

RAAD VOOR DE LUCHTVAART

Nederlands Aviation Safety Board

**AIRCRAFT ACCIDENT REPORT
92-11**

EL AL FLIGHT 1862

**BOEING 747-258F 4X-AXG
BIJLMERMEER, AMSTERDAM
OCTOBER 4, 1992**

FINAL RAPPORT

on the accident with EI AI 1862
on October 4, 1992
at Amsterdam – Bijlmermeer

1. INVESTIGATION

The Netherlands Aviation Safety Board was informed on the accident on that same day. On the recommendation of the Board, the Minister of Transport, Public Works and Watermanagement nominated a Preliminary Investigator, mr. H.N. Wolleswinkel.

An investigation was conducted under his management, resulting in a Preliminary Report of Investigation which was presented to the Board on October 4, 1993.

After having been informed on the first results of the investigation, the Board decided on June 28, 1993, to conduct a further investigation during a public hearing.

2. PUBLIC HEARING

The public hearing on this accident was held in the Netherlands Congress Centre in The Hague, on October 14 and 15, 1993.

The following sworn Experts/Witnesses presented their views to the Board:

mr. B.L. Eberhardt, mr. M.E. Lundberg, Captain W.F. Lorenz and mr. B. van Keppel from Boeing;

mr. D. Finkelstein and Captain A. Oz from EI AI;

Prof. A. Berkovits from Technion Israel Institute of Technology;

mr. Th.E. McSweeney from FAA Washington;

mr. C.W. van Santen and mr. B. Klaare from the Department of Civil Aviation;

mr. J. van Veen, formerly of ATC;
mr. S.S. Koopmans from ATC;

mr. S.S. de Haan, mr. H.J. Copier and mr. H.J. van Lente of KLM.

The Board consisted of:

mr. G.W.M. Bodewes; Chairman.

mr. J.P.H. Winkelman, mr. L.W. Snoek, mr. J. Hofstra,
mr. E.R. Müller, mr. H.P. Corssmit, mr. J. Smit, mr. C. Barendregt
and mr. M. van der Veen: Members.

mr. J.M. Jansen: Acting Secretary.

3. FINAL REPORT

Following the public hearing the Netherlands Aviation Safety Board has issued this final report in the English language. A translated version in the Dutch language will be issued later.

Hoofddorp, February 24 1994.

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- 1 NLR REPORT CR 93030C (Outboard midspar fuse pin)
- 2 NLR COMMENTS ON FATIGUE STRIATION INTERPRETATIONS
- 3 NLR REPORT CR 92454C (Inboard midspar fittings)
- 4 NLR REPORT CR 93248C (Wing forward beam)
- 5 BOEING REPORT: RESULTS OF DFDR-ANALYSIS AND PILOTED SIMULATIONS
- 6 BOEING REPORT: ANALYSIS OF ENGINE SEPARATION SCENARIOS
- 7 RLD/LI/LW REPORT: EL AL FLIGHT 1862 PERFORMANCE CAPABILITY EVALUATION
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SYNOPSIS

On October 4, 1992, at 17:20 UTC, El Al Israel Airlines (ELY) Flight 1862, a Boeing 747-200 Freighter, with three crewmembers and one non-revenue passenger on board, took off from runway 01L at Schiphol Airport and followed the Pampus departure as cleared by air traffic control services.

At 17:27.30 UTC, with the aircraft at flight level 65, engine no. 3 and its pylon separated from the aircraft and damaged part of the leading edge of the right wing. The no. 3 engine then struck engine no. 4, causing this engine and its pylon to depart the wing. During an attempt to return to Schiphol Airport control was lost and at 17:36 UTC the aircraft crashed into a residential area in a suburb of Amsterdam.

An investigation was initiated by the Netherlands Accident Investigation Bureau. The investigation team was assisted by specialists from the Aeronautical Inspection Directorate of the Department of Civil Aviation. Following the procedures contained in International Civil Aviation Organization (ICAO) Annex 13, Accredited Representatives and their advisors from Israel and the United States joined the investigation. Several organizations collaborated in the data extraction and analysis of the Digital Flight Data Recorder (DFDR). The National Aerospace Laboratory of the Netherlands was tasked with several special projects. The Air Branch of the Netherlands State Police assisted with the questioning of witnesses. Identification of the victims was carried out by the Disaster Identification Team of the State Police.

This report is issued by the "Raad voor de Luchtvaart" (Netherlands Aviation Safety Board).

All times in this report are UTC unless stated otherwise.

1 FACTUAL INFORMATION

1.1 *History of the flight*

The aircraft was on a flight from John F. Kennedy International Airport, New York, to Ben Gurion International Airport, Tel Aviv, with an intermediate stop at Schiphol Airport for a crew change and cargo processing. The aircraft arrived in Amsterdam at 13:40 and was scheduled for departure at 16:30 but received an air traffic control slot time of 17:20 for departure. The maintenance transit check was carried out. The aircraft was refuelled with 74,200 litres of Jet A1 fuel, making the total amount of fuel on board of 72 metric tons. The four people on board the aircraft at take off were the captain, copilot, flight engineer, and one non-revenue passenger. There was a total of 114.7 metric tons of cargo on board of which 6.5 metric tons were considered low grade dangerous goods.

The flightcrew involved in the accident had arrived at Schiphol Airport on a previous EI Al flight and had 20 hours crew rest prior to the beginning of their crew duty.

The air traffic situation at Schiphol Airport prior to the departure of EI Al 1862 was not extraordinary, according to ATC witnesses. Two runways were in use, 01L for take off and 06 for landing. There was moderate inbound traffic for runway 06, a moderate number of departures from 01L and several VFR flights over the northern part of the city of Amsterdam. From the beginning of EI Al 1862's emergency declaration, air traffic services for the flight were provided by Amsterdam Radar on 124.87, Schiphol Approach on 121.2, Schiphol Arrival on 118.4 and indirectly by Schiphol Tower.

The captain requested clearance for push back at 17:04. The aircraft taxied out at 17:14. The copilot was to be the pilot flying (PF), and the captain was to be the pilot not flying (PNF). The takeoff roll on runway 01L started at 17:21, with a takeoff gross weight of 338.3 metric tons, and the aircraft followed the Pampus departure as cleared by ATC. The performance limited maximum takeoff gross weight for the prevailing conditions of the flight was 359.3 metric tons. No anomalies were evident during the initial climb until 17:27.30, as the aircraft was passing through an altitude of about 6,500 feet. The flight data recorder revealed that the no. 3 and 4 engines and their pylons departed the right wing at this time. The copilot then transmitted the emergency call, "EI Al 1862, mayday, mayday, we have an emergency". The aircraft turned to the right, and according to witnesses on the ground, started dumping fuel immediately. The Amsterdam Radar controller confirmed the emergency call and immediately cleared the area of other traffic. At 17:28.06 the controller, not knowing the reason for the emergency call, asked the crew if they wanted to return to Schiphol Airport.

After the acknowledgement by the crew of their intention to return to the airport they were instructed to turn to heading 260 and were informed about their position relative to Schiphol Airport. At 17:28.17 the crew reported a fire on engine no. 3 and subsequently they indicated loss of thrust on engines no. 3 and no. 4.

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

At 17:28.57, EI AI 1862 was informed that runway 06 was in use and the wind was 040° at 21 knots. The flight crew however requested runway 27 for landing. ATC then asked the crew if they could switch radio frequency to Schiphol Approach Control on 121.2 megahertz. The crew immediately switched frequency to Approach Control. Subsequently the flightcrew was instructed to switch to Schiphol Arrival on 118.4 megahertz. Because the aircraft was only 7 miles from the airport and still flying at an altitude of 5,000 feet, a straight in approach was not feasible and the crew was instructed to turn right to heading 360 and descend to 2,000 feet. The crew was again informed about the wind (by then 050° at 22 knots).

About one minute later at 17:31.17 the controller asked what distance they required to touchdown. Shortly thereafter, the controller asked for the number of track miles the flight crew required for an approach. The crew stated that they needed "12 miles final for landing".

Together with this reply to ATC, the call "Flaps 1" could be heard as background conversation in the cockpit. ATC instructed EI AI 1862 to turn right to heading 100. During the turn the controller asked for the status of the aircraft and was informed: "No. 3 and 4 are out and we have problems with the flaps". The airplane had turned through heading 100 and was maintaining heading 120. No corrective action was taken by the controller. The aircraft maintained an airspeed of 260 knots and was in a gradual descent.

EI AI 1862 was cleared for the approach and directed to turn right to heading 270 to intercept the final approach course. The airplane was then at an altitude of about 4,000 feet, with a groundspeed of approximately 260 knots and on heading 120.

The position was 3 nautical miles north of the centreline of runway 27 at a distance of about 11 miles projected on the extended centreline of runway 27. According to the radar plot, it took about thirty seconds before the aircraft actually changed heading.

When it became apparent that the airplane was going to overshoot the localizer, the controller informed the crew accordingly and directed the aircraft to turn further to heading 290 in an attempt to intercept the final approach again but now from the south. Twenty seconds later a new heading instruction to 310 was given, along with descent clearance to 1,500 feet.

The flightcrew acknowledged this instruction at 17:35.03 and added, "and we have a controlling problem". Approximately 25 seconds later the copilot called, "Going down 1862, going down". 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 airplane crashed at 17:35.42 into an eleven-floor apartment building in the Bijlmermeer, a suburb of Amsterdam, approximately 13 km east of Schiphol Airport. The impact was centred 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 wide and 600 meters long. Firefighting and rescue operations started shortly after the crash.

The aircraft was destroyed by the impact and the resulting fire. The accident occurred during dusk.

1.2 *Injuries to persons*

Injuries	Crew	Passengers	Others
Fatal	3	1	43
Serious		11	
Minor/None		15	

1.3 *Damage to Aircraft*

At the time the pylons and the engines separated from the wing, the leading edge of the right wing, between engine no. 3 and 4, was extensively damaged, along with several airplane systems in that area. At final impact, the aircraft was destroyed by impact forces and the ensuing explosion and fire.

1.4 *Other damage*

The airplane impacted into the apex of two connected and angled apartment buildings which were partly destroyed by the impact and subsequent fire. The damage to the structure of the buildings precluded their reconstruction and the two buildings were torn down.

The soil in the impact area was heavily contaminated with airplane fuel, oil and combustion products of the airplane and freight.

1.5 *Personnel Information*

The Captain

- a. date of birth: 21-01-1933
- b. nationality: Israeli
- c. profession: Airline Transport Pilot employed by El Al since 02-08-1964.
- d. last medical check: 07-07-1992.
Result: qualified medical certificate group I, must wear correcting glasses while exercising the privileges of this licence.
Valid until: 31-01-1993
- e. licence: Israeli ATPL no. 340, first issue 20-09-1960.
Date of last validation: 11-04-1992.
The ratings on the ATPL were: Group A + C: B707, B747, DC3, Instrument airplanes
- f. total flying experience: 25,000 hours flying experience. B747: 9,500 hours of which 233 hours in the last 3 preceding months.
- g. additional information:
 - holder was qualified as captain on the B747 on 02-07-1981;
 - holder was qualified as instructor on 01-09-1992;
 - last flight was on 03-10-1992 on the route from Tel Aviv to London, to Amsterdam. After resting 20 hours, he reported for duty on 04-10-1992.

The First Officer

- a. date of birth: 07-05-1960
- b. nationality: Israeli
- c. profession: Airline Transport pilot with EI Al since 17-11-1991
- d. last medical check: 20-06-1992.
Result: qualified medical certificate group I, unrestricted.
Valid until: 20-06-1993.
- e. licence: Israeli ATPL no. 2844, first issue 04-11-1987.
Date of last validation: 25-07-1992.
The ratings on the ATPL were: Group A + B + C; B707, 1A-1124, ARAVA 101, C12D, Instrument airplanes.
Group II: B747.
- f. total flying experience: 4,288 total hours; flying experience on the B747: 612 hours of which 151 hours in the last 3 months.
- g. additional information:
 - holder became a qualified First Officer on the B747 on 31-03-1992. He was released from all limitations as a "new pilot" since 23-04-1992;
 - last flight was on 03-10-1992 on the route Tel Aviv – London – Amsterdam. After resting 20 hours he reported for duty on 04-10-1992.

The Flight Engineer

- a. date of birth: 23-05-1931
- b. nationality: Israeli
- c. profession: Flight Engineer with EI Al since 19-06-1955
- d. last medical check: 25-08-1992.
Result: qualified medical certificate group I, must wear correcting glasses while exercising the privileges of this licence.
Valid until: 28-08-1993.
- e. licence: Israeli Flight Engineers license no. 82.
Year of first issue: 1956.
Date of last validation: 23-05-1992.
The ratings on the F/E licence were: Turbojet powered airplanes; B707, B747.
- f. total flying experience: 26,000 hours;
flying experience on the B747: 15,000 hours of which 222 hours in the last 3 preceding months.
- g. additional information:
 - holder joined EI Al as a mechanic in 02-01-1950;
 - holder became a qualified Flight Engineer for B747 on 25-11-1971;
 - holder was qualified as Flight Engineer instructor from 01-02-74 till 22-05-1991
 - holder functioned as supervisor Flight Operations, in the period 1974 – 1976;

- holder left EI Al on 22-05-1991 for a period of 3 months and returned to active flight duties at the end of this period;
- last flight was on 03-10-1992 on the route Tel Aviv – London – Amsterdam. After resting 20 hours he reported for duty on 04-10-1992.

Remarks: Captain, First Officer and Flight Engineer passed their line and simulator checks in accordance with the approved training and qualifications program.

1.6 *Aircraft Information*

1.6.1 *General*

- a. nationality and registration: Israel, 4X-AXG
- b. aircraft type: Boeing 747 Freighter; Type: 258F
serial no.: 21737
year of construction: 1979
manufacturer: Boeing Commercial Airplane Company
- c. engines: 4 Pratt & Whitney JT9D-7J
fuel: Jet A 1
- d. The aircraft was registered in the Israeli aircraft register dated 19-03-1979, under the name of EI Al Israel Airlines Ltd., address: Ben Gurion Airport, P.O. Box 41, Israel 70100.
- e. The Certificate of Airworthiness form 105 was issued at 15-03-1992 and valid until 15-03-1993.
- f. At the time the aircraft departed Amsterdam Airport, the take off gross weight was 338.3 metric tons and the centre of gravity (CG) for take off was 23.1 percent mean aerodynamic chord (MAC), which was within the limits of the aircraft's flight envelope.
- g. Additional information:

This Boeing 747-258 cargo transport category airplane was manufactured in accordance with Federal Aviation Administration (FAA) type certificate no. A20W, as approved on 30-12-1969. The aircraft was certificated in accordance with the provisions of 14 CFR Part 25, effective on 01-02-1965.

The aircraft was powered by four Pratt & Whitney JT9D-7J high bypass ratio turbofan engines. The JT9D engine was certified by the FAA on 31-08-1976 with Type Certificate Data Sheet E20EA.

The aircraft accumulated 45,746 flight hours and 10,107 flight cycles. Maintenance records indicate that the aircraft and the Pratt & Whitney JT9D-7J engines were inspected and maintained in accordance with the EI Al maintenance program, the Boeing Maintenance Planning Document, the Maintenance Review Board Report, and EI Al Engineering and Quality Control Division requirements and recommendations.

All the required inspection and maintenance actions had been completed and all applicable airworthiness directives (AD's) had been accomplished, or were in the process of being accomplished within the specified time limits.

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.

1.6.2 *Pylons, Fuse Pins and Nacelle Attach Fittings*

The pylon, fuse pins and attachment fittings that comprise the engine/pylon/wing attachment system were inspected according to the applicable Service Bulletins (SB's), Service Letters (SL's) and FAA Airworthiness Directives (AD's). The Civil Aviation Authority of Israel does ratify all FAA issued AD's.

Since the last inspection of the midspar fuse pins of pylon no. 3 on June 17, 1992, the aircraft accumulated 257 flight cycles until the accident.

1.6.3 *Aircraft Design*

1.6.3.1 *Pylon to Wing Attachment Design*

The design of the engine nacelle and pylon incorporates provisions that preclude a wing fuel cell rupture in case of engine separation, by means of structural fuses. A clean breakaway of the nacelle and/or pylon from the wing is ensured when the shearloading of the fuse pins exceeds the design load conditions.

The structural fuse concept utilizes hollow shear pins at the four wing attachment fittings between pylon and wing. The wing support structure and fittings have been designed sufficiently stronger than the fuse pins thus safeguarding the wing from structural damage in case of an overload condition.

The nacelle and engine are attached to the pylon bulkheads through forward and aft engine mount fittings.

The pylon is essentially a two cell torque box containing three bulkheads: a forward engine mount bulkhead, an aft engine mount bulkhead and a rear closure bulkhead. Pylon to wing attachments are made at the aft end of the upper link, the aft end of the diagonal brace and at the two pylon midspar fittings.

The fuse pin at the forward end of the upper link, the aft end of the diagonal brace and at both midspar fittings are the primary fuse pins. The fuse pins at the forward end of the upper link and the aft end of the diagonal brace are designed to fail at a slightly lower load than the fuse pins at the other ends in order to assure a controlled separation of the pylon from the wing.

