleede

14.03.96, No. 05-569

Dear Mr. Schleede,

This letter contains results from research concerning investigations of typical aviation accidents involving inadequate pilot response to unexpected aircraft maneuvers. This research has involved the work of specialists in the fields of human factors and aviation psychology.

When a heavy aircraft (transport, passenger, or bomber) maneuvers unexpectedly into a high bank angle (due to wake vortices, autopilot malfunction, or explosion outside the aircraft, etc.), the pilot suffers a certain "psychological knock-out" (stupor) and loses spatial orientation. This stupor results from the difference between the expected and the actual attitude of the aircraft in space. For 3-4 seconds the pilot takes no actions of any kind, as his mind seeks to comprehend the reason for the airplane's "incomprehensible" attitude.

The loss of these 3-4 seconds results in an uncontrolled increase in the bank angle and a change in the pitch angle. By the time the pilot can resume piloting the aircraft the bank angle is significant (30-40 degrees), and, as a rule, the nose is pitched downward. The reflex reaction of the pilot of a heavy aircraft is always to counteract the greatest danger, an accelerated descent, for which the airspeed safety margin is usually small. This causes the pilot to pull back on the control column, which results in positive g's. Current flight conditions (day or night) do not play a significant role, since outside the clouds, where the natural horizon line blurred, as it usually is at altitudes above 2000 meters (7000 feet), pilots are more accustomed to instrument, rather than visual, flight. For this reason they are able to recover their spatial orientation using the attitude indicator.

The combination of a high bank angle and the positive g's [resulting from the pilot's pull up] creates conditions for a spin, from which it is difficult, if not impossible, to recover.

This is a general description of the problem. We see the causes as follows:

When the aircraft is actively controlled by the pilot (manually, without using automatic systems), through experience the pilot is able to develop control skills, and the pilot's sensory-motor control reaches the level of reflex, such that his reactions are only *minimally* delayed. It is as though the pilot controls his own body in space (and, in turn, the airplane), referring to the natural horizon (for low-altitude, visual flight), to identical orientation points, or to the indication system, which creates in the pilot's mind a certain "mental image" of the flight.

In this context tactile sensations play an important role. These sensations are created by the interaction of forces [from the pilot] on the controls [of the aircraft] and the corresponding responses of the aircraft, expressed in angular and linear accelerations. The sensation created is that of accelerated aircraft motion.

One could say that an automatic control system, equipment which is "operated", has the effect of "alienating" the pilot from active control of the airplane. This reduces, or even eliminates, the pilot's perception of the airplane on a proprioceptive level. The transition [back] to active manual control, other things being equal (such as the pilot's quick orientation to the controls, like the attitude indicator), now [requires] a certain amount of time so that the pilot can recover the feel [of the airplane] that has been lost during long, automated flight conditions.

A second cause is the fact that current "view from airplane to ground"-type bank angle displays require [some] time to create the "mental image" [for the pilot]. These instruments have a moving line representing the artificial horizon, and an airplane silhouette which is non-moving (with respect to the pilot and the airplane).

Statistical analysis has established that when this type of display is used, a significant number of pilot initial reaction errors occur during recoveries of the aircraft from banks (up to 9%), and significant delays occur in reading the instrument indications (up to 33% [of these delays] lasting more than 3 seconds). On the other hand, for displays of the "view from ground to airplane" type, the corresponding data are 1.4%, [with delays of] less than 1 second for up to 98% of cases [examined]. (Data were obtained from reports of the Flight Investigation Institute named after M. M. Gromov, from the Scientific Research Experimental Institute of Aerospace Medicine, and from the Scientific Research Institute named after V. P. Chkalov, 1978-1984.)

In three well-known cases involving loss of spatial orientation, pilots of Il-18 aircraft restored spatial orientation, recovered the aircraft from a bank, and landed (12-23-65, Magadan; 12-11-69, Sverdlovsk; 01-21-71 Rostov-na-Donu). It is significant that in these cases an attitude indicator of the "view from ground to airplane"-type was used. The parameters for recovering these aircraft from the banks were as follows:

12-23-65

Il-18 No. 75688. Night, automated flight, above the clouds. In 43 seconds the airplane descended from 8000 to 4000 meters, vertical speed of 170 meters/second was reached, indicated airspeed increased from 470 to 730 kilometers/hour, the maximum bank angle was 90 degrees, and load factor during recovery was 3.25 (maximum operational load factor is 2.5). The airplane suffered significant structural deformation during recovery. Cause: crew accidentally disconnected the autopilot.

