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Two Engines Separate from the Right Wing and Result in Loss of Control and Crash of Boeing 747 Freighter

The official report of the Netherlands Aviation Safety Board concluded that the original design of the engine pylons, together with the continuous airworthiness measures and the associated inspection system, did not guarantee the minimum required level of safety of the Boeing 747 at the time of the accident.

Editorial Staff

The crew of the Boeing 747-200 freighter made a normal takeoff from Schiphol Airport, Amsterdam, Netherlands, on an instrument flight rules (IFR) flight plan to Tel Aviv, Israel. Seven and a half minutes later, while the aircraft was climbing through 6,500 feet (1,982 meters), the No. 3 pylon and its engine separated from the right wing and damaged part of the wing's leading edge. The No. 3 engine then struck the No. 4 engine, causing it to also separate from the aircraft.

While attempting to return to Schiphol Airport, the crew lost control of the aircraft, which crashed into an apartment building in a suburb of Amsterdam. The three crew members and one nonrevenue passenger were killed. In addition, 43 persons on the ground were killed, 11 persons were seriously injured and 15 persons received minor injuries in the Oct. 4, 1992, accident.

The final report of the Netherlands Aviation Safety Board (NASB) concluded that the probable causes of the accident were: "The design and certification of the B-747 pylon was found to be inadequate to provide the required level of safety. Furthermore, the system [designed] to ensure structural integrity by inspection failed. This ultimately caused — probably initiated by fatigue in the inboard midspar fuse pin — the No. 3 pylon and engine to separate from the wing in such a way that the No. 4 pylon and engine were torn off, part of the leading edge of the wing was damaged and the use of several systems was lost or limited."

The report concluded: "This subsequently left the flight crew with very limited control of the airplane. Because of the marginal controllability, a safe landing became highly improbable, if not virtually impossible."

The investigation was hampered because the cockpit voice recorder (CVR) was never found. The digital flight data recorder (DFDR) was severely damaged, but the data concerning the accident flight were recovered.

The B-747-200 freighter was owned and operated by El Al Israel Airlines. The accident aircraft arrived in Amsterdam at 1540 hours local time, after flying from John F. Kennedy International Airport, New York, New York, U.S., the report said. The accident crew (captain, first officer and flight engineer) and a nonrevenue passenger boarded the aircraft after it was fueled and loaded with cargo.

At 1921, the flight departed Amsterdam. The takeoff and initial climb were normal until 1927:30, the report said. As the aircraft climbed through 6,500 feet, the No. 3 and No. 4 pylons and engines separated from the right wing. The first officer then transmitted to air traffic control (ATC), "El Al 1862, Mayday, Mayday, we have an emergency," the report said.

"The aircraft turned to the right and, according to witnesses on the ground, started dumping fuel," the report said. The Amsterdam Radar controller acknowledged the flight's emergency call, and cleared the area of other traffic. After confirming that the crew wanted to return to Schiphol Airport, the controller instructed the flight to turn to a heading of 260 degrees. “At 1928:17, the crew reported a fire on engine No. 3 and, subsequently, they indicated [a] loss of thrust on engines No. 3 and No. 4,” the report said. [The report attributed the flight crew’s announcement of a fire on the No. 3 engine to a “double fault indication of the (engine-fire detection) system,” which, according to the system logic, triggered a fire warning, and the crew’s “limited field of view from the cockpit to the wing area.”]

“Witnesses heard one or more banging sounds, and saw a dark plume of smoke trailing the aircraft,” the report said. “Some witnesses saw objects fall. Other witnesses also saw fire on the right wing which eventually disappeared. When the aircraft turned right, two vapor trails were seen to emerge from the wingtips.”

At 1928:57, the controller told the crew that Runway 6 was in use, and that the wind was from 40 degrees at 21 knots. “The flight crew, however, requested Runway 27 for landing,” the report said. “Because the aircraft was only seven miles [11.3 kilometers] from the airport, and still flying at an altitude of 5,000 feet [1,525 meters], a straight-in approach was not feasible, and the crew was instructed to turn right to heading 360 and descend to 2,000 feet [610 meters]. The crew was again informed about the wind (by then 50 degrees at 22 knots).”