Nacelle load components in the vertical and side directions are absorbed by the forward pylon bulkhead while vertical, side, torque and drag components are reacted at the aft mount bulkhead. These pylon loads go to the four wing attachment fittings through the pylon front spar and lower spar, the midspar and the pylon skin. Primary drag loads go through a thrust link into the diagonal brace. An additional side brace from the pylon midspar to the wingbox takes pylon side shear into the wing. A schematic of the pylon to wing attachments fittings is given in figure 1.

1.6.3.2 *Hydraulic Systems*

Four separate and independent main hydraulic supply systems are provided to meet the power requirements of the flight control and landing gear systems. Each main supply system is associated with an engine with most of its components located in the pylon area above and aft of the engine. See figure 2.

The four main hydraulic supply systems are functionally identical. The systems differ only in reservoir capacity and the location of some components. Hydraulic power for each system is provided by two pumps installed in parallel. An engine driven pump is in operation at all times when the airplane engine is running. This pump is supplemented by an air driven pump powered by the pneumatic system and controlled from the flight engineer's station. The air driven pump can be turned off, run continuously or be operated in the automatic mode, where it will remain off until the demand exceeds the capacity of the engine driven pump.

Hydraulic system indications and warnings include standard pressure and fluid quantity gages and indicating lights.

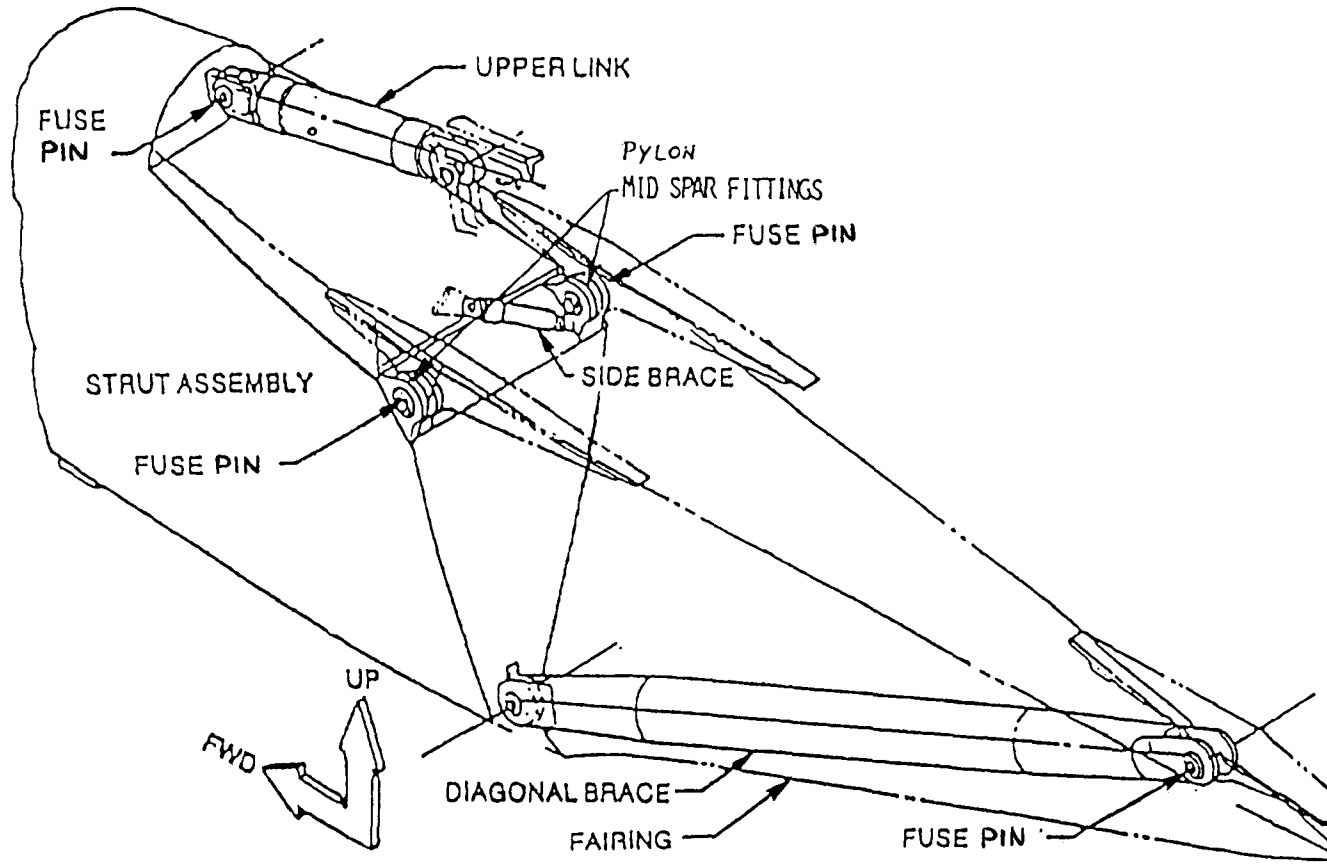
1.6.3.3 *Pneumatic System*

The pneumatic system consists of a manifold of ducts and valves that supplies hot air from the engine for the airconditioning and the pressurization system, engine starting, and thermal anti-icing. Bleed air is also used to actuate the leading edge flaps, air driven hydraulic pumps, lower cargo compartment heating, potable water systems pressurization and thrust reversers.

The primary supply of pneumatic air is from the mid compressor stage of each engine, through a check valve. When mid stage bleed air pressure is not high enough to supply system demands, high stage bleed air is used. Switching from low to high stage bleed on each engine is controlled automatically by the high stage bleed air valve.

The pneumatic manifold is separated into left, right, and centre sections by two wing isolation valves. See figure 3.

Figure 1. PYLON TO WING ATTACHMENTS RH WING



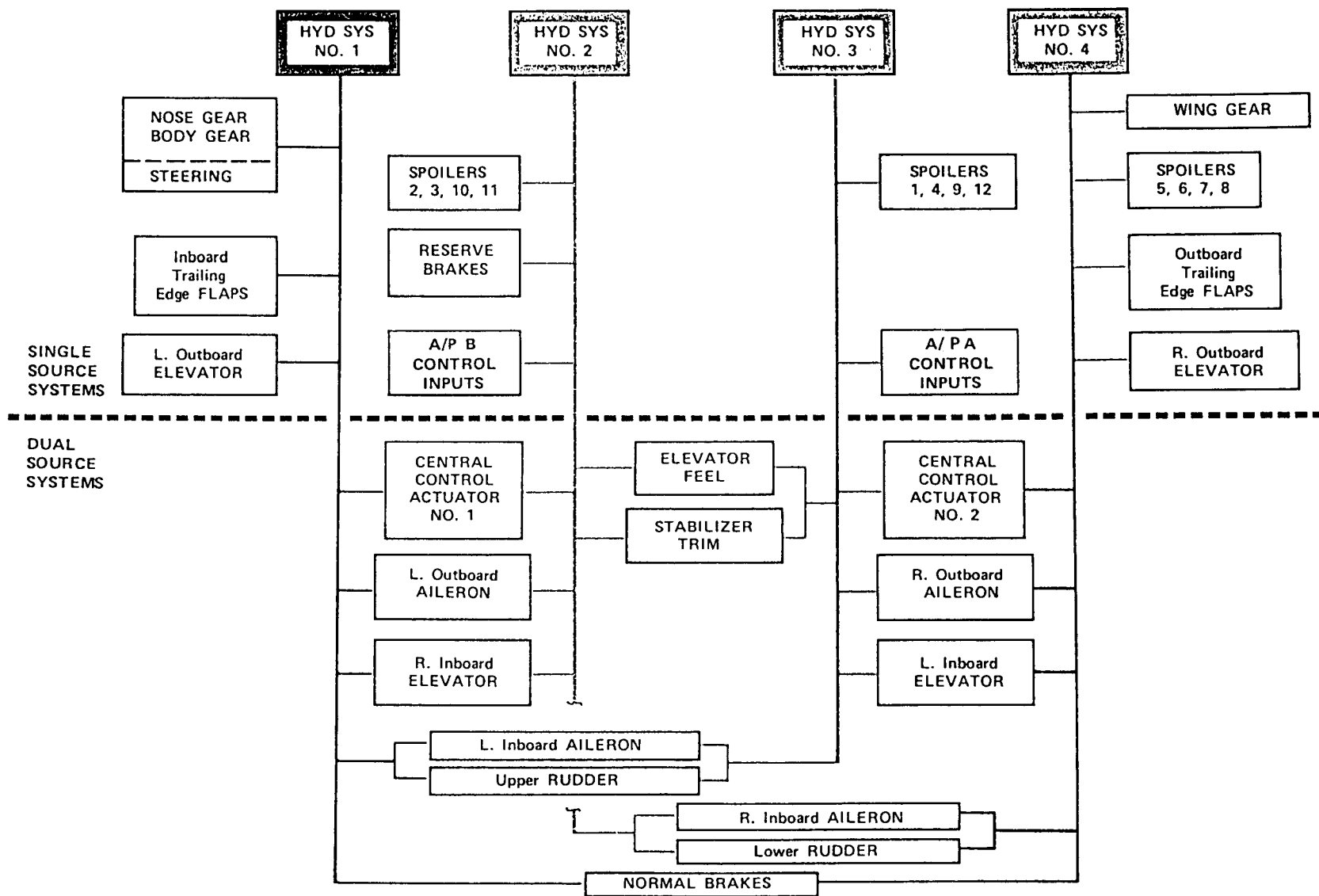


Figure 2. HYDRAULIC POWER SYSTEM

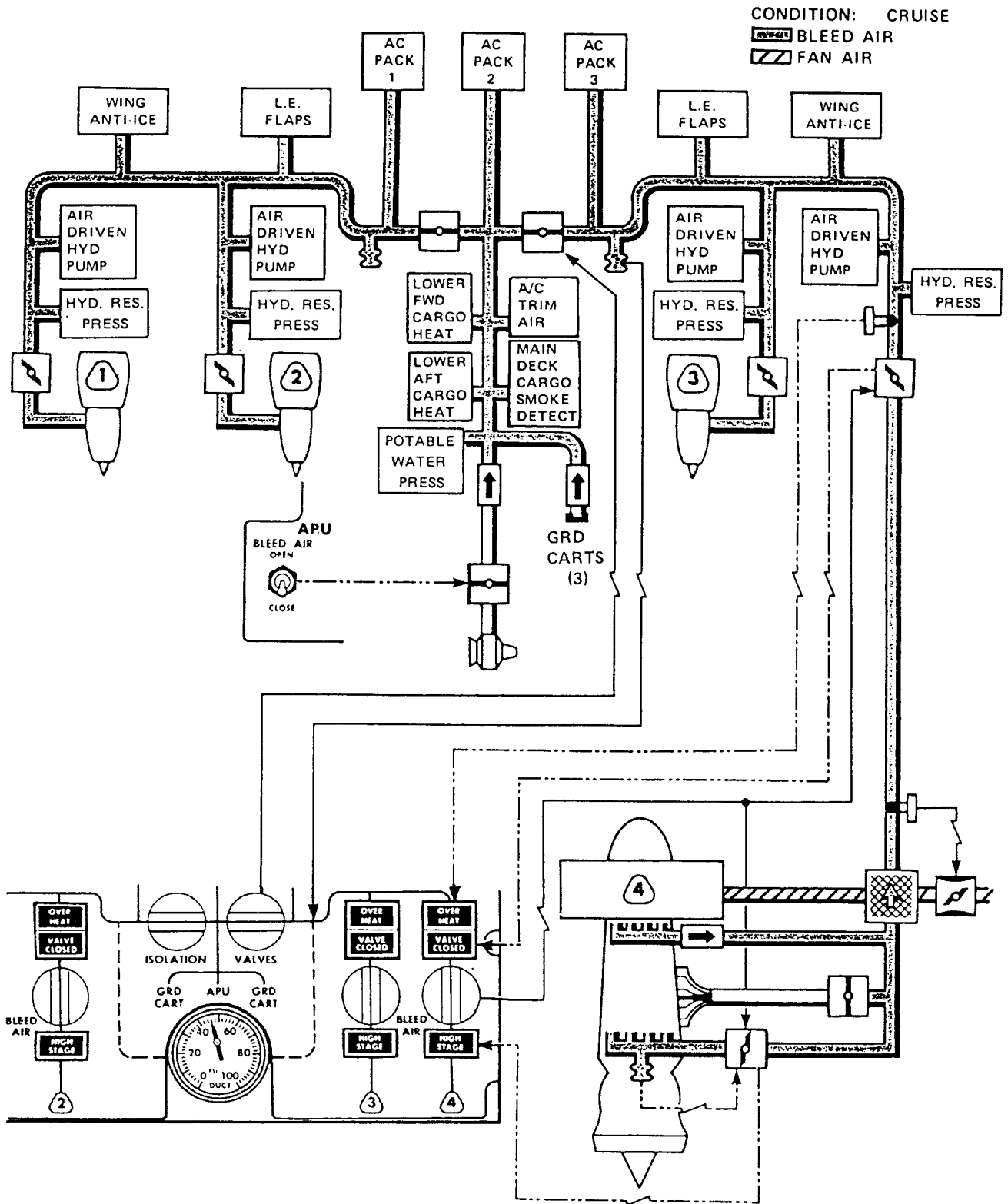


Figure 3. PNEUMATIC SYSTEM

1.6.3.4 *Electrical System*

AC Power

Primary AC power is supplied by four engine driven generators. Four AC busses are directly fed from their associated generators. Connection of these busses to a sync bus allows parallel operation. A split system breaker in the sync bus permits division of the bus system into two independent halves. The engine driven generators can be paralleled in any combination.

An essential AC bus can be powered independent from the main AC busses. A standby AC bus uses a battery powered static inverter when no other source of AC power is available.

DC power

Primary power for the DC busses is obtained from the main AC busses through transformer/rectifier units.

Secondary DC power is available from the main battery for the battery busses.

1.6.3.5 *Flight Controls*

Primary airplane control is provided by ailerons, elevators, and rudders. The control surfaces are positioned by hydraulic power packages served by four independent hydraulic systems. Control of the surfaces is accomplished by conventional duplicated aileron control wheels, control columns, and rudder pedals. The distribution of hydraulic supply from the various hydraulic systems to the various control surfaces is presented in figure 2.

The rudder control system contains a rudder ratio changer, which modifies the relationship between rudder pedal and rudder deflection in such a way that at a constant rudder pedal position the rudder deflection decreases with increasing speed, for reasons of structural protection.

Additional controls consist of trailing edge flaps, leading edge flaps, spoilers and an adjustable horizontal stabilizer. Trailing edge flaps are hydraulically powered and controlled by a flap control lever in the pilot's control stand. Leading edge flaps are primarily powered by pneumatic motors which are controlled by an electrical output from the trailing edge flap system. Back-up power to the leading edge and trailing edge flaps is provided by electric motors which are controlled by switches on the pilot's overhead panel.

The spoilers are hydraulically powered from different hydraulic systems. When used for lateral control, the spoilers are positioned by an output from the aileron control system. When used as speed brakes, the spoilers are controlled by a speed brake control lever. The horizontal stabilizer is positioned by hydraulic motors controlled primarily by trim switches on the control wheels. Levers on the pilots' control stand provide an alternate mechanical method of controlling the hydraulic actuators of the horizontal stabilizer that overrides all other command signals.

At higher speeds the outboard ailerons are normally locked out and kept in a neutral position by a lockout mechanism. To unlock the outboard ailerons the outboard trailing edge flaps must move more than 0.5 degree and the DC essential bus must be powered. Inability to extend the outboard trailing edge flaps via the normal (hydraulic) or alternate (electrical) means results in unavailability of the outboard ailerons.

1.6.3.6 Fuel System

The airplane fuel system provides a means of storing fuel in the airplane, provisions for distribution to the engines, provisions for pressure fuelling and defuelling, a fuel jettison system and an electronically controlled fuel quantity indication system.

All fuel is stored in the wing and wing centre section. The tank sections are integral tanks, utilizing the sealed structure to retain the fuel.

Fuel is fed into the pylon compartment via the engine fuel shut off valve. This valve is mounted on the front spar inside the wing tank and can be closed to isolate the engine from its fuel. When shutting the engine down by pulling the fire handle, this valve is commanded closed. This valve can also be closed by placing the start lever to the cut-off position.

Fuel jettison is accomplished through separate pumps except for the centre wing tank where override/jettison pumps serve a dual purpose. Tank interconnection for fuel feed and jettison is limited to gravity feed transfer from the reserve tanks to the main tanks, and is controlled by electric motor operated valves. All pump and valve controls, along with fuel quantity indicators and indicating lights, are located on the flight engineer's panel.

1.6.3.7 Engine Fire Detection and Extinguishing Systems

The engine fire detection system on each engine consists of two continuous sensor loops and a fire detection electronics module. Cockpit fire warning is provided by illumination of engine fire handles, master warning lights and a cancellable fire warning bell. On the flight engineer's panel a fault indicator light is provided to indicate when any of the 8 engine loops has failed. The nacelle temperature indicator will indicate which loop is faulted.

Each sensor loop is located at the critical locations throughout the engine, such that a fire will trigger the sensor. Normally the detection logic requires fire signals from both sensor loops, before a fire warning is generated in the cockpit. This design feature is intended to reduce the probability of false warnings. The corresponding system configuration is called: "BOTH".

