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Silk Air 185 Aircraft Accident Summary:

Brief overview:
On December 19, 1997 a Silk Air Boeing B737-300 aircraft departed Soekarno-Hatta International Airport, Jakarta with 104 aboard (97 passengers, 5 cabin crew and 2 cockpit crew). The aircraft took off in daylight with good weather conditions and climbed to 35,000 feet. The voice and data recorders were deactivated with no abnormal data, then, according to radar information, the aircraft suddenly dropped 400 feet in 8 seconds and continued in a rapid descent initiating in-flight breakup followed by complete disintegration of the aircraft upon impact with the Musi River. Although 73% of the wreckage was recovered, most of the samples consisted of small highly distorted parts. All 104 persons on board were killed.

Rapperport Associates was engaged to develop a simulation of the final flight path based on flight recorder data, radar information and debris field Silk Air 185 wreckage scatter.

Detailed accident summary:
On December 19, 1997 a Silk Air Boeing B737-300 aircraft (flight MI 185), was on a scheduled commercial international passenger flight routing Singapore – Jakarta – Singapore. The Singapore to Jakarta leg was uneventful. After completing a turnaround in Jakarta, the aircraft departed Soekarno-Hatta International Airport at 15:37 local time with 97 passengers, 5 cabin crew and 2 cockpit crew for the return leg. At 15:37 local time flight MI 185 took off, climbed to 35,000 feet and assumed a Palembang heading. At 16::05:15.6, the cockpit voice recorder (CVR) ceased recording with no abnormal data. The last readable data from the flight data recorder (FDR) was at 16:11:27.4. Jakarta Air Traffic Control (ATC) radar recording showed that MI 185 was still at 35,000 feet at 16:12:09. The next radar return, eight seconds later, indicated that MI 185 was 400 feet below cruise altitude of 35,000 feet and a rapid descent followed. The last recorded radar data at 16:12:41 showed the aircraft at 19,500 feet. The empennage (the tail section including stabilizing and flight control surfaces) of the aircraft subsequently broke up in flight and the aircraft crashed into the Musi River delta, about 50 kilometers north-north-east of Palembang at about 16:13. The accident occurred in daylight and in good weather conditions.

All 104 persons on board were killed and the aircraft was completely destroyed on impact with the Musi River. The wreckage had penetrated deep into the river bottom complicating recovery efforts. The impact force was so great and the destruction was so extensive that most of the recovered fragments from the river consisted of small highly distorted parts. Portions of the rudder skin and the outboard sections of the horizontal stabilizer were recovered on land, the furthest about four kilometers from the main impact site. About 73% by weight of the wreckage was recovered.

http://www.ibtimes.com/pilot-suicide-when-its-captain-who-crashes-plane-1519756

The Republic of Indonesia's National Transportation Safety Committee (NTSC) was unable to determine the reasons for the departure of the aircraft from its cruising level of FL350 and the reasons for the termination of the flight recorders. Engineering simulations of flight path data derived from pre-upset FDR data, recorded radar information, and wreckage locations were conducted to determine the final trajectory of the aircraft from the time it departed cruise flight until the end of recorded data. The conclusions of the draft final NTSC report state that analysis of the simulation results indicated that no single mechanical failure of the airplane structure or flight control systems would have resulted in movement of the airplane through recorded radar data points. Moreover, there was no evidence of any combination of systems failures.

The circuit breaker panel located directly behind the captain's seat contains the circuit breakers for both the CVR and FDR. It was determined that the cockpit door did not open before the CVR ceased recording at 0905:15.6, thus it is evident that the captain would have been in the best position to manually pull the CVR circuit breaker at the time that it stopped. It was noted that the captain had pulled a CVR circuit breaker on a previous occasion to preserve a conversation between the Pilot-In-Command and his copilot in violation of standard operating procedure.

Comments on the draft final NTSC report submitted by the accredited representative of the United States National Transportation Safety Board (NTSB) are:

1. The evidence supports a conclusion that no airplane-related mechanical malfunctions or failures caused or contributed to the accident.
2. The accident airplane's flight profile is consistent with sustained nose-down manual flight control inputs.
3. The evidence suggests that the CVR was intentionally disconnected.
4. Recovery of the airplane was possible but not attempted.
5. It is more likely that the nose-down flight control inputs were made by the captain than by the first officer.

Plaintiff's alleged that the departure from cruise flight was due to uncommanded hard over rudder deflection.