About one minute later, the controller asked the crew about the distance required for their approach. The crew replied that they needed “12 miles [19.3 kilometers] final for landing,” the report said. Together with this reply, the call “Flaps one” could be heard in the background.

The controller instructed the crew to turn right to 100 degrees, then asked the crew about the aircraft status. The crew replied, “No. 3 and [No.] 4 are out and we have problems with our flaps,” the report said. The aircraft turned through 100 degrees, maintaining a heading of 120 degrees. “No corrective action was taken by the controller,” the report said. The aircraft was now maintaining 260 knots, and was in a gradual descent.

The flight was cleared for the approach, and given a heading of 270 degrees to intercept the final approach course, the report said. The aircraft was at approximately 4,000 feet (1,220 meters), and on a heading of 120 degrees. At this point, the aircraft was three nautical miles (NM) (5.5 kilometers) north of the extended centerline of Runway 27, and about 11 miles (17.7 kilometers) from the runway. “According to the radar plot, it took about 30 seconds before the aircraft actually changed heading,” the report said.

The controller noticed that the flight was going to overshoot the localizer, and instructed the crew to turn further right to a heading of 290 degrees, to intercept the localizer from the south, the report said. Twenty seconds later, the controller instructed the flight to turn to 310 degrees, and to descend to 1,500 feet (457 meters).

At 1935:03, the crew acknowledged the controller’s instructions and added, “and we have a controlling problem,” the report said. About 25 seconds later, the first officer radioed, “Going down 1862, going down ... ,” the report said. “In the first part of this transmission, commands from the captain to raise all the flaps and to lower the landing gear could be heard. During the middle part of this transmission, a sound was heard, and in the final part of the transmission, another sound was audible. These sounds were later analyzed and determined to be the stick shaker and the ground-proximity warning system respectively,” the report said.

At 1935:42, the aircraft crashed into an 11-story apartment building, approximately 13 kilometers (eight miles) east of Schiphol Airport. “The impact was centered at the apex of two connected and angled blocks of apartments, and fragments of the aircraft and the buildings were scattered over an area approximately 400 meters [1,320 feet] wide and 600 meters [1,980 feet] long,” the report said. The aircraft collided with the two buildings while in a right bank of slightly more than 90 degrees, and in a nose-down attitude of approximately 70 degrees.

“Fire-fighting and rescue operations started shortly after the crash,” the report said. The aircraft was destroyed by the impact and the ensuing fire. The two apartment buildings were partly destroyed, and later demolished.

The report described the wreckage pattern: “The initial impact area in the frontal face of the buildings was small. Pavement and walkways along the initial impact area, and rather high trees immediately in front of the building remained undamaged. Most of the structure in front of the wings of the aircraft was recovered from this area. Parts of the cockpit section, cockpit interior, controls and human remains of the crew were recovered at the right hand side of the apex [of the two buildings].”

The report continued: “Ground water level, mud and [local] repeatedly ensuing fires formed generally hazardous conditions, seriously impairing the possibility of retrieving the flight recorders, which were not found in the main wreckage area. The DFDR was recovered after a scrutinous inspection of the already removed mixture of debris of the aircraft and rubble. The possibility has to be considered seriously that the CVR was stolen from the area, as were several other parts, [e.g.], the left-hand steering wheel.”

The DFDR was heavily damaged by the crash impact and postcrash fire, the report said. Nevertheless, the DFDR tape was recovered. “The tape itself was found broken at four places, where it was not wound on the reels. The tape exhibited cracks, discoloration and contamination, particularly at the section that contained the information of the last two and a half minutes of the flight. A small amount of water was also found in the crash-protection unit of the recorder. Notwithstanding the damage, a readout was accomplished on some parameters.”