The engine fire detection loops consisted of an inconel tube containing thermistor (thermal resistor) material in which one electric conductor is embedded. If the temperature rises, the resistance between the conductors drops and within certain rate of change of resistance criteria the signal is treated by the fire detection electronics module as a fire signal.

In case of a short circuit between the two conductors the fire detection electronics module determines a fault signal for the respective loop.

The logic used to indicate a fire warning in the cockpit with the fire detection system in the configuration "BOTH" is as follows:

Loop A sense	Loop B sense	Indication
fire	fire	fire
fire	fault	fire
fire	none	fault
fault	fault	fire
fault	none	fault

Logic of fire warning indication

From the table above it can be concluded, that with the fire detection system in the normal "BOTH" configuration, if both loops detect a fault signal, a fire warning will be generated in the cockpit. According aircraft operating procedures the engine fire procedure should than be executed.

Engine fire extinguishing is provided by two bottles per engine with an extinguishing agent, which are located in the pylons. In the cockpit just below the engine fire handles an electrically signalled "BOTTLE DISCHARGED" light is provided which illuminates, when the indicated bottle has been discharged.

1.6.4 *Service Bulletins and Airworthiness Directives*

Since the certification of the Boeing Model 747 numerous Service Bulletins and Airworthiness Directives were issued by Boeing and the FAA. For an overview see reference 11.

The most significant Service Bulletins and Airworthiness Directives concerning the pylon structure are explained in more detail in the following subchapters.

1.6.4.1 *Service Bulletins Applicable to Midspar Fuse Pins*

The first Service Bulletin for midspar fuse pins, SB 747-54-2063, was issued on August 10, 1979, after Boeing was informed in the late 1970's of cracks in the original, old style "bottle bore" configuration midspar fuse pins. This Service Bulletin recommended repetitive inspections of old style fuse pins for cracks every 2,500 flight hours. It also recommended an inspection for corrosion and application of corrosion preventive compound (CPC). The FAA made the recommended inspections mandatory in AD 79-17-04.

Revision 1 of this Service Bulletin, issued August 13, 1981 provided the terminating action for the repetitive inspections of old style pins by replacement with new pins having a "bulkhead" configuration. The FAA subsequently amended AD 79-17-04 on March 16, 1982, to announce that installation of the new style fuse pins was a terminating action for the repetitive inspection requirement.

In 1986, Boeing issued a revised ultrasonic procedure for improved detection of cracks in old style fuse pins (SB 747-54-2063R4). The FAA made the improved procedure mandatory with AD 86-22-01, that also superseded AD 79-17-04.

In April 1988, Boeing received a report of a crack in a new style fuse pin. Analysis of the pin indicated that the crack initiated from corrosion pits on the inner diameter of the fuse pin. The corrosion pits were attributed to the absence of primer and CPC on the inner surface of the fuse pin.

In response, on March 29, 1990, Boeing issued Revision 7 to SB 747-54-2063, adding instructions for an one-time inspection of new style fuse pins for the presence of CPC.

The FAA issued a Notice of Proposed Rule Making (NPRM) on November 6, 1990, proposing to require an one-time inspection of new style fuse pins for the presence of primer and CPC per SB 747-54-2063, Revision 7, prior to the accumulation of 12,000 flight hours after the effective date. This revision was made mandatory with the issuance of AD 91-09-01 on May 28, 1991.

In January 1992, Boeing began a review of the in-service history of the new style fuse pins. The review was initiated due to reports of

corrosion in new style fuse pins that reportedly had been inspected per AD 91-09-01. At that time, Boeing had received only five reports of cracks in new style fuse pins. In these cases the crack initiated in corrosion pits and the pins did not have the required primer and/or CPC. However, during the spring and summer of 1992, as the deadline for inspecting new style fuse pins pursuant to AD 91-09-01 took effect, Boeing received additional reports of cracks in new style fuse pins.

From the time of the original installation of new style fuse pins in 1980, through September 1992, 14 instances of cracks in new style midspar fuse pins and 9 reports of cracks in new style diagonal brace fuse pins were reported to Boeing. Boeing began an engineering investigation of other fuse pin designs and undertook to develop procedures for ultrasonic inspection of new style fuse pins for cracks. An All Operators meeting was held in Seattle, on September 21, 1992, to discuss the in-service history of new style fuse pins and the forthcoming Boeing recommendation for repetitive ultrasonic inspections of new style fuse pins. Boeing informed operators that it was developing a new style fuse pin to replace all B747 midspar fuse pins and described the pin development schedule.

1.6.4.2 *Service Bulletins Applicable to Diagonal Brace Fuse Pins*

Service bulletin 747-54-2066 was issued November 7, 1979, after Boeing had received reports of fractured diagonal brace to inboard engine strut fuse pins.

Analysis indicated that the fractures were caused by cyclic loading, and initiated in an circumferential machining groove in the pin bore inboard recess.

Boeing recommended a visual or ultrasonic inspection upon accumulation of 5,000 or more flights and recommended repeat inspections visually every 350 flights or an ultrasonic inspection every 1,200 flights, until the pins were replaced with a new design pin for terminating action. This service bulletin was effective for B747 airplanes with Pratt and Whitney JT9D-70 engines only. The FAA issued AD 79-22-03, making provisions of the SB mandatory.

Service Bulletin 747-54-2101 was issued April 11, 1983, after Boeing received reports of fractured diagonal brace to wing fuse pins. Boeing recommended a visual or ultrasonic inspection upon accumulation of 5,000 flights on the pins, and advised repeat inspections every 350 flights visually or 1,200 flights ultrasonically. When cracks were found, the existing pin had to be replaced with the new improved design pin.

This Service Bulletin was made applicable to all B747 airplanes with JT9D, CF-6 and RB211 engines. FAA issued AD 83-24-05, making provisions of this SB mandatory.

With Service Bulletin 747-54-2102, Boeing recommended that operators replace the inboard and outboard upper link and outboard diagonal brace fuse pins to reduce the possibility of fuse pin fracture, although no fuse pin fracturing of those fuse pins had been reported. This Service Bulletin was not made mandatory by FAA.

1.6.4.3 *Service Bulletins Applicable to Attach Fittings*

Service Bulletin 747-54-2062 was issued August 17, 1979, after operators reported cracks in the inboard engine strut to diagonal brace attach fittings. Boeing recommended an inspection upon accumulation of 5,000 flights, and a reinspection interval of 1,000 flights if no

cracks were found. FAA mandated the Service Bulletin with AD 79-17-07.

Service Bulletin 747-54-2100, issued June 20, 1983, prescribes an ultrasonic inspection of the inboard and outboard midspar fitting or spring beam aft lugs of each pylon for cracks initiating in the lug bores. Some operators had reported lug corrosion and in one case both lugs of the inboard pylon were found broken. Analysis of the broken part indicated that the breaks were the result of fatigue cracking initiating at corrosion pits in the bore surface of the outer lug fitting. AD 85-22-07, dated November 24, 1985 was issued to make provisions of the SB mandatory.

1.6.4.4 *Service Bulletins Applicable to the Nacelle Strut Rear Engine Mount Bulkhead*

Service Bulletins 747-54-2033/2042/2059 and 2065 cover the subjects of nacelle strut engine aft mount bulkhead cracking, inspection and modification.

Although the majority of cracks in the aft mount bulkhead was found on B747's with Pratt and Whitney JT9D-7 engines, the SB also applied to the General Electric CF6 and Pratt and Whitney JT9D-70 powered airplanes. These SB's were not adopted as FAA Airworthiness Directives.

1.7 *Meteorological Information*

Weather information was obtained from the meteorological service of the Royal Dutch Meteorological Institute at Schiphol Airport.

1.7.1 *General Conditions*

A high pressure area centred over the southern part of Scandinavia and a low pressure area centred over the Gulf of Genua created a strong north easterly flow of dry air over the Netherlands at the time of the accident.

1.7.2 *Conditions at the time of the Crash*

altitude ft	wind degrees/knots	temperature ∞C
groundlevel	040/23 gust 33	13
1,0000	50/30-35	12
2,0000	50/35-40	10
3,0000	70/40	10
5,0000	70/30-35	8

Wind and temperature conditions

visibility:

- from the ground to 2,000 feet, 15 kilometres.

weather:

- clear and dry.

clouds:

- 1/8 alto cumulus at 13,000 feet.

freezing level:

- 8,000 feet.

turbulence:
– light to moderate.

light condition:
– dusk

1.7.3 *Aerodrome Terminal Information Service (ATIS)*

When requesting the airway clearance, the crew informed ATC that they received ATIS information "Tango". Information Tango reads:

Main departure runway 01L, main landing runway 06,
040 degrees 23 knots, maximum 30 knots, minimum 13
knots, temperature 14, dewpoint 8, QNH 1012 hectopascals.

1.8 *Aids to Navigation*

All ground navigational aids for the Pampus departure and the instrument landing system for runway 27 were fully serviceable.

1.9 *Communications and Recordings*

1.9.1 *ATC Communication Recordings*

All ATC communications were recorded on a magnetic tape recording system, with a time coding.

A transcript of the relevant ATC, airport, and fire brigade communication recordings is attached as Appendix 4.1

1.9.2 *Other Communication Recordings*

The recording system also records a number of telephone lines.

A transcript containing information received from the Rescue Coordination Centre in IJmuiden (RCC) is attached as Appendix 4.2.

1.9.3 *Radar Data Recordings*

Information from the Schiphol primary and secondary radar was also continuously recorded on tape. A videorecording of the replay of the radar tape was made, and later, the radio conversations with the aircraft were dubbed onto the videotape.

A plot of the radar tape, together with key transmissions from the radio telephony, is attached as Appendix 3.1. This plot has been transferred onto a map in Appendix 3.2.

1.10 *Airport Information*

Schiphol Airport is located to the southwest of Amsterdam. Runway 01L was in use as the preferential take off runway and runway 06 as the preferential landing runway.

After the EI AI 1862 emergency call was made and after the flight crew requested to land on Runway 27, this runway was made available and the runway and approach lighting were activated. All required services were operational.

1.11 *Flight Recorders*

1.11.1 *Digital Flight Data Recorder*

The EI AI aircraft was equipped with a Sundstrand Digital Flight Data

Recorder (DFDR). The following information applies to the DFDR:

Model : 573
Manufacture Part No. : 981-6009-011
Manufacture Ser. No. : 2793

The DFDR was removed from the accident site and transported via the Netherlands Accident Investigation Bureau in Hoofddorp to the Aircraft Accident Investigation Board (AAIB) in Farnborough, England, and from there to the Engineering Services Division of the NTSB in Washington D.C., USA.

The DFDR was found in a heavily damaged condition. The outer case suffered massive impact damage during the crash and was further damaged by post-crash fire.

The shock and heat resistant crash protection unit, which contained the DFDR tape and the tapedrive mechanism, was slightly damaged by heat and water. Some small parts of the wiring and electronic circuit boards were burned.

The tape itself was found broken at four places, where it was not wound on the reels. The tape exhibited cracks, discoloration, and contamination, particular 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 this damage, a readout was accomplished on all recorded parameters. Validations were accomplished on some parameters. The data were converted into graphical plots and time correlated with the ATC time reference.

1.11.2 *Cockpit Voice Recorder*

The EI AI aircraft was equipped with a Fairchild Cockpit Voice Recorder (CVR). The following information applies to this recorder:

Model : A-100
Manufacture Part No. : 93A100-30
Manufacture Ser. No. : 4186

Despite intensive search activities to recover the CVR from the wreckage area, the recorder was not found. EI AI personnel stated that a CVR had been installed in the aircraft.

1.12 *Wreckage and Impact Information*

1.12.1 *Impact Area of the Engines and Wing Components*

Engines 3 and 4, with their related pylons, were recovered from the water at a position approximately 0.5 kilometre from the entrance to Naarden Harbour, approximately 200 meters apart.

Numerous engine cowling and reverser parts, some parts of the right wing leading edge structure, leading edge flap no. 18, a pneumatic duct and the no. 3 and 4 diagonal braces, were found on land in close proximity to the engines.

1.12.2 *Main Impact Area*

EI AI 1862 crashed into an eleven-story residential building located in a suburb of Amsterdam, the Bijlmermeer, approximately 13 kilometres east of the airport. The impact was centred at the apex of a block of apartments and debris were scattered over an area of about 400

meters wide and 600 meters long. The relative small impact area among high obstacles such as buildings and trees, indicated a very steep final flight path angle.

The scattering of fragments, in particular those of the left wing, the tail section and fragments of the cockpit, in combination with the damage of the building, indicated that the aircraft had attained a bank angle of slightly over 90° to the right and a nose down attitude of approximately 70° upon impact. The heading on impact was generally to the East.

Aircraft configuration at impact was TE flaps up, LE flaps partially extended, stabilizer trim approx 4.2 units aircraft nose up, wing gears up, body gears and nose gear in transit.

1.12.3 *Damage to Aircraft*

1.12.3.1 *Damage to Right Wing Structure*

On land, in the area to the West and Southwest of the location where engines no. 3 and 4 were recovered, several parts of the leading edge flaps and RH wing leading edge structure were recovered. The largest parts comprised a slightly damaged and partly opened LE flap and drive (no. 18), the top skin panel above pylon no. 3 and the adjacent inboard top skin panel located above the most outboard Krügerflap.

The top skin panel above pylon no. 3 showed extensive chafing from the pylon structure. Smaller parts of LE flaps and wing LE structure were found in this same area.

In the same area a slightly damaged about 2 meters long pneumatic duct of the bleed air system was found. This part is normally located in the wing leading edge, between engines no. 3 and 4.

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 1 meter left of pylon no. 3 to approx 1 meter right of no. 4. It is assumed that due to 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.

Figure 4 illustrates the estimated damage to the right hand wing.

*Note:*The amount of damage on the left wing leading edge after separation of pylon no. 2, from a B747 accident at Anchorage on March 31, 1993, is indicative for the amount of damage probably inflicted on the EI AI 1862 right wing leading edge.

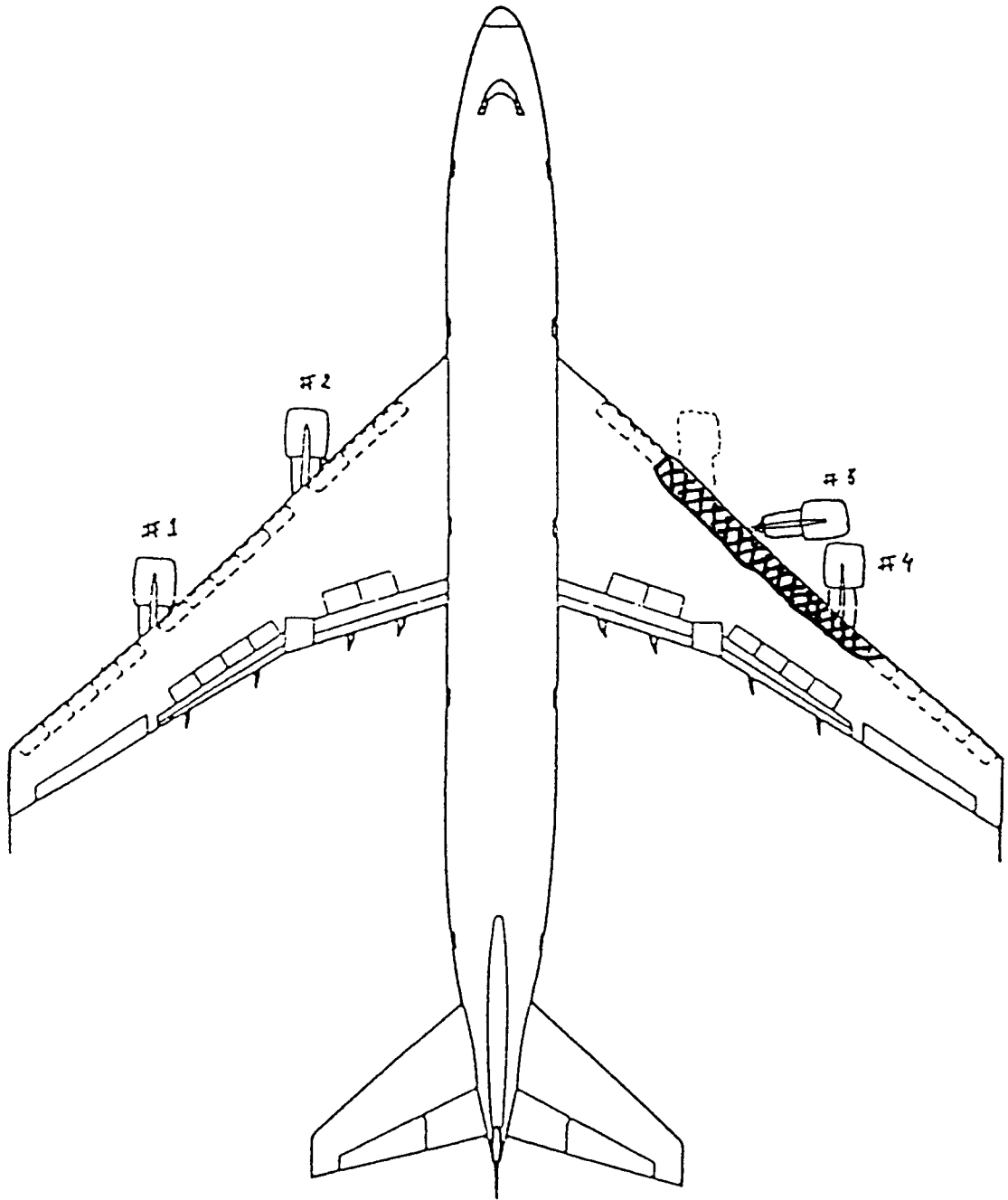


Figure 4. ESTIMATED DAMAGE TO RH WING LEADING EDGE

1.12.3.2 *Damage to Engines*

Engines no. 1 and 2

Engines no. 1 and 2 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.