Litigation summary:
Trials were to be held in three jurisdictions – Seattle Washington, Cleveland Ohio and California. The first case was tried in California and resulted in a jury verdict of $43 million for three estates; thus, exposing Parker Hannifin to a substantial downside should they lose the following trials. In a sudden turn of events, Boeing settled on the eve of trial and prior counsel was relying on testimony from Boeing's expert to put their case in with regard to all issues having to do with flight control, avionics, final flight path and aircraft accident reconstruction. The Parker Hannifin expert was not prepared to testify about the flight control and final flight path issues and the results were quite disappointing. The jury awarded each of the three estates $14 million which meant that Parker Hannifin had a $1.0 billion exposure for the seventy three victims involved in the upcoming trial.

Predecessor council and predecessor experts were subsequently replaced. Successor council (Jones Day) and experts (Rapperport Associates, Inc.) were retained with regard to the avionics and aircraft accident reconstruction defense issues for the upcoming trials involving fifty three estates.

The Plaintiff's postulated that the rudder deflected to the blowdown limit (the largest achievable angle of a rudder in flight is called its blowdown limit; it is achieved when the force from the air or blowdown is equal to the maximum available hydraulic pressure.). Rudder deflection proposed by plaintiff's expert was 9° (blowdown limit). Rapperport Associates conducted an accident reconstruction that examined intentional pilot nose down maneuver versus a rudder hard-over. The issue of recovery and controllability from rudder hard-over at cruise altitude was studied. Our analysis showed that the final flight trajectory was consistent with constant, intentional, forward column force and inconsistent with a hydraulic system malfunction.

The Ohio trial involved the fifty three estates (seventy three victims). Three of the estates were moved to Washington State and the remaining fifty remained in Ohio to be tried. The case settled on extremely favorable terms with all claims filed in Federal Court.

References:

1. Aerodynamic Principles of Large Airplane Upsets: http://www.boeing.com/commercial/aeromagazine/aero_03/textonly/fo01txt.html
2. Stall: http://en.wikipedia.org/wiki/Stall_(fluid_mechanics)
    a. Aircraft rudder blowdown limit: http://en.wikipedia.org/wiki/Rudder
3. Possible rudder related accidents involving Boeing 737's: http://www.b737.org.uk/rudder.htm

The Rudder Story

The safety record of the 737 has been exemplary with less than 120 hull losses in almost 40 years. However two mysterious accidents that were possibly rudder related in the early 1990's brought the design into sharp focus which resulted in a huge redesign & retrofit program which will not end until late 2008.

Additional References:

- Technical description of the rudder system
- Report on the 2000 Boeing 737 rudder conference
- **The Accidents**
- 3 March 1991, UA585, a 737-200Adv crashed on approach to Colorado Springs. The aircraft departed from controlled flight approximately 1,000 feet above the ground and struck an open field. After a 21-month investigation, the Board issued a report on the crash in December 1992. In that report, the NTSB said it "could not identify conclusive evidence to explain the loss of the aircraft", but indicated that the two most likely explanations were a malfunction of the airplane's directional control system or an encounter with an unusually severe atmospheric disturbance.
- 8 Sep 1994, US427, a 737-300 was approaching Pittsburgh Runway 28R when ATC reported traffic in the area, which was confirmed in sight by the First Officer. At that moment the aircraft was leveling of at 6000ft (speed 190kts) and rolling out of a 15deg left turn (roll rate 2deg/sec) with flaps at 1, the gear still retracted and autopilot and auto-throttle systems engaged. The aircraft then suddenly entered the wake vortex of a Delta Airlines Boeing 727 that preceded it by approx. 69 seconds (4,2mls). Over the next 3 seconds the aircraft rolled left to approx. 18deg of bank. The autopilot attempted to initiate a roll back to the right as the aircraft went in and out of a wake vortex core, resulting in two loud "thumps". The First Officer then manually overrode the autopilot without disengaging it by putting in a large right-wheel command at a rate of 150deg/sec. The airplane started rolling back to the right at an acceleration that peaked 36deg/sec, but the aircraft never reached a wings level attitude. At 19.03:01 the aircraft's heading slewed suddenly and dramatically to the left (full left rudder deflection). Within a second of the yaw onset the roll attitude suddenly began to increase to the left, reaching 30deg. The aircraft pitched down, continuing to roll through 55deg left bank. At 19.03:07 the pitch attitude approached -20deg, the left bank increased to 70deg and the descent rate reached 3600f/min. At this point, the aircraft stalled. Left roll and yaw continued, and the aircraft rolled through inverted flight as the nose reached 90deg down, approx. 3600ft above the ground. The 737 continued to roll, but the nose began to rise. At 2000ft above the ground the aircraft's attitude passed 40deg nose low and 15deg left bank. The left roll hesitated briefly but continued and the nose again dropped. The plane descended fast and impacted the ground nose first at 261kts in an 80deg nose down, 60deg left bank attitude and with significant sideslip. All 132 on board were killed.