When investigators examined the wreckage, they determined that the "aircraft configuration at impact was TE [trailing-edge] flaps up, LE [leading-edge] flaps partially extended, stabilizer trim approximately 4.2 units aircraft nose-up, wing gears up, body gears and nose gears in transit," the report said.

The No. 1 and No. 2 engines were found in the main impact area near the apartment building. "Examination of the engine fragments and analysis of the damage indicated that the engines were operating at high power up to the impact with the ground," the report said. "No evidence was found of pre-existing damage to the engines which might have been caused by an external or internal source."

"Engines No. 3 and [No.] 4 were dredged from the lake located below the aircraft's flight path, together with the engine pylons and many parts of their nose cowls and thrust reversers," the report said. "Internal rub marks and other witness marks indicated that when the engines hit the water they were either at a low rotating speed or had stopped. Internal examination of engine [No.] 3 and [No.] 4 showed no abnormal signs of pre-existing damage."

Investigators reviewed the possibility of a bird strike on the accident aircraft, and found no evidence of bird impact on the No. 3 and No. 4 engines or the engine cowlings, the report said. The possibility of sabotage was also examined, and no evidence was found that sabotage caused the accident, the report said.

The maintenance records for the accident aircraft were reviewed, and "all the required inspection and maintenance actions had been completed, and all applicable airworthiness directives (ADs) had been accomplished, or were in the process of being accomplished within the specified time limits," the report said. "Examination of the service records, crew write-ups, action items, trend monitoring data and flight recorder data of previous flights did not reveal any significant deviations."

The NASB determined that "the accident sequence was initiated by the in-flight separation of the No. 3 engine pylon from the wing," the report said. "Engine and pylon No. 3 separated from the wing and collided with engine No. 4, in an outward and rearward direction. In view of the amount of LE flaps and LE structure found, the right wing leading edge must have been damaged up to the front spar of the right-hand wing, over an area approximately one meter [3.3 feet] left of pylon No. 3 to approximately one meter right of No. 4. It is assumed that [because of] the speed of the aircraft, the aerodynamic distortion and turbulence, some parts were blown off the leading edge of the right-hand wing up to the front spar."

After the No. 3 and No. 4 pylons and engines separated, investigators believed, the crew flew the aircraft under the following conditions:

- The right wing leading edge was severely damaged;
- The right wing leading-edge flaps were partially damaged;
- The right outboard aileron was "floating" at five degrees trailing edge–up;
- There was limited roll control because no outboard aileron was available, and the spoiler system was only partially available;
- There was limited rudder control because of a lagging of the lower rudder for unknown reasons;
- The right inboard aileron was probably less effective because of disturbed airflow created by the damaged wing leading edge and the loss of the No. 3 pylon; and,
- Engines No. 1 and No. 2 were at high thrust settings.

The NASB concluded that "the separation of the engine pylon was caused by a failure of connecting components that attach the pylon to the wing of the airplane," the report said. "To determine the initial failure origin, a total of nine different scenarios were identified, each of which could lead to the separation of the engine pylon from the wing."

Investigators believed that the most likely sequence of events that led to the separation of the engine pylon was "(1) a fracture initiated by a fatigue crack of the shear face of the inboard midspar fuse pin," the report said, " ... followed by (2) a sequential failure of the outboard lug of the inboard midspar fitting. Then (3), the outboard shear face. Finally (4), the inboard shear face of the outboard midspar fuse pin. The subsequent pylon engine separation occurred during the flight out of Schiphol Airport at 6,500 feet and at an IAS [indicated airspeed] of 367 knots."

The NASB analyzed the U.S. Federal Aviation Administration's (FAA's) supervision of the continued airworthiness of the B-747. "This organization [the FAA] carries out its responsibility mainly by issuing airworthiness directives [ADs], many of which were originally Boeing service bulletins [SBs]," the report said. "In [the] case of the Boeing 747, the FAA issued a large number of ADs addressing numerous fatigue problems in the pylon structure, including fuse pins, lugs and fittings. Nevertheless, new cracks and failures were discovered frequently, giving doubt about the ultimate strength of the structure."