No evidence was found of preexisting damage to the engines which might have been caused by an external or internal source.

Engines no. 3 and 4

Engines no. 3 and 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 significant damage to the engines was external and occurred when the engines hit the water. 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 3 and 4 showed no abnormal signs of preexisting damage.

Significant fan blade tip rubbing was found at two places in the fan cases of engine 3 and 4. This kind of damage is typical of fan blade tip rubbing when the engines are at a high speed of rotation. In this case the location of the rub within the fan cases indicated a gyroscopic effect of the engine rotating parts such as the fan, the compressor and turbine disks, at engine separation.

Engine cowlings and pylons of engine no. 3 and 4

The engine no. 3 inlet was recovered from the lake below the aircraft's flight path practically intact and together with the engine, whereas engine no. 4 inlet was found in smaller parts. The pylons of engine no. 3 and 4 were still attached to the engines, however pylon no. 4 separated from its engine during recovery from the water.

Matching of the engine cowling and inlet parts of engines no. 3 and 4 revealed that engine no. 3 and 4 had collided. The right hand side of engine no. 3 inlet cowling showed a circumferential dented damage pattern from a rotating part which left paint smear at the three o'clock position, caused by the engine no. 4 spinner.

Fairing seal of pylon no.3

When the wing forward beam and fairing seal of pylon no. 3 were recovered excessive chafing was noted at the wing forward beam. The question arose whether or not this amount of chafing could have been caused by the disconnection of either inboard or outboard midspar fitting. When studies carried out in relation to the "separation scenarios" showed that a fracture of either inboard or outboard midspar fitting/pin prior to the accident flight was highly improbable this issue was not further investigated.

1.12.3.3 *Damage to Hydraulic Systems*

When engines no. 3 and 4 separated from the aircraft, the no. 3 and no. 4 hydraulic systems were severely damaged. The engine no. 3 and 4 hydraulic engine driven pumps, as well as the air driven pumps and some of the system hydraulic lines, were found in close proximity to the engines in the lake below the flight path. Due to the severe damage, hydraulic systems no. 3 and 4 ceased operation, and consequently system 3 and 4 hydraulic pressure was not available to the relevant flight controls and other user systems.

Figure 5 gives an overview of the remaining and lost hydraulic systems after engine separation.

Engines no. 1 and 2 and their hydraulic pumps were not damaged in flight. Due to the damage to the right hand wing pneumatic ducting, the pneumatic pressure needed for the air driven pumps in the left wing bleed air duct was lower than the normal system pressure.

1.12.3.4 *Damage to Pneumatic System*

When the engines no. 3 and 4 separated from the aircraft, the pneumatic system was severely damaged. An almost undamaged component of the right wing pneumatic bleed air duct between the engine no. 3 and 4 was found near the engines on land below the flight path. The damaged bleed air pipe ducting allowed venting of bleed air supplied by the engines no. 1 and 2.

Based on DFDR data for engine EPR and EGT it can be calculated that after engines no. 3 and 4 separated, engines 1 and 2 continued to provide enough bleed air to keep the pneumatic pressure at the airconditioning pack no. 3 valve position above the minimum required to keep this valve open. This valve automatically closes when pressure in the duct drops below 8 psi. The DFDR data indicates that the pack no. 3 valve did not close after engine separation. This also indicates that the pressure in the duct remained above 8 psi. This means that the wing isolation valves were in the open position.

1.12.3.5 *Damage to Electrical System*

After engine no. 3 and engine no. 4 separated from the aircraft the electrical power supply from generator no. 3 and no. 4 was lost.

DFDR data show that in general however electrical power remained available to all electric and electronic systems. However some erroneous instrument indications may have been possible.

1.12.3.6 *Damage to Fuel System*

When the engines broke away from the right wing, the engine fuel supply lines were ruptured. As no parts of the engine fuel shut off valves and the associated section of the right hand wing front spar were recovered, it could not be determined if the separation of the engines led to damage to the fuel shutoff valve actuator motors. These are mounted on the front spar of the wing.

Damage to the fuel system piping could have resulted in loss of fuel being pumped from the tank through the fuel manifolds and engine fuel shut off valve on the front wing spar.

1.12.3.7 *Damage to Fire Detection and Extinguishing Systems*

Damage to fire detection loops after engine separation resulted probably in electrical short cuts which caused fault-fault indications and subsequent fire warnings. Fire warning at engine

HYDRAULIC SYSTEMS

FUNCTIONAL

LOST

SYSTEM NO. 1	SYSTEM NO. 2		SYSTEM NO. 3	SYSTEM NO. 4	
LEFT OUTBOARD AILERON LEFT INBOARD AILERON LEFT CENTRAL CONTROL ACTUATOR	LEFT OUTBOARD AILERON RIGHT INBOARD AILERON LEFT CENTRAL CONTROL ACTUATOR SPOILERS 2, 3, 10, 11		RIGHT OUTBOARD AILERON LEFT INBOARD AILERON RIGHT CENTRAL CONTROL ACTUATOR SPOILERS 1, 4, 9, 12	RIGHT OUTBOARD AILERON RIGHT INBOARD AILERON RIGHT CENTRAL CONTROL ACTUATOR SPOILERS 5, 8	ROLL
LEFT OUTBOARD ELEVATOR RIGHT INBOARD ELEVATOR	LEFT OUTBOARD ELEVATOR RIGHT INBOARD ELEVATOR STABILIZER PITCH TRIM (*)		RIGHT OUTBOARD ELEVATOR LEFT INBOARD ELEVATOR STABILIZER PITCH TRIM	RIGHT OUTBOARD ELEVATOR LEFT INBOARD ELEVATOR	PITCH <i>(*) half rate</i>
UPPER RUDDER	LOWER RUDDER		UPPER RUDDER	LOWER RUDDER	YAW
INBOARD TE FLAPS				OUTBOARD TE FLAPS	FLAP
AFT MAIN GEAR ACTUATOR NOSE GEAR ACTUATOR				FORWARD MAIN GEAR ACTUATOR	GEAR
NOSE GEAR STEERING				SPOILERS 6, 7	GROUND
NORMAL BRAKES (SECONDARY)	RESERVE BRAKES			NORMAL BRAKES (PRIMARY)	USERS

Figure 5. REMAINING AND LOST HYDRAULIC SYSTEMS

no. 3 was reported by the flight crew. It is not known if the engine fire warning continued during the remainder of the flight nor if the bottle discharge light was illuminated in the cockpit.

1.13 *Medical and Pathological Information*

All pathological investigation was made for the purpose of identification.

1.14 *Fire*

1.14.1 *Fire on Board*

Examination of the separated engines no. 3 and 4, their associated pylons and parts of the structure that broke off the aircraft at engine separation, did not show any signs of fire or soot.

After engine separation some witnesses reported a short, sparklike fire which extinguished shortly afterwards. No fire was noticed on the aircraft during its subsequent flight apart from two not confirmed witness reports about fire just prior to impact.

1.14.2 *Fire on the Ground*

Upon impact with the apartment buildings and the ground the aircraft disintegrated. The spilled fuel resulted in explosion. Aircraft debris and burning fuel were thrown over an area of about 400 meters wide and 600 meters long. The burning fuel set fire to a number of adjacent apartments. Additional damage to the apartments occurred because of the blast of the explosion. A large amount of the aircraft wreckage was consumed by fire.

1.14.3 *Fire Brigade Response on the Airport*

The Airport fire brigade unit "Sloten" was told that a B747 was returning to Schiphol Airport with engine problems. The unit, consisting of three MAC 11 vehicles, one SAV vehicle and 11 firefighters, went to the readiness positions for Runway 06, the preferential landing runway. The unit was in position within one minute of notification.

When the message was received that EI AI 1862 was intending to land on Runway 27, the unit moved to the readiness positions for that runway. After sighting a large fireball to the east the fire brigade unit was directed to the scene of the accident.

1.14.4 *Fire Brigade Response Outside the Airport*

Four airport fire brigade vehicles in coordination with the Amsterdam City fire brigade started fire fighting activities after arriving at the scene of the accident.

The main fire was under control within several minutes, using foam.

1.15 *Survival Aspects*

The accident was not survivable for the persons on board of EI AI 1862 because of the impact forces and the ensuing explosion and fire.

1.16 *Tests and Research*

Note: Test and research efforts were directed to investigate the recovered parts of the pylon. Only in a later stage of the investigation it became clear that probably a not recovered part failed first.

1.16.1 *Metallurgic Investigation of Outboard Midspar Fuse Pin*

At the accident site, a section of the outboard wing support fitting (inboard side only) was recovered with the central part of the outboard midspar fuse pin in place. The inboard fracture surface failed in shear, while the outboard fracture surface exhibited signs of metal-fatigue.

The Dutch National Aerospace Laboratory was contracted to carry out a metallurgic investigation of the fuse pin. The results of this investigation are contained in report CR 93030 C: "Investigation of the Outboard Midspar Fuse Pin from the Pylon of Engine #3 of EI Al 1862". The laboratory concluded the following:

1. A large fatigue crack was present at the outboard location of minimum wall thickness of the fuse pin, which was of the "bottle bore" configuration. This fatigue crack was up to 4 millimetre in depth and encompassed about 50 % of the inside circumference.
2. The fatigue crack had developed from multiple initiation sites along poor quality machining grooves. There was no evidence of corrosion pitting that could have contributed to fatigue initiation.
3. The material of the fuse pin met the chemistry specification for 4330 M steel. However, hardness measurements indicated that the tensile strength was about 117 ksi, which is lower than the specified range of 126 – 139 ksi.

It should be noted that a low hardness does not mean the pin was understrength, because sometimes the final machine cut is adjusted based on the testing conducted in the sampling process.

Boeing also carried out a metallurgic investigation of the fuse pin. The Boeing findings concur with the NLR findings.

Boeing was able to derive a crack growth curve of the fatigue fracture surface as a function of total airplane cycles (flight cycles) versus crack depth.

Based on this curve Boeing concludes that at the last inspection of the fuse pin, 257 flights before the accident flight, the fatigue crack would have had a depth of .14 inch. As the ultrasonic reference depth is .085 inch a detectable crack existed at the last inspection.

EI Al however contests the Boeing findings regarding the crack growth data.

EI Al is of the opinion that the redistribution of loads after the initial failure in the inboard midspar fitting lug resulted in a significant increase in crack growth rate during a number of flights and that it is therefore conceivable that the crack was of less than detectable length at the last ultrasonic inspection.

The NLR was requested to comment on this fundamental difference of opinion between Boeing and EI Al regarding the interpretation of the striation count of the fatigue crack in the outboard midspar fuse pin.

The NLR concludes that: "The intermediate markings between 'heavy striations' cannot be interpreted unambiguously".

1.16.2 *Metallurgic Investigation of Inboard Midspar Fitting Lug*

The inboard midspar fitting of pylon no. 3, with some attachment structure, was recovered from the Gooimeer. The outboard lug of the clevis fitting had failed. The National Aerospace Laboratory was also contracted to examine this part and the results are contained in their report CR 92454 C: "Investigation of the Inboard Midspar Fitting of Engine no. 3 of EI Al 1862". The results of this investigation can be summarized as follows:

1. In all probability the lug fractured and failed by overload, under a combination of bending and tensile loads. The caveat "In all probability" is considered necessary because the fracture surface details had been almost completely destroyed by corrosion, most probably as a consequence of immersion in the water.
2. Checks of the lug material, 4330 M low-alloy high-strength steel showed that it met the requirements of hardness, tensile strength and chemistry. The steel microstructure was also satisfactory.

Boeing also carried out a metallurgic investigation of the lug and came to the same conclusions as the Aerospace Laboratory, saying, "The lug fracture was determined to be ductile (i.e. no fatigue) and appears to have resulted from tension and to a lesser extent from lateral bending."

1.16.3 *Bird Impact*

A detailed study into bird migration during the flight of the accident aircraft was made by the expert of the Royal Netherlands Air Force. The study revealed heavy bird migration in the Schiphol area during the 14 minute flight of the aircraft, and birds could be found up to an altitude of 5,000 feet.

The chances of a bird impact were considered at its maximum just after take off, and were estimated to be lower at the altitude of 6,000 feet and above.

Engines no. 3 and 4 and all the parts from the leading edge of the right hand wing were examined under ultraviolet light and via chemical tests. The internal and external examination of engine no. 3 and 4 and of the engine cowlings showed no evidence of bird impact.

Examination of variable camber flap 18 and two parts of the right wing leading edge structure showed signs of possible bird impact, however, laboratory analysis could not determine whether the deposits on the parts were of animal nature. In some cases there was not enough material to test, and in all cases, the parts had been exposed to sunlight and water for a too long period of time.

Some bird feathers were found on a leading edge part that probably belonged to the left wing. This part was found at the crash site. Chemical analysis by the Zoological Institute of the University of Amsterdam confirmed that the remnants indicated a pigeon.

1.16.4 *Sabotage*

A detailed investigation into the possibility of sabotage was performed. Details including the type of cargo, the dispatching of the airplane, various security aspects and general maintenance activities were examined. The engines and pylons were visually inspected for signs of high energy explosion or other sabotage.

Also, several airplane structural parts and foreign objects associated

with the wreckage were subjected to chemo analysis with negative results. No evidence of sabotage was found.

1.16.5 *Trajectory Engine No. 3*

Boeing studied engine trajectories for a variety of fuse pin release scenarios and thrust levels. The strut and engine were treated as rigid bodies, while the upper link and diagonal brace were modelled as beams. The midspar fuse pins and fittings were modelled as zero length springs. Dynamic loads noted during the release sequence scenario 4 that more than one fitting would need to be below strength for a pylon release to occur. The study indicated that most of the no. 3 pylon fuse pin release sequence scenarios resulted in the no. 3 engine striking the no. 4 engine, but not necessarily in the orientation noted during the El Al accident.

The release sequence that came the closest to the El Al trajectory was inboard midspar fitting failure, followed by outboard midspar fitting failure, upper link failure, and finally diagonal brace failure.

1.17 *Additional Information*

1.17.1 *Other Related Incidents and Accidents*

Below a summary is given of known accidents or incidents involving pylon problems which occurred during the past years.

1. December 27, 1979. London Heathrow Airport. A B747-121 Freighter. During landing no. 4 pylon bulkhead began to break free of the pylon because of fatigue and other pre-existing damage. The aircraft accumulated 43,615 hours and 9,505 cycles.
2. December 29, 1991. Near Taipei, Taiwan. A B747-200 Freighter with P&W engines. During climbout passing 5,200 feet, engine/pylon combination no. 3 and 4 separated from the wing. The aircraft accumulated 45,868 hours and 9,094 flight cycles. Preliminary investigation revealed that from pylon no. 3 both inboard midspar fitting lugs had failed, partly in fatigue and partly ductile. A section of the fuse pin of the outboard midspar fitting was also recovered but the fracture surface was ductile. Investigation still in progress.
3. March 31, 1992. Istres, France. A B707-321CH Freighter. While climbing from FL 290 to FL 330, passing FL 320 with 280 knots engine/pylon combination no. 3 and 4 separated from the wing. Right wing on fire. A successful emergency landing was carried out. Investigation revealed that the no. 3 engine/pylon combination separated first and hit the no. 4 engine, causing the separation of pylon no. 4. The inboard midspar fitting lug of pylon no. 3 was broken due to fatigue.
4. April 25, 1992. Miami, Florida. A B707-324C. During take off no. 3 engine/pylon combination separated from the wing. The aircraft accumulated 53,257 hours and 20,399 flight cycles. The investigation revealed the inboard midspar fitting of pylon no. 3 showed fatigue cracking.
5. September 11, 1992. A B747-200 standing on the apron. Engine/pylon combination no. 3 was slightly drooped inward and a 2 centimetre gap was noticeable between the strut and the aircraft's wing. Inspection revealed the outboard midspar fuse pin was broken and severely corroded in three places. The aircraft accumulated 42,106 hours and 9,176 flight cycles.

6. October 8, 1992. A B747-212B passenger aircraft. Visual inspections of the pylon wing attachment revealed a cracked inboard midspar fitting lug of pylon no. 3 with signs of fatigue in a region of severe corrosion pitting in the bore of the lug. The aircraft accumulated 51,798 hours and 10,837 flight cycles.
7. February 1, 1993. A B747-212B passenger aircraft. While performing a corrosion check during a C-inspection, a crack was detected in the inboard lug of the inboard midspar fitting of pylon no. 3.
Another crack was found in the forward lug of the diagonal brace. The aircraft accumulated 49,908 hours and 10,580 flight cycles.
8. March 31, 1993. Anchorage, Alaska. A B747-121 Freighter. During climbout passing 2,000 feet in turbulence, engine/pylon no. 2 separated from the wing. Despite having severe control problems, the crew made a successful emergency landing.
Preliminary investigation revealed that the engine/pylon combination separated from the wing because of structural overload. The leading edge between engines no. 1 and 2 was severely damaged. A three inch crack was found in a thin web section between the pylon midspar attachment fittings.
(Boeing indicated that the crack had sealant on it, meaning the crack would be there for a while). The airplane accumulated 83,906 hours and 18,387 flight cycles.