- In 1996 the crew of an Eastwind Airlines flight 517 briefly lost control of their 737 as they approached Richmond, Va.
- Unfortunately, none of the aircraft involved had modern, highly informative flight data recorders, so the NTSB staff was forced to make assumptions in developing its hypotheses.
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- The NTSB, FAA, Boeing, US Airways and ALPA all had different opinions about the cause of these accidents:
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- **The US Air View**
- According to US Airways the cause was: "An uncommanded, full rudder deflection or rudder reversal that placed the aircraft in a flight regime from which recovery was not possible using the known recovery procedures. A contributing cause of this accident was the manufacturer's failure to advise operators that there was a speed below which the aircraft's lateral control authority was insufficient to counteract a full rudder deflection.".
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- **The ALPA View**
- ALPA believes that the airplane experienced an uncommanded full rudder deflection. This deflection was a result of a main rudder power control unit (PCU) secondary valve jam which resulted in a primary valve overstroke. This secondary valve jam and primary valve overstroke caused USAir 427 to roll uncontrollably and dive into the ground. Once the full rudder hardover occurred, the flight crew was unable to counter the resulting roll with aileron because the B737 does not have sufficient lateral control authority to balance a full rudder input in certain areas of the flight envelope.
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- **The Boeing View**
- Charlie Higgins, a Boeing vice president who heads up airplane safety and performance for Boeing, said the rudder control units from the 737s in the Pittsburgh and Colorado Springs crashes were both thoroughly examined as a part of the NTSB's accident investigations. No jam was detected in either unit, he said. But the tests showed that extreme temperature differences between the chilly outside atmosphere and piping-hot hydraulic fluid coursing through the backup rudder could cause the mechanism to fail. That would leave the plane without navigational control if the primary rudder failed. Under even the most severe flying conditions, the temperature differential between the hydraulic fluid and the surrounding components never exceeds 90 degrees. The rudder failure took place only when the differential was 180 degrees or higher. We can't see a flight where that would occur.
- The company points to pilot error in the Pittsburgh crash, suggesting the pilots may have mishandled the plane in reaction to the turbulence, with the first officer inadvertently holding the left rudder pedal to the cockpit floor as he and the Captain pulled back on the control stick to break their plunge. They blame a rogue wind in the United Airlines crash and a mis-rigged yaw damper for the Eastwind incident.

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- **The NTSB View**
- Dennis Crider, chairman of the NTSB's Aircraft Performance Group, told the board members "A rudder reversal scenario will match all three events,"
- The Boeing Co., hotly contests such a finding, saying there is no physical evidence that supports rudder reversal scenarios in the three incidents.
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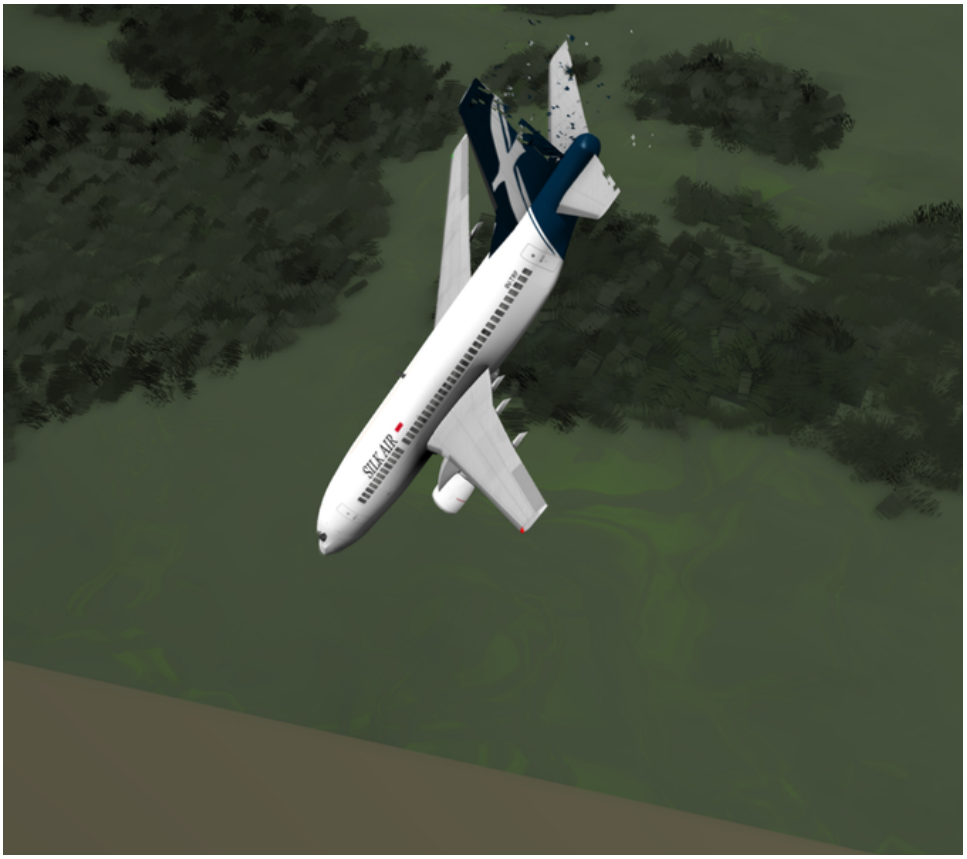
- **The FAA View**
- The FAA argues that no one will ever know the cause with any certainty, so it has focused on making the plane safer.