The report continued: "In addition to the fatigue problems, a static problem was identified in service. On several occasions, so-called crank-shafting of fuse pins was reported. Apparently, a plastic deformation of the fuse pins can occur at operational load conditions. Over a time period of 15 months, three pylons ([on airplanes operated by] China Airlines, El Al and Evergreen) have failed in flight, resulting in two fatal [accidents] and one serious accident."

[The other fatal accident occurred on Dec. 29, 1991. While passing through 5,200 feet (1,586 meters) on a climbout, a China Airlines B-747-200 freighter experienced separation of pylons and engines No. 3 and No. 4. All five crew members were killed when the airplane collided with a hillside near Taipei, Taiwan, while attempting to return to the airport. An Evergreen International Airlines B-747-121 freighter encountered severe turbulence at 2,000 feet (610 meters) during climb after takeoff from Anchorage, Alaska, U.S. The No. 2 pylon and engine separated from the wing. Despite having extreme difficulty in controlling the aircraft, the crew made a successful emergency landing.]

The NASB concluded: "The original design together with the continuous airworthiness measures and the associated inspection system did not guarantee the minimum required level of safety of the Boeing 747 at the time of the accident."

As a result of this accident, and other occurrences of wing-pylon problems on the B-747, "Boeing developed a stainless steel fuse pin with a considerably improved fatigue and crack growth life," the report said. "Furthermore, the static strength and fatigue, and crack growth analysis, will be supported by tests."

The U.S. National Transportation Safety Board (NTSB) recommended that the FAA take a number of actions relating to the design of, and inspection procedures for, the B-747:

- Reduce the recurrent inspection interval for the old-style fuse pins from 500 flight cycles to 100 flight cycles or fewer, and specify a time for removing the old-style fuse pins from service;

- Reduce the inspection intervals for the new-style fuse pins if a need for reduction is indicated by inspections;

- Require an ultrasonic inspection, in place of visual inspection, of the wing spar lug and pylon clevis of the midspar attachments;

- Establish an inspection requirement for the upper-link and diagonal-brace attachment hardware;

- Apply the inspection program for the new-style pins and the pylon-attachment fittings to General Electric (GE)-powered airplanes;

- Require Boeing to obtain flight test data to be used in engineering analysis to validate that the pylon-to-wing attachments have adequate safety margins for all flight conditions and engine configurations; and,

- Require Boeing to make available a newly designed fuse pin for the B-747 engine pylon-to-wing midspar attachment to replace current fuse pins that are susceptible to corrosion or fatigue cracking.

By the end of July 1995, the NTSB had classified the FAA's responses to these recommendations "closed — acceptable action," meaning that the recommendations had been implemented or alternate actions taken to the same effect.

One other NTSB recommendation was:

- Require the installation of a midspar fuse pin–indicating stripe on each side of the B-747 engine nacelle struts, in accordance with a Boeing service bulletin, and require a check for wing-to-pylon misalignment before each flight.

The FAA disagreed with the recommendation to require preflight inspections on the grounds that misalignment could be too small to detect from the ground during visual inspection.

The background and qualifications of the flight crew were reviewed. The captain, age 59, held an Israeli Airline Transport License (ATPL), with type ratings in the B-747, Boeing 707 and McDonnell Douglas DC-3. He had 25,000 hours total flying time, and 9,500 hours in the B-747. The captain had flown 233 hours in the B-747 in the 90 days preceding the accident. He held a current first-class medical certificate, with a requirement to wear corrective glasses while exercising the privileges of his certificate, the report said.

The first officer, age 32, held an Israeli ATPL, with type ratings in the B-707 and the B-747. He had 4,288 hours total flying time, and 612 hours in the B-747. The first officer had flown 151 hours in the B-747 in the 90 days preceding the accident. He held a first-class medical certificate with no limitations, the report said.

The flight engineer, age 61, held an Israeli flight engineer license, with ratings for the B-747 and B-707. He had 26,000 hours total flying time, and 15,000 hours in the B-747. The flight engineer had flown 222 hours in the B-747 in the 90 days preceding the accident. He held a first-class medical certificate, with the requirement to wear corrective glasses while exercising the privileges of his certificate, the report said.