After the EI AI accident the frequency of fuse pins inspection was increased. Numerous reportings from operators regarding pylon-wing attachment fitting problems were received. In most cases the reportings dealt with cracked fuse pins at different pylon-wing attachment fitting locations.

Note: Occurrence numbers 3 and 4 were with B707's with hush kits installed. The existing B707 AD's are not adjusted to account for the difference in loads due to the installed hushkits.

1.17.2 *Additional Investigation*

After the first issue of the preliminary report several subjects were investigated additionally.

By pure coincidence an aircraft spotter took some photographs of EI AI 1862 when it arrived at Schiphol Airport on October 4, 1992. On these photographs it appears that engine no 3 has an upward tilt in relation to the other three engines. The question arose whether this upward tilt could have been caused by disconnections of the wing to strut attachments. Experts explained that a disconnection could not possibly result in a tilt as shown on the photographs. Because a transit maintenance check (including condition of engine and strut) was properly carried out and also because the Board at this stage of the investigation became aware of the technical improbability that pylon no.3 attachments had failed prior to the accident flight, further investigation on this subject was put aside.

Another subject of additional investigation was the question if the depleted uranium balance weights in the EI AI Boeing represented potential health hazards. From the originally installed depleted uranium weights, two were replaced by Tungsten so not more than 400 kg. of depleted uranium was involved in the crash and the fire

after impact. A radiation expert of ECN (Netherlands Energy Research Foundation) at Petten, stated that the low radioactivity of depleted uranium does not represent a real danger.

Although the material, being a heavy metal, is poisonous it can only enter a human body in soluble state as uraniumoxide, as a dust or as a vapour. Disintegration to dust or vaporisation will not take place in a crash or the resulting fire.

The boiling point of depleted uranium (3813 °C) exceeds the possible temperature of a kerosine fire by far.

A third additional investigation concerned several transmissions received by the Rescue Coordination Centre in IJmuiden (RCC) from yachts in or near the IJsselmeer harbour of Naarden on marifone channel 16 (for urgent and emergency naval communications). After the reception of reports that ".....an aircraft had lost a part of an engine" and that ".....only one side of the engines was still working", RCC contacted ACC Schiphol by telephone. In this telephone conversation RCC asked if it was known that an airplane was in trouble over the Hilversum/Naarden area. This was acknowledged by ACC and, on RCC's question if it was correct that an engine had separated, ACC answered that they did not know the exact details but that ".....they are in contact with us anyhow" . After the confirmation that the aircraft was still airborne and the statement ".....we know about it" the conversation ended. During this telephone call RCC received a subsequent channel 16 report ".....that the aircraft was probably dumping fuel" and ".....must have lost one or two of its engines" and several minutes later (a few seconds before impact) a report ".....that the two right hand engines are off and the two port engines are still on" RCC did not resume contact with ACC. Subsequently reports came in that the airplane had crashed and smoke was seen.

There has definitely been a misunderstanding between RCC and ACC about the possibility of engine separation. The knowledge of RCC, however, at the time of the telephone call was not very precise, which makes it understandable that they did not persist on the subject.

2. ANALYSIS

2.1 *General*

The flightcrew was trained and certificated in accordance with appropriate Israeli CAA, EI Al and Industry standard requirements and procedures.

The airplane was inspected and maintained in accordance with EI Al and Boeing maintenance procedures.

Meteorological conditions and navigation and communication facilities did not contribute to the accident.

The Board determined that the accident sequence was initiated by the in-flight separation of the no. 3 engine pylon from the wing. The Board's investigation examined the probable causes for this separation and the probable causes for the subsequent loss of control.

The Board's analysis of this accident included an evaluation of:

- evidence to determine the initial failure origin;
- the design and certification of the fused pylon concept;
- the effectiveness of FAA's supervision on continuing airworthiness;
- performance of the flightcrew;
- ATC services;
- actions taken since the accident.

2.2 *Engine Pylon Separation*

At the time of the accident the airplane had a valid Certificate of Airworthiness. The maintenance transit check was properly carried out at Schiphol Airport. No defects were recorded which could have played a role in the accident.

External and internal examination of the engines showed that all damage was either a result of gyroscopic effects during pylon separation or the impact of engine no. 3 with engine no. 4 and/or the impact of the engines with the water. No physical evidence was found inside the engines indicating that a surge could have occurred. Also examination of the EI Al maintenance records and DFDR data from before the accident flight revealed no signs of surges.

The possibility of sabotage was examined by several police and security agencies familiar with sabotage techniques and terrorist activity. No evidence of sabotage was found.

The Board therefore 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.

To determine the initial failure origin a total of 9 different scenarios were identified each of which could lead to the separation of the engine pylon from the wing.

Separation Scenarios:

1. Upper link/pin fractured or disconnected first;
2. Inboard midspar fitting/pin fractured or disconnected first;
3. Outboard midspar fitting/pin fractured or disconnected first;
4. Simultaneous fracture or disconnection of both the inboard and outboard midspar fitting/pins;
5. Diagonal brace/pin fractured or disconnected first;

6. Massive static overload occurred;
7. Bird impact occurred;
8. Engine seizure occurred;
9. Side brace fractured or disconnected first.

Scenarios 4 through 9 were eliminated as viable options. The reasons are summarized below:

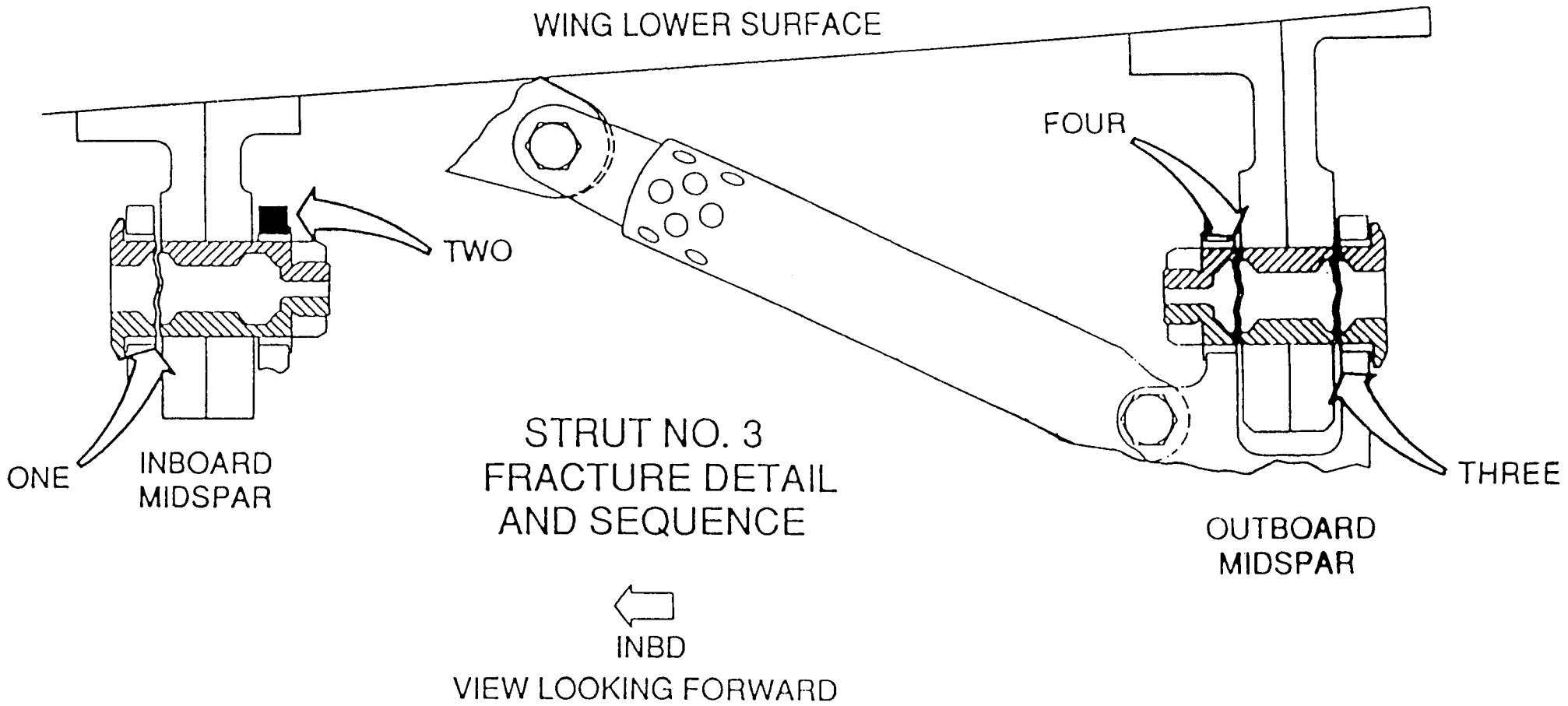
- Scenario 4: only a large overload in lateral direction could have caused this type of failure. There was no evidence on the DFDR that any unusual load occurred.
- Scenario 5: examination of the diagonal brace and its attachments indicate that the disconnection was due to overload at engine separation.
- Scenario 6: there was no indication of any unusual loading on the DFDR.
- Scenario 7: no evidence of foreign object damage, e.g. bird impact, to the engine prior to the separation was found.
- Scenario 8: examination of the engine indicated that the fan was rotating at the time of separation, therefore no engine seizure could have occurred.
- Scenario 9: examination of the side brace and its attachment indicated that the disconnection was due to an overload at engine separation.

As the upper part of the upper link and corresponding fitting was not recovered the question arose whether or not this link was properly attached at the time of the separation. By means of a stress analysis it was shown that the fracture of the upper link in the noted bending/torsion mode could only have occurred if the wing-end pin was in place and intact. Scenario 1 could therefore be eliminated.

The elimination process resulted thus in two possible remaining scenarios. The approach taken for the further evaluation of these scenarios was mainly one of deduction, augmented with stress and load analysis. Using this approach it could be proven that a separation initiated by a failure in the outboard midspar fitting was highly improbable.

The inboard midspar fitting was recovered. The outboard lug of the fitting had fractured with a 150 degrees segment of the lug missing. The lug fracture was determined to be ductile (i.e. no fatigue) and appeared to have resulted primarily from tension and to a lesser extent from lateral bending. The ductile failure can only be explained if it was eccentrically loaded. For this to occur the inboard shear face of the fuse pin must have sheared first in order to subject the lug to an eccentric load.

Figure 6. PROBABLE SEPARATION SEQUENCE



As there is no in service evidence that the EI Al airplane experienced a static overload preceding the accident it is assumed that the inboard shear face of the fuse pin was initially fatigued and then failed under normal flight conditions.

Based on this assumption separation scenario 2 was further developed with regard to the question whether the failure did occur before the fatal flight or during this flight.

Figure 6 shows pylon no. 3 fracture details for scenario 2 and the sequence of each fracture in time numbered 1, 2, 3 and 4.

By applying the methodology as explained above, it can be proven that a fracture of the inboard fuse pin before the start of the flight out of Schiphol Airport is highly improbable. The load carrying capability of the remaining structural elements, taking into account dynamic effects, is sufficient to carry the redistributed loads.

Therefore the scenario which is most likely, is (1) a fracture initiated by a fatigue crack of the shear face of the inboard midspar fuse pin. This was 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 6500 feet and at an IAS of 267 knots.

2.3 *Design and Certification Assessment*

As outlined in paragraph 1.6.3.1 the pylon is designed to break cleanly away from the wing.

The certification basis of the Boeing 747 includes a Fatigue Evaluation of Flight Structure as laid down by FAR part 25.571 Am.8. This evaluation requires that:

“Those parts of the structure (including wings, fixed and movable control surfaces, the fuselage and their related primary attachments), whose failure could result in catastrophic failure of the airplane, must be evaluated under the provisions of either paragraph (b), Fatigue Strength, or (c), Fail-safe Strength of this section.”

Based on the similar fuse pin design of the Boeing 707, Boeing concluded that the fused pylon concept effectively protected wing structure and fuel tanks against consequences of pylon overloads. A detailed fail-safe analysis of this nacelle and pylon concept was made by Boeing. This analysis addressed all critical load conditions resulting from abnormal flight or landing conditions.

It should be noted that the report does not address the specific fail-safe load analysis assuming a fatigue failure or obvious partial failure of a single principle structural element.

It is important to note that during type certification a then state-of-the-art fatigue analysis of the pylon structure was performed by Boeing in order to establish the maintenance requirements for the Boeing 747. In real life this did not turn out to be sufficiently reliable. At that time full scale testing was not part of the USA airplane certification process.

Boeing did not conduct any structural testing of the pylon to positively determine its static strength, fatigue and fail-safe characteristics. The FAA accepted Boeing's contention that since the Boeing 707 pylon had proved reliable, the nearly identical design of the Boeing 747 pylon would also be reliable. Therefore on the date of type certifi-

cation the nacelle and pylon design met all applicable airworthiness requirements.

The supervision of the continued airworthiness of the Boeing 747 type design is a responsibility of the FAA. This organization carries out its responsibility mainly by issuing Airworthiness Directives, many of which were originally Boeing Service Bulletins. In case of the Boeing 747 the FAA issued a large number of AD's 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.

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 (China Airlines, El Al and Evergreen) have failed in flight, resulting in two fatal and one serious accident.

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.

2.4 *Final loss of Control*

The analysis concerns the controllability and performance aspects of the airplane.

2.4.1 *Controllability*

Assuming a fixed rudder deflection an increase in thrust asymmetry generates a yaw, resulting in a sideslip which in turn induces a roll moment. These motions can be controlled by:

- a rudder deflection to stop the yaw;
- a lateral control deflection to stop the roll;
- a thrust reduction.

Loss of part of the leading edge flaps and damage of the right wing results in a change in lift generating capability of that wing. At small angles of attack the lift on both wings is essentially equal, at higher angles of attack the increase of lift on the damaged wing is less than the increase in lift on the undamaged wing. An increase in angle of attack will therefore generate a roll moment. In the case of El Al 1862 this increase caused bank steepening during the right turns in the direction of the damaged wing. This effect was confirmed by DFDR data.

In general modern airplanes have adequate control capability to turn in either direction in a two engine inoperative situation. However turning into the direction of the functioning engines will create a flight condition with more margin. It is recommended to emphasize this basic knowledge during training.

2.4.2 *Performance*

An energy analysis was performed based upon altitude and airspeed data from the DFDR. It should be realised that this method does not allow extrapolation of performance capabilities in other conditions than those encountered during this flight. Based on this analysis the following conclusions can be made:

- Marginal level flight capability was available at 270 knots and go-around power with a limited manoeuvring capability;
- At MCT thrust and 270 knots IAS there was no level flight capability;
- Performance degraded below about 260 knots at increased angles of attack. Deceleration to 256 knots resulted in a considerable sink rate.

It is therefore believed that the performance deterioration at increased angles of attack is the most likely explanation for the advancement of the throttles during the final stage of the flight.

2.4.3 *Synthesis*

After separation of the engines and pylons the crew flew the aircraft in the following condition:

1. RH wing leading edge severely damaged.
2. RH wing leading edge flaps partly lost.
3. RH outboard aileron floating at 5 degrees trailing edge up.
4. limited roll control due to:
 - no outboard aileron available;
 - spoiler system partly available.
5. limited rudder control due to lagging behind of lower rudder for unknown reasons.
6. RH inboard aileron probably less effective due to disturbed airflow created by damage of the wing leading edge and loss of pylon no. 3.
7. engine no. 1 and 2 at high thrust settings.

Until the last phase of the flight aircraft control was possible but extremely difficult. 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. During the last minute the following occurred as can be derived from DFDR data. The aircraft decelerated when the pitch attitude was increased probably to reduce the rate of descent.

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 2.

All this generated an increased roll moment to the right by:

1. asymmetric lift generation at increased angle of attack
2. high thrust asymmetry
3. loss of aerodynamic efficiency of the RH inboard aileron at increased angle of attack
4. possible asymmetric lift due to leading edge flaps operation.

The resulting roll moment exceeded the available roll control.

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, 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.

2.5 *Performance of the Flight Crew*

This part of the investigation was hampered by the lack of CVR infor-

mation. Apart from the available factual information, deduction based on general airline flying knowledge and Boeing 747 flying experience was used to achieve a best estimate of what happened in the cockpit after engine separation.

The DFDR revealed that during the manoeuvring of the airplane the limited availability of the flight controls obliged the captain to use up to full rudder pedal deflection and various control wheel deflections between 20 and 60 degrees to the left.

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 at manoeuvring speed.

During investigation in the Boeing simulator it was noted that with flaps up (which locks out the outboard ailerons) under the above mentioned conditions and with maximum rudder deflection appr. 30 degrees left wing down control wheel deflection was needed to maintain straight flight.