Photo gallery of Silk Air 185 crash:

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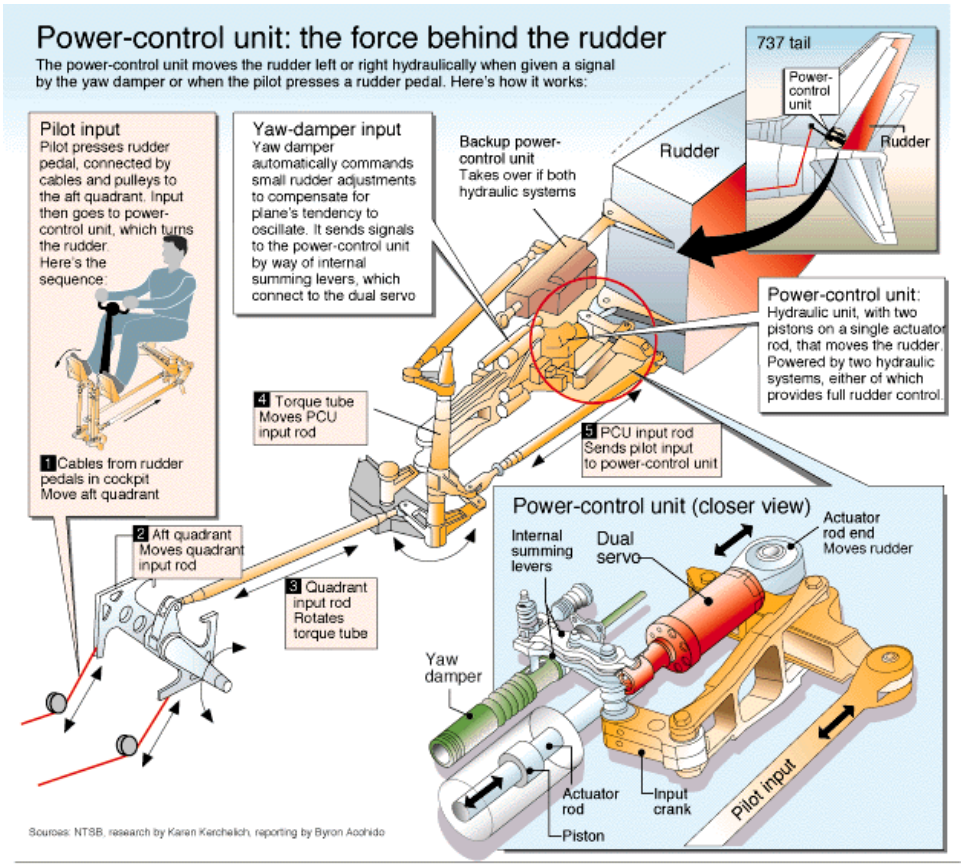
Power-control unit: the force behind the rudder
The power-control unit moves the rudder left or right hydraulically when given a signal by the yaw damper or when the pilot presses a rudder pedal. Here's how it works:
737 tail
Power-control unit
Rudder
Rudder
Pilot input
Pilot presses rudder pedal, connected by cables and pulleys to the aft quadrant. Input then goes to power-control unit, which turns the rudder. Here's the sequence:
Yaw-damper input
Yaw damper automatically commands small rudder adjustments to compensate for plane's tendency to oscillate. It sends signals to the power-control unit by way of internal summing levers, which connect to the dual servo
Backup power-control unit
Takes over if both hydraulic systems
Power-control unit:
Hydraulic unit, with two pistons on a single actuator rod, that moves the rudder. Powered by two hydraulic systems, either of which provides full rudder control.
1 Cables from rudder pedals in cockpit Move aft quadrant
2 Aft quadrant Moves quadrant input rod
3 Quadrant input rod Rotates torque tube
4 Torque tube Moves PCU input rod
5 PCU input rod Sends pilot input to power-control unit
Power-control unit (closer view)
Internal summing levers
Dual servo
Actuator rod end Moves rudder
Yaw damper
Actuator rod
Piston
Input crank
Pilot input
Sources: NTSB, research by Karen Kerchelich, reporting by Byron Acohido