The day before the accident flight, all three crew members had flown together on the route from Tel Aviv to London, then to Amsterdam, the report said. The crew reported for duty on the day of the accident flight after resting for 20 hours.

When the accident flight departed Amsterdam, the first officer was the pilot flying, and the captain was communicating with ATC, the report said. After the engines separated from the right wing, the Mayday call and all following communications were made by the first officer. "The captain clearly took over control and kept control of the airplane throughout the remainder of the flight," the report said.

Investigators reviewed the performance of the flight crew after the engines separated. DFDR data revealed that the captain was at times using full rudder pedal deflection, and control wheel deflections from 20 degrees to 60 degrees to the left, the report said. "The Boeing training manual states that in an asymmetric flight condition with two engines inoperative on one side, there should be enough rudder authority to allow the control wheel to be almost neutral up to MCT [maximum continuous thrust] at maneuvering speed," the report said.

During a flight in a B-747 simulator, "it was noted that with flaps up (which locks out the outboard ailerons) under the above-mentioned conditions and with maximum deflection, approximately 30 degrees left wing–down control wheel deflection was needed to maintain straight flight," the report said. "In the case of El Al 1862, the damage to the right wing and the up-floating right outboard aileron required even more left wing–down control wheel deflection."

The report noted: "This supports the hypothesis that the crew faced a very unusual situation. At 260 knots, the airplane was almost out of control with full deflected rudder and 60 to 70 percent of maximum control. This was very different from what the crew would expect from their knowledge of an experience with an aircraft with two engines inoperative."

Investigators then evaluated the crew's handling of the aircraft in the final moments of the flight. "Until the last phase of the flight, aircraft control was possible, but extremely difficult," the report said. "The aircraft was in a right turn to intercept the localizer, and the crew was preparing for the final approach, and may have selected the leading edge flaps electrically ... . The aircraft decelerated when the pitch attitude was increased, probably to reduce the rate of descent."

The report continued: "The associated increase in angle-of-attack caused an increased drag. Additional drag of a sideslip and possible extended leading-edge flaps resulted in a further speed decay. This speed decay was probably the reason to increase thrust on the two remaining engines, No. 1 and [No.] 2."

Those conditions resulted in an increased roll moment to the right caused by:

- asymmetric lift generation at an increased angle-of-attack;
- high-thrust asymmetry;
- a loss of aerodynamic efficiency of the right inboard aileron at an increased angle-of-attack; and,
- possible asymmetric lift caused by leading-edge flaps operation.

"The resulting roll moment exceeded the available roll control," the report said. "Near the end of the flight, the crew was clearly confronted with a dilemma. On the one hand, they needed extra thrust to decrease the rate of descent and maintain speed, [but] on the other hand the higher thrust increased the control difficulties. In general, in case of degraded performance, thrust should be confined to that level at which aircraft control can be maintained."

Investigators reviewed the crew's immediate decision and actions to return to Schiphol Airport. "The decision to land as soon as possible committed the crew to perform under extreme time constraints. The complexity of the emergency, on the other hand, called for time-consuming and partly conflicting checklist procedures. Warnings and indications in the cockpit were most likely compelling and confusing. Furthermore, the pilots were confronted with a controllability and performance situation which was completely unknown to them, and they were not in a position to make a correct assessment."

The report concluded: "The [NASB] is of the opinion that given the situation of the crew as described above, and the marginal controllability, the possibility for a safe landing was highly improbable, if not virtually impossible."

The performance of the air traffic controllers who handled the accident flight was reviewed. The NASB believed that the exchange of information during the emergency was at times inadequate. "The crew only gave sparse information concerning their problems and intentions," the report said. "The controller occasionally used nonstandard phraseology which was not as explicit or understandable as would be desirable in an emergency situation ... . Pilots and ATC personnel should be aware that for the adequate handling of an emergency, it is vital to use standard phraseology, and to exchange all necessary information about the urgency and the severity of the situation."