12-20-69

Il-18 No. 75699. Night, automated flight, above the clouds. In 18 seconds the aircraft descended from 8400 to 7000 meters, vertical speed increased to 95 meters/second, maximum bank angle was 70 degrees, and load factor during recovery was 2.5. Airspeed increased from 440 to 600 kilometers/hour.

01-21-71

Il-18 No. 75727. Automated flight. In 44 seconds the aircraft lost altitude from 7800 to 5000 meters, vertical velocity reached was 130 meters/second, indicated airspeed increased from 500 to 680 kilometers/hour, maximum bank angle was 90 degrees, load factor during recovering was 2.7 (maximum operational load factor is 2.5). During recovery the airplane was significantly deformed. Cause: malfunction of the autopilot or accidental disconnection of the autopilot by the crew.

In our opinion, these causes (lack of pilot's active sensory-motor control [of the airplane] and inadequate visual clarity of the attitude indicator) to a significant degree account for cases in which pilots of heavy aircraft, having unintentionally gotten into maneuvers with high bank angles, were unable to quickly regain control.

One factor in the A-310 crash near Mezhdurechenskoe (03-22-94) was pilot loss of spatial orientation, as well as lack of ability to guide the airplane in a unusual attitude. As is well-documented, the captain, who was an experienced pilot (9675 total flight hours, 5595 hours as a captain, and 895 hours as an A-310 captain), was not seated at his position. The co-pilot (pilot first class*, total flight hours 5855, as an A-310 co-pilot 440) attempted to recover control of the aircraft during a 63 degree bank. However after he had pulled back the control column, his accompanying deflection of the pedal (most likely involuntary) put the airplane into a spin.

There are reasons to assume preliminarily that in the crash near Khabarovsk the pilots also did not have a clear awareness of the bank angle. The captain (pilot first class

* refers to the highest rank of the Russian civil aviation pilot -Tr.

with 12,225 total flight hours, of which 5016 were in the Tu-154, including 3974 as captain) attempted to recover the airplane [from] an 80 degree bank, but without success.

In both cases the pilots were highly qualified civil aviation line pilots, and there are no grounds to criticized their pilot proficiency.

A 1973 analysis of data on recoveries of Il-18 aircraft from steep banks, conducted by the State Scientific Research Institute of Civil Aviation, the Ilyushin Experimental Design Bureau, the Flight Research Institute of the Aviation Industry, and the Central Institute of Aero- and Hydrodynamics, showed that for an airplane in an unusual attitude involving a high bank angle, it is necessary first to bring the airplane out of the bank, and then out of the descent. [This is because] bringing the control column back prior to recovery from the bank puts the airplane into a steep spiral with the nose pitched down and increases the speed of vertical descent. Attempts to bring the airplane out of the resulting spiral by pulling back the control column alone are ineffective and can lead to dangerous results, since the aircraft ultimately may exceed allowable [physical] limits.

In instances of delayed intervention to recover control of an airplane, especially if that delay involves recovery of the aircraft from the bank, if the engine thrust settings have been left unchanged from the initial engine thrust [settings] for cruising at flight level, increase in the bank is accompanied by a rapid increase in the airspeed, [and] extreme values of M and V [refers to M_{df} and V_{df} - Tr.] are reached very rapidly (in 20-25 seconds). These conditions may lead to an unusual attitude on board the aircraft.

The following steps may be regarded as effective preventive measures:

1. simulator training for pilots in recovery of aircraft from an unusual attitude, using unanticipated introduction of these situations [in simulations]

2. regular flight training, with an instructor, involving aircraft control systems on maneuverable airplanes

3. regular return to manual flight mode (during long flights) to reduce de-adaptation to aircraft control and restore the "feel of the airplane"

4. additional research concerning Airworthiness Standards with respect to requirements for attitude indicators and special aspects of pilot activity during use of highly automated systems for automatic flight control

These measures require further research. We have the scientific and methodological "start" to conduct further research, we plan to conduct such research in the near future, and we propose to discuss the possibility of conducting joint research. If you are interested in data on other specific accidents, we would be pleased to provide them.

Deputy Chairman of the Commission

//signature// R. Tejmurazov

Deputy Chairman of the Commission
for Aviation Accident Investigations

//signature// V. Kofman

Deputy Chief of the Scientific Technical Center
Test Pilot

//signature// V. Ovcharov