In the case of EI AI 1862 the damage to the right wing and the upfloating right outboard aileron required even more left wing down control wheel deflection. This can be observed on the DFDR and was also noticed during simulator investigation.

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% of maximum lateral control. This was very different from what the crew would expect from their knowledge of and experience with an aircraft with two engines inoperative.

When EI AI 1862 departed from Schiphol Airport the captain was the pilot not flying (PNF) and was identified communicating with ATC until the moment that engines no. 3 and 4 separated from the right wing. The "mayday" call and the following radiocommunication were identified as being done by the first officer. The captain clearly took over control and kept control of the airplane throughout the remainder of the flight.

With respect to resource management at the flightdeck the Board is of the opinion that in general the captain is in a better (management) position when he can leave or delegate control of the airplane to a fully qualified first officer.

Given the severe controllability problems the Board respects the decision of the captain to take over control despite the fact that the first officer was fully qualified. The Board also realizes that the situation did not stabilize in such a way that the captain could reasonably return control to first officer.

Within one minute after engine separation the crew decided to return immediately and to land on runway 27, in spite of the unfavourable wind conditions for this runway. The crew may have been urged to this decision for the following reasons:

- the possibility of having been hit by a missile causing a quickly deteriorating situation;
- the believe that they were experiencing one or two uncontrollable engine fires with the possibility that these fire(s) would burn into the wing;
- the assumption that the airplane was too heavy to maintain straight and level flight;
- the crew was familiar with Schiphol Airport, knew the lay-out of the runways and knew that runway 27 was the longest and the nearest available runway.

The captain's decision to land on runway 27, despite the fact that this was not the runway in use, was an understandable decision under the circumstances.

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 Board 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.

2.6 *ATC Performance*

Although Air Traffic Control was not a contributing factor to the accident the Board believes that improvements can be made with regard to the handling of in-flight emergencies.

The exchange of information was at times inadequate. The crew only gave sparse information concerning their problems and intentions. The controller occasionally used nonstandard phraseology which was not as explicit or understandable as would be desirable in an emergency situation. In these situations crews most certainly are working under extreme workload conditions and the controllers may feel reluctant to interfere with a crew involved in an emergency situation. However 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.

ATC was confronted with the unexpected intention of the crew to land on runway 27 instead of the runway in use (runway 06), the runway to which the crew initially was directed. 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 set-up 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.

During the procedure to vector the airplane for runway 27 it flew over the city of Amsterdam. The Board is fully aware of the responsibility and authority of the captain of an airplane in distress. The Board also realizes that after the declaration of an emergency ATC recognizes as its main task, the assistance of the crew in its efforts to recover the airplane.

However, the Board feels that in the handling of emergency situations not only the safety of airplane and passengers but also the possible risk to third parties should be taken into account.

Information regarding the separation of both engines no. 3 and 4 did not reach the ATC controllers concerned with the emergency and was therefore not relayed to the crew.

Although it remains questionable if, when relayed, this knowledge would have changed the course of events, it could have given the crew at least a better understanding of the unusual situation.

2.7 *Actions Taken Since the Accident*

When it became evident that also the "bulkhead style" fuse pin was not only prone to corrosion but also cracked under service conditions, Boeing decided in November 1992 to develop a new design of the fuse pin taking into account the following design objectives:

- static strength should be increased to such a level that the design loads for abnormal flight conditions could be met without a failure of the fuse pin. However, in case of wheels-up landing the wing should not be damaged in order to prevent fuel spillage;
- the fatigue life and crack growth life should be increased to such a value that fatigue cracking should not occur throughout the life of the airplane and inspection intervals should be sufficiently long;
- the new fuse pin should not be prone to any corrosion in order to fulfil the fatigue life objective;
- the manufacturing process should be easy to control and not result in, for example, tooling marks which could initiate fatigue cracking.

Based on the above listed design requirements Boeing developed a stainless steel fuse pin with a considerably improved fatigue and crack growth life. Furthermore the static strength and fatigue and crack growth analysis will be supported by tests.

When the inboard midspar fitting of the China Airlines Boeing 747 was recovered it became evident that both lugs had failed due to fatigue and after assessing the damage to the wing leading edge of the Evergreen Boeing 747 caused by the separation of engine no. 2, Boeing decided that the Boeing 747 should meet the fail-safe requirements with respect to pylon-to-wing attachment.

As a consequence Boeing re-assessed the current pylon design in order to meet the fail-safe requirements. The hardware fix currently proposed by Boeing will add an additional link to the midspar mounting in order to meet the fail-safe requirements. Extensive local redesign of the pylon structure should eliminate most of the currently effective inspections. The diagonal brace and upper link will be replaced by designs with a higher load carrying capability.

The Board is of the opinion that:

- a full scale test should be carried out for the redesigned pylon to qualify static, fatigue and fail safe characteristics;
- an extensive flight load measurement program involving revenue flights should be accomplished in order to gain a better knowledge of the actual loads on the pylon structure.

Boeing's intended modification program will probably start somewhere in the second quarter of 1994 and will require somewhere between 12 and 17 days down time and about 10.000 man hours per airplane. Total time to modify all Boeing 747 airplanes will be 5 to 7 years.

In the interim, safety of the fleet of not yet modified airplanes will be guaranteed by:

- new stainless steel fuse pins;
- adapted inspection program for the lugs;
- use of a newly developed ultrasonic sensor, able to detect smaller cracks.

3 CONCLUSIONS

3.1 Findings

1. The airplane was inspected and maintained in accordance with EI Al and Boeing maintenance procedures.
2. The flight crew was trained and certificated in accordance with appropriate Israeli CAA, EI Al, and industry standard procedures.
3. At an altitude of about 6,500 feet the no. 3 pylon failed, this pylon and no. 3 engine separated from the right wing.
4. The no. 3 engine struck the no. 4 engine, causing the – no. 4 pylon and engine to separate from the wing.
5. 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 4 hydraulic systems were completely and the pneumatic system was partially disabled.
6. 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.
7. Due to 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 nor the damage to the wing.
8. Performance and controllability were so severely limited that the airplane was marginally flyable.
9. Current standard industry training requirements and procedures do not cover complex emergencies like encountered by EI Al 1862.
10. After declaring an inflight emergency, the flight crew decided to return to Schiphol Airport immediately and land on runway 27, although runway 06 was in use for landing.
11. 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.
12. During the vectoring to the final approach, the flight crew stated to air traffic control that they were experiencing problems with the aircraft's flaps. Shortly before intercepting the final approach they reported controlling problems.
13. 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.
14. Exchange of information between EI Al 1862 and ATC was not always adequate.
15. The effectiveness of the fused pylon concept in protecting the wing structure and fuel tanks against the consequences of pylon overloads was based on the history of the similar fuse-pin design of the Boeing 707.

16. 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 structural element.
17. 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 S.B.'s and A.D.'s were issued addressing numerous fatigue problems in the pylon structure including fuse-pins, lugs and fittings.
18. Inspection and analysis performed by specialists on recovered vital parts of the pylon construction revealed severe damage due to fatigue.
19. 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.
20. After analysing 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.
21. Over a period of 15 months, three pylons have failed in flight, resulting in two fatal 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.

3.2 *Probable Causes*

The design and certification of the B 747 pylon was found to be inadequate to provide the required level of safety. Furthermore the system 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.

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.

4 RECOMMENDATIONS

- 4.1 Redesign the B747 pylon structure including attachment to engine and wing. All SB's and AD's should be terminated after the redesign.
- 4.2 The redesign program for the pylon should include a full scale fatigue and failsafe test.
- 4.3 A large scale inflight fleet-wide 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.
- 4.4 Review present methods of controlling structural integrity, such as non destructive inspection techniques and airworthiness directive requirements, in the current design B747 pylon assembly.
- 4.5 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.
- 4.6 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;
 - use of thrust in order to maintain controllability;
- 4.7 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.
- 4.8 Expand the information on inflight emergencies in appropriate guidance material to include advice how to insure that pilots and air traffic controllers are aware of the importance to exchange information in case of inflight emergencies. The use of standard phraseology should be emphasized.
- 4.9 Evaluate and where necessary develop common guidelines on emergency procedures and phraseology to be used between ATC, Fire Brigade, Airport Authorities and RCC.
- 4.10 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.

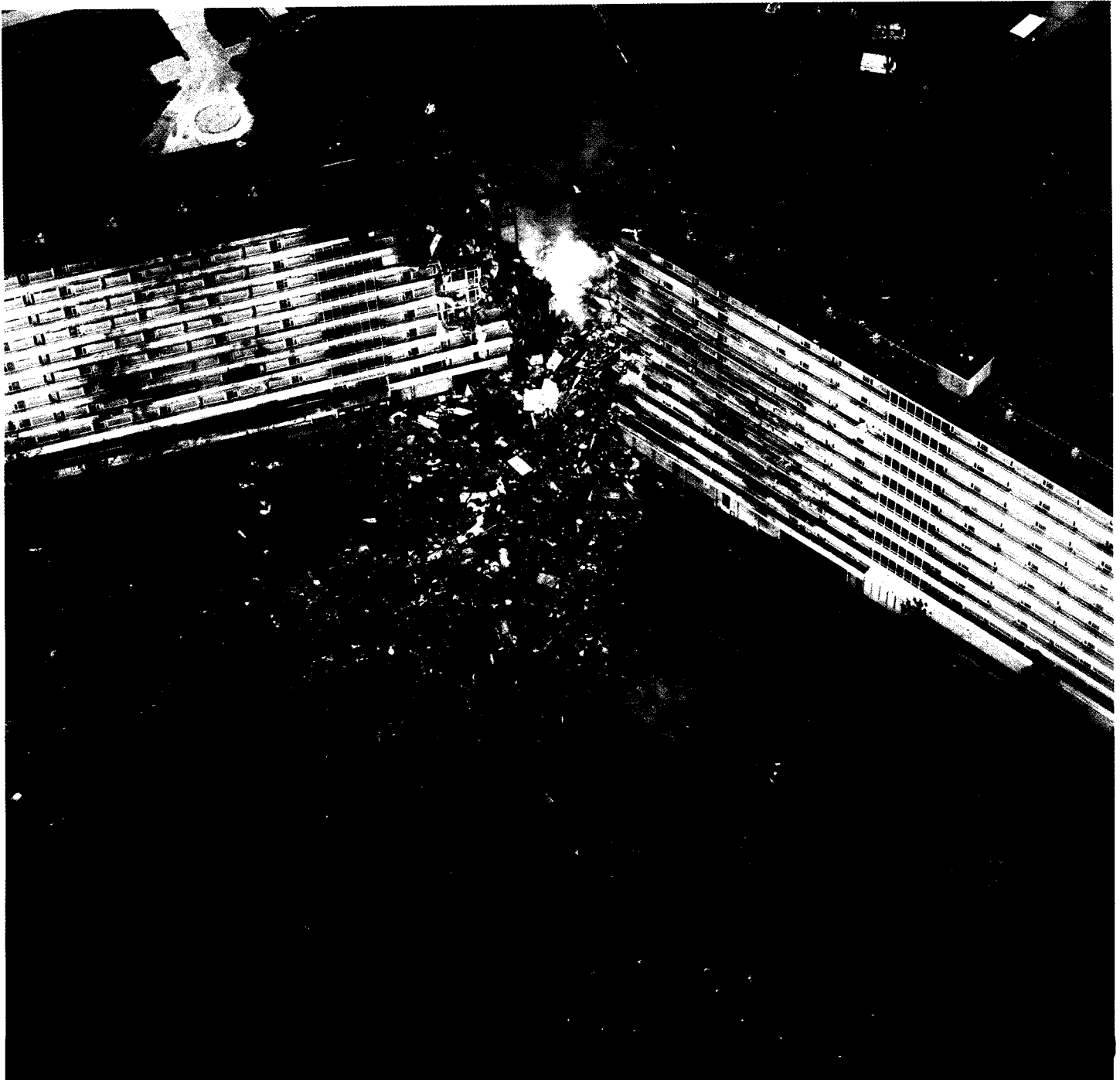
- 4.11 Review design philosophy of fire warning systems, to preclude false warnings upon engine separation.
- 4.12 Review flight control design to ensure that flight control surfaces do not contribute adversely to airplane control in case of loss of power to a control surface.
- 4.13 Fire resistance of DFDR and CVR should be improved.
- 4.14 Investigate the advantages of installation cameras for external inspection of the airplane from the flightdeck.

APPENDIXES

APPENDIX 1

MAIN IMPACT AREA

SEEN AGAINST IMPACT DIRECTION



APPENDIX 2.1

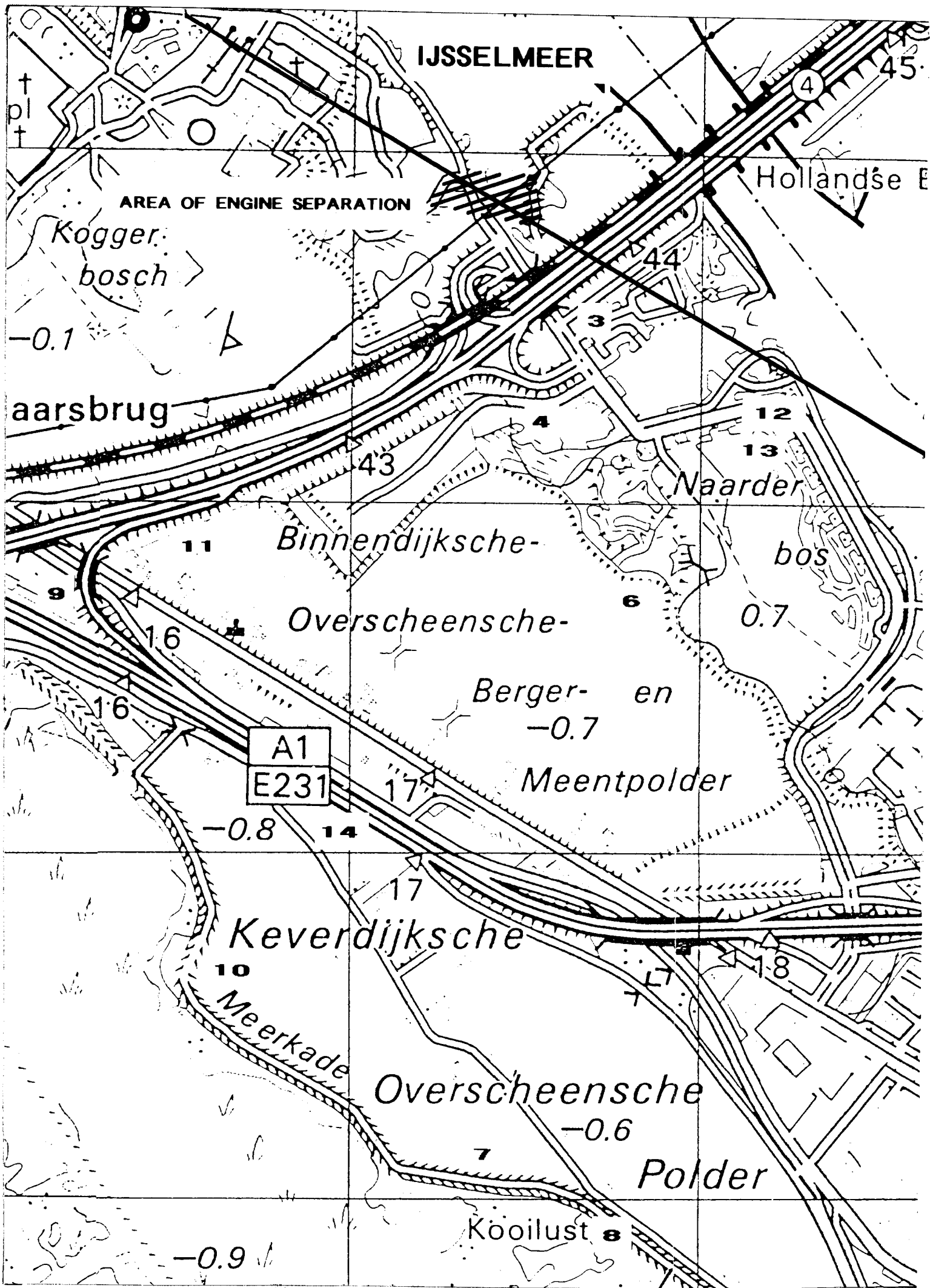
DESCRIPTION OF THE WRECKAGE AREA AFTER ENGINE SEPARATION

- The knowledge that engine 3 and 4 separated from the aircraft and the position thereof was mainly obtained by eye witnesses and was later confirmed by data of the radio communication with the aircraft.
Engine 4 was recovered on 4 October 1992, engine 3 on 14 October 1992.
- The area North of the "Hollandse Brug" and to the South till Naarden Harbour were extensively searched by specialised salvage vessels of the Netherlands Royal Navy A.O. the "Serberus" and the "Nautilus", making use of sonar and skindivers, moreover by patrol vessels of the State Water Police, a survey vessel of the Min. of Waterregulation with sonar equipment and a private company (B.T.S) with specialised equipment for salvages.
- The entire area under the flight path, both over water and land, was intensively searched by the members of the Accident Investigation Bureau by means of the helicopter of the State Air Police.
By helicopter an oil slick was observed West of Pampus, several days after the accident. A vessel with experimental equipment for underwater metal detection searched the sea bottom over the area for 3 days, yet to no avail. The source of the oil slick stopped venting after a day and no metal or clue was found as to the determination whether it had any relation to the aircraft.
- On the map the overall positions are indicated of the main wreckage parts. Numerous small parts that were picked up by civilians and handed over to the local police are not indicated.
They contained no significant technical information.