In evaluating the radar vectors provided by ATC, the report said: "The attempt of the controller to position the airplane by radar vectoring to a point 12 NM on the localizer for Runway 27 was not completely successful. A wider than normal setup of the circuit would have better allowed for the possible steering errors and slow reactions to heading changes which occurred, and which may be expected in emergency situations."

The NASB also commented on the controller's vectoring of the accident flight over the city of Amsterdam during the emergency. "The [NASB] feels that in the handling of emergency situations, not only the safety of airplane and passengers, but also the possible risk to third parties [on the ground] should be taken into account," the report said.

The weather at the time of the accident was reviewed. The conditions at Schiphol Airport at the time of the crash consisted of $^{1}/_{8}$ alto-cumulus clouds at 13,000 feet (3,965 meters), and the visibility from the ground to 2,000 feet was 15 kilometers (9.3 miles), the report said. The surface wind was from 40 degrees at 23 knots, with gusts to 33 knots, and the temperature was 13 degrees C (55 degrees F). There was light-to-moderate turbulence, the report said.

As a result of its investigation, the Netherlands Aviation Safety Board concluded the following:

- "The airplane was inspected and maintained in accordance with El Al and Boeing maintenance procedures;
- "The flight crew was trained and certificated in accordance with appropriate Israeli CAA [Civil Aviation Authority], El Al and industry standard procedures;
- "At an altitude of about 6,500 feet, the No. 3 pylon failed. This pylon and No. 3 engine separated from the right wing;
- "The No. 3 engine struck the No. 4 engine, causing the No. 4 pylon and engine to separate from the wing;
- "The leading-edge flaps and a portion of the fixed leading edge of the wing back to the front spar were extensively damaged. The No. 3 and [No.] 4 hydraulic systems were completely [disabled] and the pneumatic system was partially disabled;
- "The flight crew reported a fire on the No. 3 engine to ATC. Given the system logic, a fire warning may have been the result of a double fault indication of the system;
- "[Because of] the limited field of view from the cockpit to the wing area, the flight crew was not able to observe the separation of the No. 3 engine, [or] the damage to the wing;
- "Performance and controllability were so severely limited that the airplane was marginally flyable;
- "Current standard industry training requirements and procedures do not cover complex emergencies like [that] encountered by El Al 1862;
- "After declaring an emergency, the flight crew decided to return to Schiphol Airport immediately and land on Runway 27, although Runway 6 was in use for landing;
- "Because the airplane became too high and too close to the airport to accomplish a straight-in landing, the flight crew was vectored through an approximate 360-degree pattern of descending turns to intercept the final approach course;
- "During the vectoring to the final approach, the flight crew stated to air traffic control that they were experiencing a problem with the aircraft's flaps. Shortly before intercepting the final approach, they reported controlling problems;