POSITION OF RECOVERED PARTS (See attached map)

1. Engine no. 4, with pylon and cowling parts of no. 4
2. Engine no. 3, with pylon and cowling parts of no. 3 and 4, parts of fanblades of no. 4
3. Diagonal brace no. 3
4. Diagonal brace no. 4
5. Spinner no. 4
6. Part of tailcone no. 3
7. Tip of tailcone no. 3
8. Reverser screen parts
9. Cowling parts no. 3
10. Cowling parts
11. Part wing leading edge
12. Leading edge flap no. 18 (RH wing) and flapdrive
13. Air driven pump no. 3 and 4
14. Rear part of pylon no. 4
15. Pneumatic system bleed air pipe (near Muiden, not on the map)

Scattered over the area: small parts of honeycomb material of cowling no. 4 and parts of leading edge panels and structure of the RH wing



IJSSELMEER

AREA OF ENGINE SEPARATION

Hollandse E

Koggerbosch

-0.1

aarsbrug

Binnendijksche

Overscheensche

Berger- en
-0.7

Meentpolder

Naarder

bos

0.7

A1
E231

-0.8

Keverdijksche

10

Meerkade

Overscheensche

-0.6

Polder

Kooilust

-0.9

WRECKAGE DISTRIBUTION CHART ACCIDENT ELAL 4X-AXG 4-10-1992

IMPACT AREA AFTER ENGINE SEPARATION



brug



RECONSTRUCTED AIRCRAFT FLIGHTPATH

De Schelp

GOOIMEER

Naarderbos
NN



19

0.4

Ronduit

Zanddijk

3.2

Valkeve

0.4

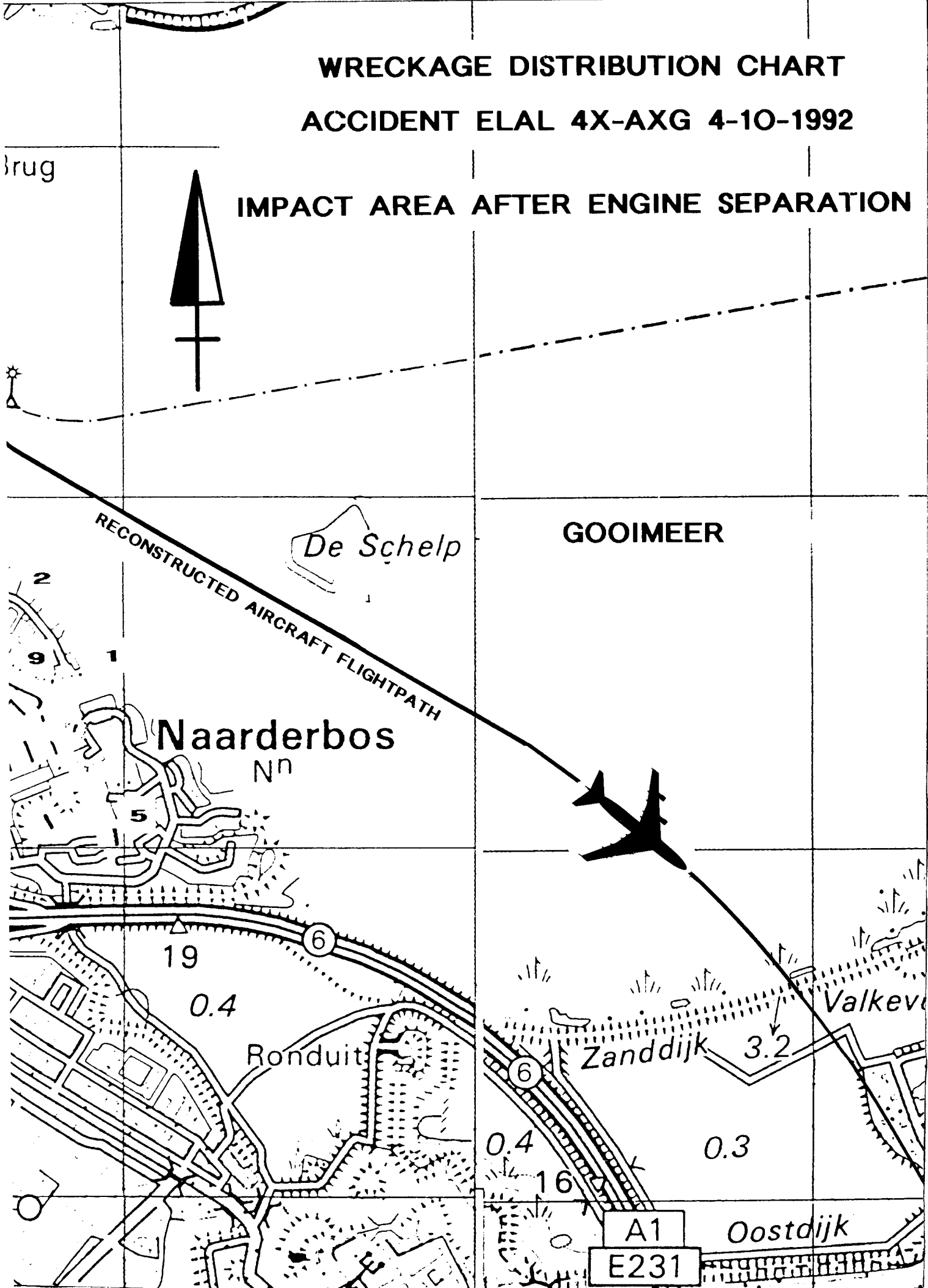
16

0.3

A1

Oostdijk

E231



APPENDIX 2.2

DESCRIPTION OF THE MAIN IMPACT AREA

1. The aircraft 4X-AXG, ELAL flight 1862 crashed into the joint apex of the eleven story buildings "Kruitberg" and "Groeneveen", (see the picture in appendix 1), in the suburb "Bijlmermeer", Amsterdam South East, at a distance of approx. 13 km from the threshold of Runway 27 of Schiphol Airport. The impact direction was generally East.
 - 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.
 - After penetration of the heavy parts of the centre section and empennage through the blocks these and associated parts came to rest immediately behind the blocks, the scatter pattern was longest at this side. On impact an explosion of the fuel scorched the facades of the blocks over a wide area. The scatter pattern amounted roughly 400 meters wide and 600 meter long, the engines 1 and 2 and skin panels of the left hand wing being the farthest in the trail. Parts of the cockpit section, cockpit interior, controls and human remains of the crew were recovered at the right hand side of the apex. On the map the distribution of the principal wreckage parts is given.
 - From the above data, it could be derived that the aircraft impacted with a very high vertical component with only a slight horizontal displacement. The aircraft collided with the buildings in a steep flightpath angle, a bank angle of slightly over 90° to the right and a nose down attitude of approx. 70°. The configuration could not be established at the scene of the accident and could only be confirmed after detailed inspection of the various parts and remainders there of.

- The aircraft was demolished completely, the majority of the fragments consisted of small parts. The wreckage parts penetrated deeply into the ground at the rear side of the blocks, piles of debris were mixed with heavy parts of building structure, household items, all initially fiercely burning.
- Ground water level, mud and locally 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 scrupulous 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, a.o. the left hand steering wheel.

- The initial salvage operation lasted for about one and a half week. The removal of the rubble was done by all sorts of lifting, excavation and removal equipment, frequently interrupted when local fires ensued or excavation of human remains prevailed. Local fires revived for three days.
- The survey of the main wreckage area for the purpose of accident investigation was done by the members of the Accident Investigation Bureau assisted by the State Air Police and members of the various divisions of the Netherlands DGAC.

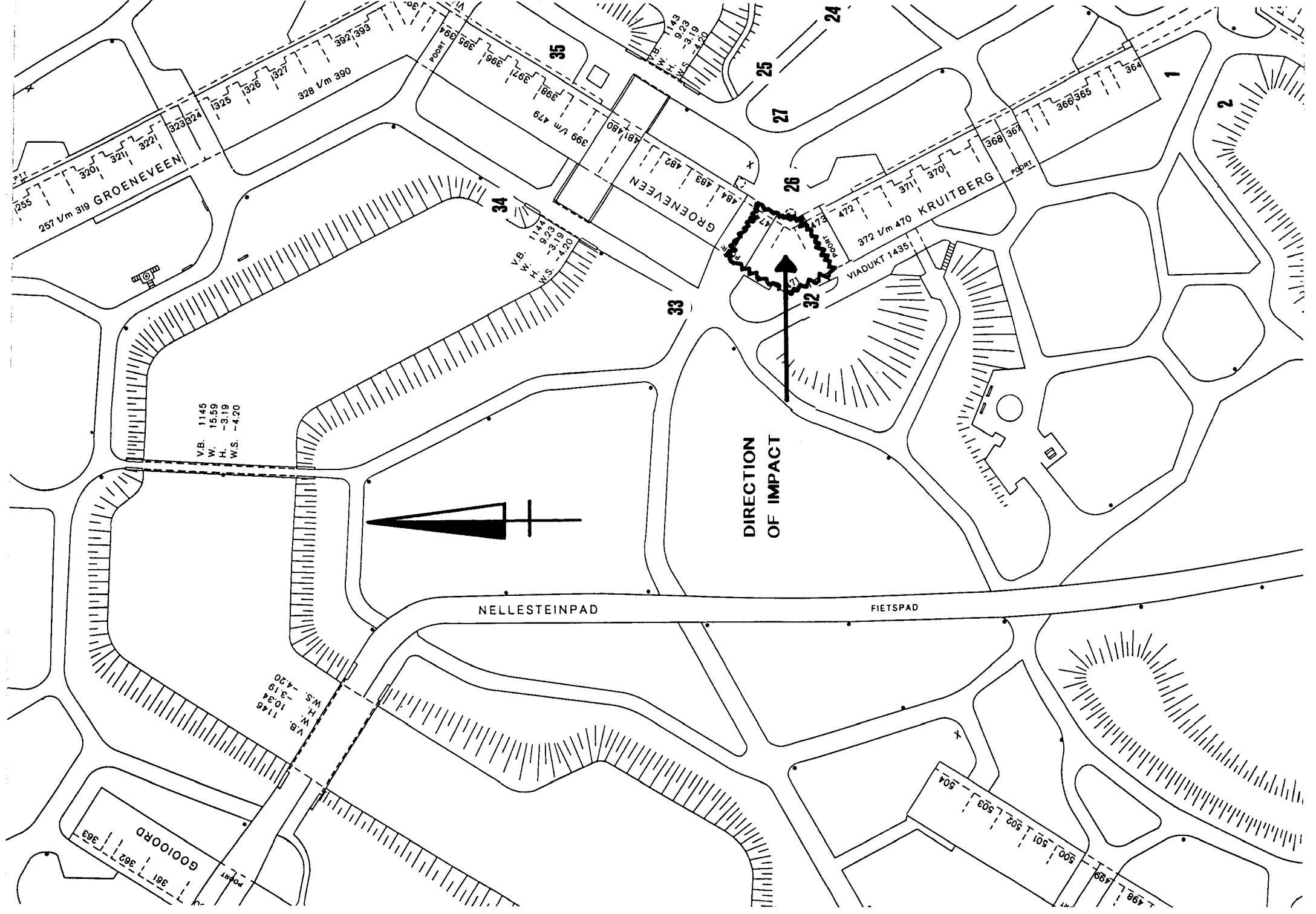
WRECKAGE DISTRIBUTION

MAIN IMPACT AREA

(See attached map)

1. Blue part of fin
2. Blue part of fin
3. Part bottom skin L.H. wing, approx. 8 meters long
4. Part L.H. wingskin
5. Maingear wheel
6. Wingskin stringer
7. Part L.H. wingskin
8. Wingskin stringers and part engine cowling
9. Part engine hot section, wingskin, booster pump, part of pylon, engine cowling
10. Engine pylon
11. Part wingskin
12. Part engine Jetpipe
13. Part bottom skin L.H. wing with fuel booster pump
14. Part engine pylon, with part of engine mounting and part of engine
Parts wingskin
15. Part wingskin
16. Engine cowling
17. Part of wing and fairing
18. Part wingskin with fuel tank access panels
19. Engine cone
20. Engine inlet cowling
21. Blue part of fin and fairing
22. Part L.E. flap and engine cone attachment
23. Freight container
24. Part stabilizer. Engines 1 and 2
25. Undercarriage beam. Parts main gear
26. Tailsection with APU and flight controls
27. Parts maingear (wing and body)
Wing centersection
28. Engine cowling
29. Main gear door
30. Part rudder

31. Pylon with engine casing
32. Parts tailsection
33. Main gear door and fuselage parts
34. Parts R.H. wing
35. Parts L.H. wing, parts fin and stabilizer



V.B. 1145
W. 15.59
H. -3.19
W.S. -4.20

V.B. 1146
W. 10.34
H. -3.10
W.S. -4.20

DIRECTION
OF IMPACT

NELLESTEINPAD

FIETSPAD

GOLOORD
361 362 363

500 501 502 503 504

255 320 321 322 323 324
257 V/m 319 GROENEVEEN

325 326 327 328 V/m 390 391 392 393 394 395 396 397 398 399 V/m 479

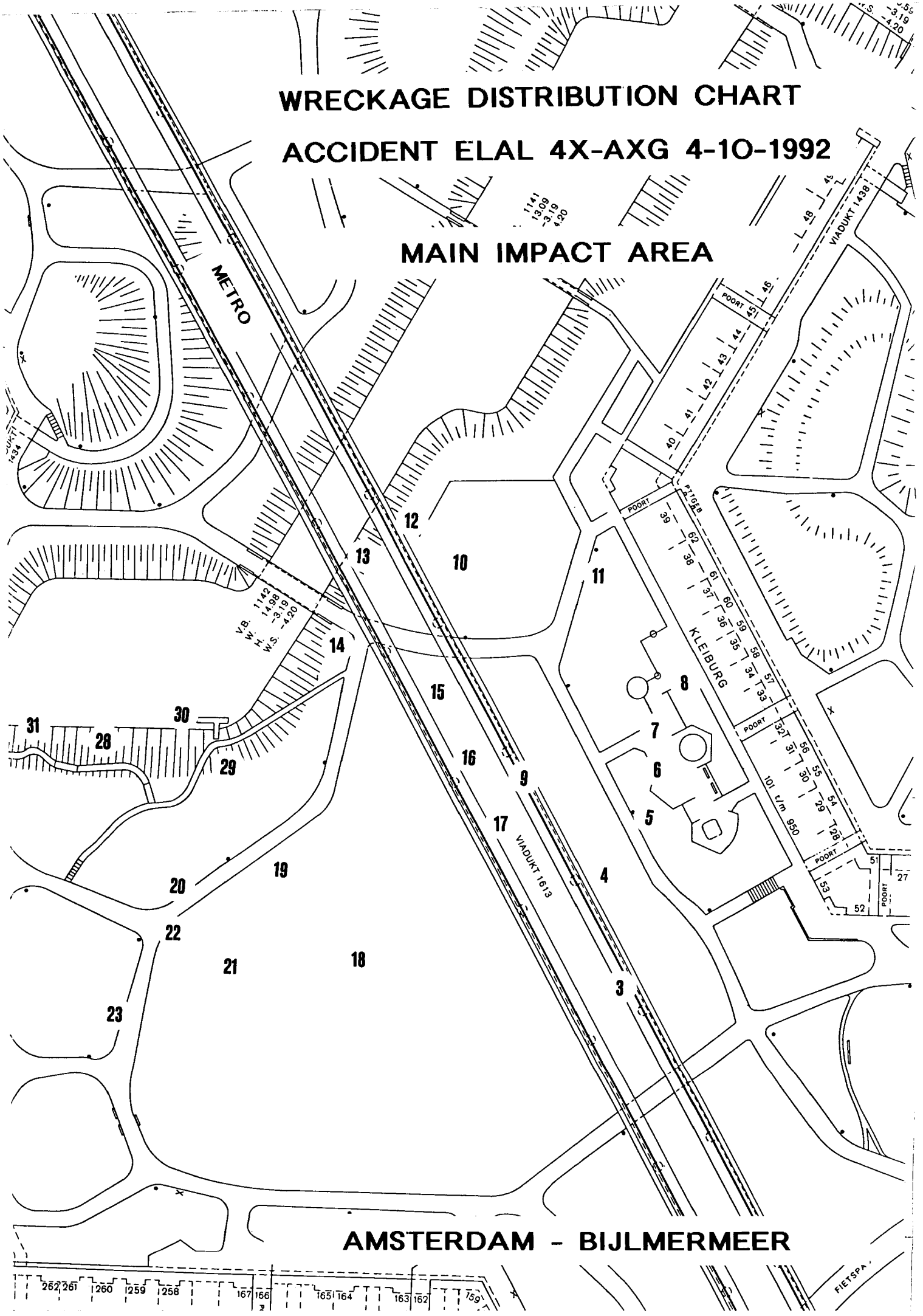
GROENEVEEN
481 480 483 482 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500