ATC Transcript of El Al 1862's Final Moments

19:27:56	**CREW:**	El Al 1862, Mayday, Mayday, we have an emergency.
19:28:00	**ATC:**	El Al 1862, roger. Break, KLM 237, turn left heading 090.
19:28:06	**ATC:**	El Al 1862, do you wish to return to Schiphol?
19:28:09	**CREW:**	Affirmative, Mayday, Mayday, Mayday.
19:28:11	**ATC:**	Turn right heading 260, field eh ... behind you eh ... in your — to the west eh ... distance 18 miles.
19:28:17	**CREW:**	Roger, we have fire on engine number number 3, we have fire on engine number 3.
19:28:22	**ATC:**	Roger, heading 270 for downwind.
19:28:24	**CREW:**	270 downwind.
19:28:31	**ATC:**	El Al 1862, surface wind 040 at 21 knots.
19:28:35	**CREW:**	Roger.
19:28:45	**CREW:**	El Al 1862, lost number 3 and number 4 engine, number 3 and number 4 engine.
19:28:50	**ATC:**	Roger, 1862.
19:28:54	**CREW:**	What will be the runway in use for me at Amsterdam?
19:28:57	**ATC:**	Runway 6 in use, sir. Surface wind 040 at 21 knots, QNH 1012.
19:29:02	**CREW:**	1012, we request 27 for landing.
19:29:05	**ATC:**	Roger, can you call Approach now, 121.2 for your line-up?
19:29:08	**CREW:**	121.2, bye bye.
19:29:08	**ATC:**	Bye.
19:29:25	**CREW:**	Schipol, El Al 1862, we have an emergency, eh ... we're number t— ... eh ... 3 and 4 engine inoperative [badly readable, probably: "intending" or "returning"] landing.
19:29:32	**ATC:**	El Al 1862, roger, copied about your emergency, contact 118.4 for your line-up.
19:29:39	**CREW:**	118.4, bye.
19:29:49	**CREW:**	Schiphol, El Al 1862, we have an emergency, number 3 and number 4 engine inoperative, request 27 for landing.
19:29:58	**ATC:**	You request 27, in that case heading 360, 360 the heading, descend to 2,000 feet on 1012, mind, the wind is 050 at 22.
19:30:10	**CREW:**	Roger, can you say again the wind please?
19:30:12	**ATC:**	050 at 22.
19:30:14	**CREW:**	Roger, what heading for Runway 27?
19:30:16	**ATC:**	Heading 360, heading 360 and [then] give you a right turn on, to cross the localizer first, and you've got only seven miles to go from present position.

19:30:25	**CREW:**	Roger, 36 copied.
19:31:17	**ATC:**	El Al 1862, what is the distance you need to touchdown?
19:31:27	**CREW:**	12 miles final we need for landing.
19:31:30	**ATC:**	Yeah, how many miles final ... eh correction ... how many miles track miles you need?
19:31:40	**CREW:**	... Flap one ... we need ... eh ... a 12 miles final for landing.
19:31:43	**ATC:**	Okay, right right heading 100, right right heading 100.
19:31:46	**CREW:**	Heading 100.
19:32:15	**ATC:**	El Al 1862, just to be sure, your engines number 3 and 4 are out?
19:32:20	**CREW:**	Number 3 and 4 are out and we have ... eh ... problems with our flaps.
19:32:25	**ATC:**	Problem with the flaps, roger.
19:32:37	**CREW:**	Heading 100, El Al 1862.
19:32:39	**ATC:**	Thank you, 1862.
19:33:00	**CREW:**	Okay, heading ... eh ... and turning, eh ... maintaining.
19:33:05	**ATC:**	Roger, 1862, your speed is?
19:33:10	**CREW:**	Say again?
19:33:12	**ATC:**	Your speed?
19:33:13	**CREW:**	Our speed is ... eh ... 260.
19:33:15	**ATC:**	Okay, you have around 13 miles to go to touchdown, speed is all yours, you are cleared to land Runway 27.
19:33:21	**CREW:**	Cleared to land 27.
19:33:37	**ATC:**	El Al 1862, a right right turn heading 270 adjust on the localizer, cleared for approach.
19:33:44	**CREW:**	Right, right 270.
19:34:18	**ATC:**	El Al 1862, you're about to cross the localizer due to your speed, continue the right turn heading 290, heading 290, 12 track miles to go, 12 track miles to go.
19:34:28	**CREW:**	Roger, 290.
19:34:48	**ATC:**	El Al 1862, further right, heading 310, heading 310.
19:34:52	**CREW:**	310.
19:34:58	**ATC:**	El Al 1862, continue descent 1,500 feet, 1,500.
19:35:03	**CREW:**	1,500, and we have a controlling problem.
19:35:06	**ATC:**	You have a controlling problem as well, roger.
19:35:25	**CREW:**	Going down 1862, going down, going down, copied going down. [Background: "Raise all the flaps, all the flaps raise, lower the gear."]
19:35:47	**ATC:**	Yes, El Al 1862, your heading.

Source: Netherlands Aviation Safety Board

- "During preparation for final approach, speed reduction made the airplane exceed the limits of its remaining control capability. The airplane crashed into an apartment complex;
- "Exchange of information between El Al 1862 and ATC was not always adequate;
- "The effectiveness of the fused-pylon concept in protecting the wing structure and fuel tank against the consequences of pylon overloads was based on the history of the similar fuse-pin design of the Boeing 747;
- "Certification of the B-747 pylon included a fail-safe analysis of the nacelle and pylon concept. At that time, this analysis, however, did not address the specific fail-safe requirement assuming a fatigue failure or partial failure of a single structure element;
- "A then state-of-the-art fatigue analysis of the pylon structure was made to establish the maintenance requirements. In real life, this did not turn out to be sufficiently reliable. From August 1979 on, a large number of SBs and ADs were issued addressing numerous fatigue problems in the pylon structure including fuse pins, lugs and fittings;
- "Inspection and analysis performed by specialists on recovered parts of the pylon construction revealed severe damage [caused by] fatigue;
- "No firm conclusion could be drawn whether or not the fatigue crack in the outboard midspar fuse pin was detectable at the last ultrasonic inspection;
- "After analyzing the possibilities, it is assumed that the separation was initiated by a fatigue crack in the inboard shear face of the fuse pin in the inboard midspar fitting; [and,]
- "Over a period of 15 months, three pylons have failed in flight, resulting in two fatal [accidents] and one serious accident. The original type design together with the continuous airworthiness measures and associated inspection system did not guarantee the minimum required level of safety of the Boeing 747."

The NASB issued the following recommendations as a result of its investigation:

- "Redesign the B-747 pylon structure, including attachment to engine and wing. All SBs and ADs should be terminated after the redesign;
- "The redesign program for the pylon should include a full-scale fatigue and fail-safe test;

- "A large-scale in-flight fleetwide fatigue load measurement program should be carried out, both on wing, fuselage and fin-mounted engines in order to establish more realistic load spectra for fatigue evaluations;

- "Review present methods of controlling structural integrity, such as nondestructive inspection techniques and airworthiness directive requirements, in the current-design B-747 pylon assembly;

- "If a structural design concept is used as the basis for the certification of another design, in-service safety problems for both designs should be cross-referenced;

- "Evaluate and where necessary improve the training and knowledge of flight crews concerning factors affecting aircraft control when flying in asymmetrical conditions such as with one or more engines inoperative, including:
  - advantages and disadvantages of direction of turn;
  - limitation of bank; [and,]
  - use of thrust in order to maintain controllability;

- "Evaluate and where necessary improve the training and knowledge of flight crews in cockpit resource management in order to prepare them for multiple systems failures, conflicting checklist requirements and other beyond-abnormal situations;

- "Expand the information on in-flight emergencies in appropriate guidance material to include advice [on] how to [ensure] that pilots and air traffic controllers are aware of the importance to exchange information in case of in-flight emergencies. The use of standard phraseology should be emphasized;

- "Evaluate and where necessary develop common guidelines on emergency procedures and phraseology to be used between ATC, fire brigade, airport authorities and RCC [rescue coordination center];

- "Expand the training of pilots and ATC personnel to include the awareness that in the handling of emergency situations, not only the safety of airplane/passengers, but also the risk to third parties, especially residential areas, should be considered;

- "Review design philosophy of fire-warning systems, to preclude false warnings upon engine separation;

- "Review flight control design to ensure that flight control surfaces do not contribute adversely to airplane control in case of loss of power to a control surface;

- "Fire resistance of DFDR and CVR should be improved;

- "Investigate the advantages of [the] installation [of] cameras for external inspection of the airplane from the flight deck."♦

Editorial note: This article was adapted from *El Al Flight 1862, Boeing 747-285F, 4X-AXG, Bijlmermeer, Amsterdam, October 4, 1992*, Aircraft Accident Report no. 92-11, prepared by the Netherlands Aviation Safety Board. The 81-page report, which was published in February 1994, is in English and includes diagrams and illustrations.

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