VIADUKT 14351
372 V/m 470 KRUITBERG
371 370 369 368 367 366 365 364

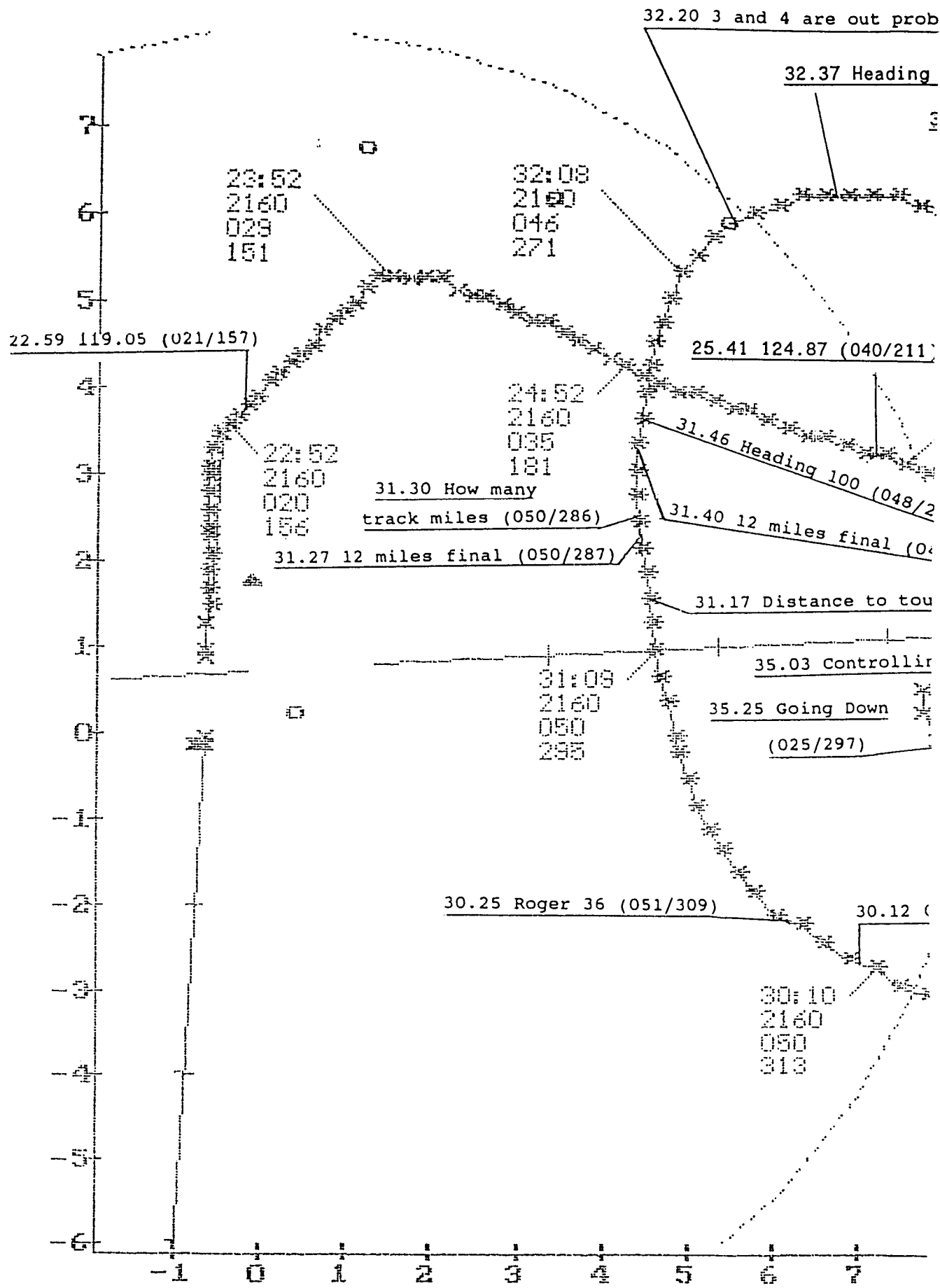
WRECKAGE DISTRIBUTION CHART

ACCIDENT ELAL 4X-AXG 4-10-1992

MAIN IMPACT AREA



* := Combined
 0 := Primair
 x := Secundair
 Inhoudlabel : Tydkmin:sec) of Tracknr
 Logging Datum : 041092
 SSR code of Tracknr:Sec
 Mode-c
 Logging Tyd : 17:20:20-17:35:35
 DD-80Z/SB (C) rj



APPENDIX 3.1

ems with flaps (0 ?/271) (043/271)

100 (041/266)

3.00 Heading 120 maintaining (040/268)

33:08
2160
041
267

33.13 Speed 260 (041/266)

33.15 Cleared to land (042/267)

33.37 Turn right 270 cleared for approach (041/260)

25:51
2160
041
218

33.44 Right 270 (041/262)

34:08
2160
039
262

26:51
2160
000

1/269)

34.18 Heading 290 (036/267)

hdown (050/290)

problem (028/292)

34.28 Roger 290
(036/272)

27.56 Mayday (060/274)

34.48 Further right heading 310
(030/285)

28.11 Turn right 260 (051/285)

35:08
2160
028
295

34.52 310 (029/288)

28:11
2160
051
285

28.17 Fire Engine 3 (048/291)

0/22 (050/313)

34.58 Descent 1500 (028/292)

28.22 Heading 270 (046/294)

29.58 Heading 360 Descent 2000 050/22 (049/326)

28.31 Wind 040/21 (043/311)

29.49 Emergency request 27 (049/327)

28.45 Lost 3 and 4 engine (042/323)

28.54 RWY in use ? (040/332)

29:11
2160
042
336

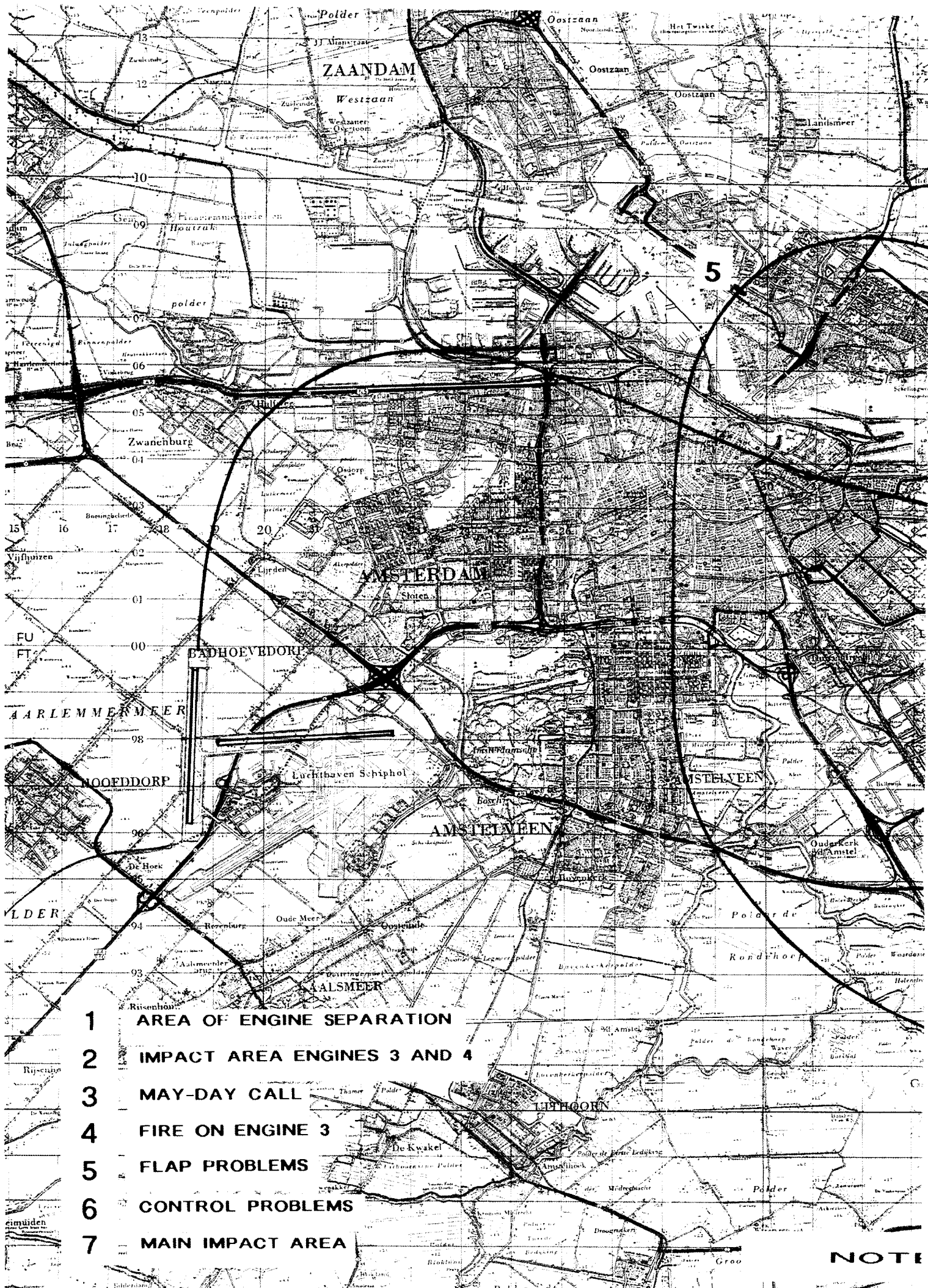
28.57 RWY 06 040/21 1012 (040/332)

29.02 Request 27 (041/338)

29.39 118.4 bye (048/334)

29.08 121.2 (041/334)

9 10 11 12 13 14 15 16



- 1 AREA OF ENGINE SEPARATION
- 2 IMPACT AREA ENGINES 3 AND 4
- 3 MAY-DAY CALL
- 4 FIRE ON ENGINE 3
- 5 FLAP PROBLEMS
- 6 CONTROL PROBLEMS
- 7 MAIN IMPACT AREA

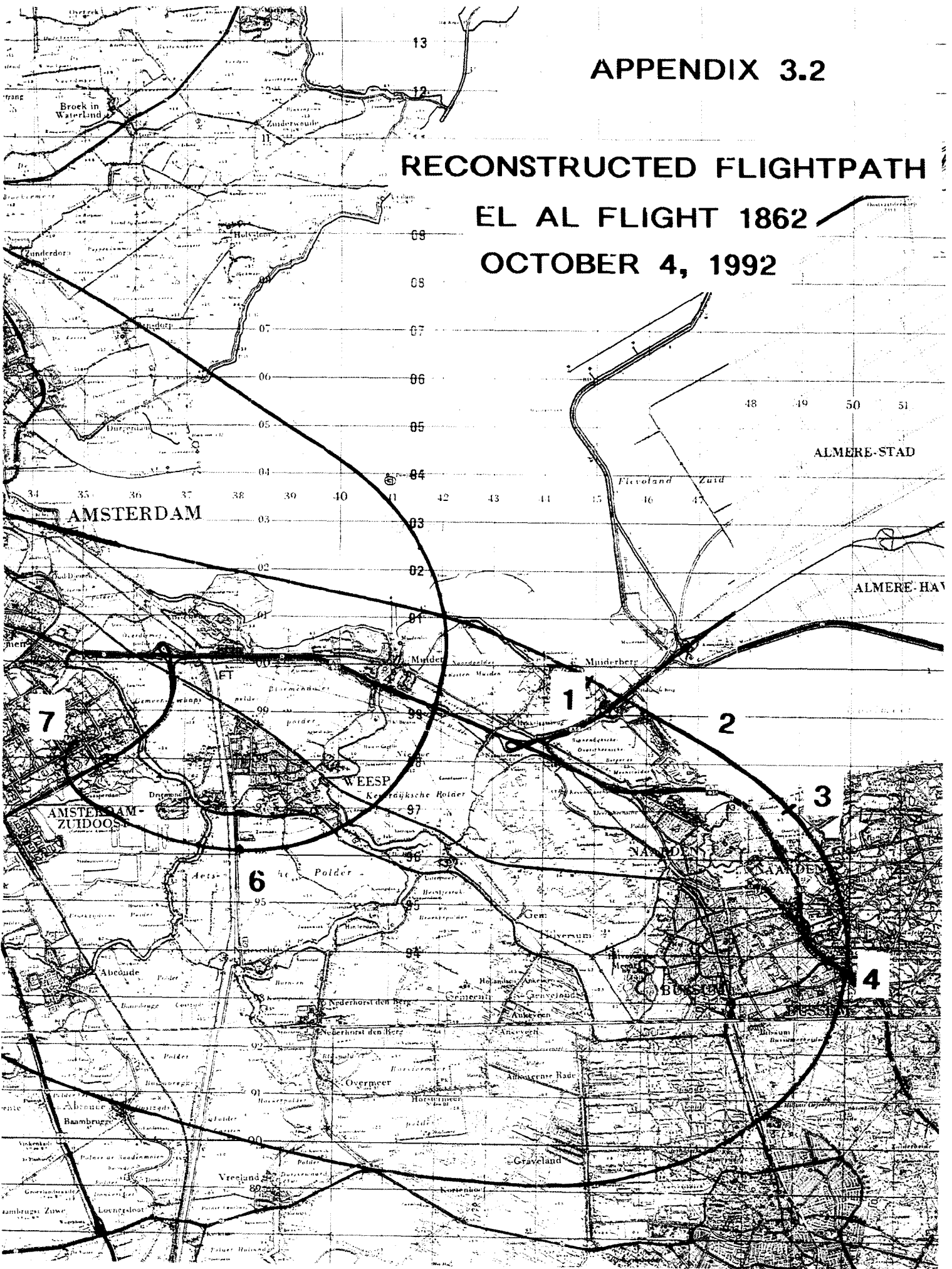
NOTE

APPENDIX 3.2

RECONSTRUCTED FLIGHTPATH

EL AL FLIGHT 1862

OCTOBER 4, 1992



MAIN CHART NOT REVISED SINCE 1989

APPENDIX 4.1

TRANSCRIPT OF ATC RADIO AND TELEPHONE COMMUNICATION

Time: (UTC)	From - To	E = El Al 1862 Sd = Schiphol SOC/CD Gc = Schiphol Ground T = Schiphol Tower A = Schiphol Approach Ar = Schiphol Arrival O = ACC Controller sector 2	Time: (UTC)	From - To	Po = ACC Planner sector 2 At = Assistant Tower Ap = Assistant Approach B = Fire-Brigade Aa = Airport Operations Duty Manager	Time: (UTC)	From - To	Other relevant air-traffic; the radio telephony designator of the airline company and the pronunciation in radio telephony (R/T): KLM = KLM (R/T: KLM) EIN = Aer Lingus (R/T: Shanrock) IBE = Iberia (R/T: Iberia) DLB = Lufthansa (R/T: Lufthansa) BAW = British Airways (R/T: Speedbird) KLC = KLM Cityhopper (R/T: City)	Time: (UTC)	From - To	BOZ 083/92, 2 november 1992
Begin			Begin			Begin			Begin		TRANSCRIPT OF FLIGHT
					[] = Translation						EL AL 1862
											ON OCTOBER 4TH 1992
End		— = Interference audible in radio telephony communications	End		In italics = Text proposed by the investigation-team of the Inspection Directorate	End		Note: At some places the original text is replaced by "(name)", this to safeguard the privacy of the people concerned	End		BOZ/AGE

170202 170209	E - Sd	Schiphol, El Al 1862, good evening, information fango, IPR to Tel Aviv									
170211 170223	Sd - E	El Al 1862, roger .. eh .. standby shortly, it will be runway 01L, you have a slot of 20, clearance to Ben Gurion, Pampus-departure, squawk 2150									
170225 170230	E - Sd	Roger, El Al 1862, clearance to Ben Gurion, Pampus-departure, to squawk 2150									
170231 170234	Sd - E	Correct El Al 1862, call you back for start-up on this, standby									
170236 170238	E - Sd	(.. Unreadable ...)									
170408 170412	E - Sd	Schiphol, El Al 1862 .. eh .. we request a push-back from our stand									
170414 170420	Sd - E	El Al 1862, well you .. eh .. may taxi via the south so it's .. eh .. rather short taxiway to 01L, standby									
170421 170422	E - Sd	Roger, standing by									
170540 170545	Sd - E	El Al 1862, your start-up is approved now, push-back on 121.8, shalom									
170545 170546	E - Sd	Shalom, thank you									
170607 170613	E - Gc	Ground, El Al .. eh .. 1862, good afternoon, eh .. freight .. eh .. number 3 and request push-back									
170614 170615	Gc - E	1862, push-back approved									

170616 170616	E - Gc	Thank you								
171324 171326	E - Gc	El Al 1862 ready for taxi								
171327 171334	Gc - E	El Al 1862 taxi OIL, via the south and fit in behind the Saab at your eleven o'clock								
171336 171339	E - Gc	Roger, behind the Saab .. eh .. OIL								
171734 171737	Gc - E	El Al 1862 contact Tower on 118.1, good- bye								
171737 171738	E - Gc	Good day								
171804 171806	E - T	El Al 1862, good evening								
171806 171810	T - E	Good evening El Al 1862, line-up in se- quence OIL								
171811 171811	E - T	Roger								
171911 171913	E - T	El Al 1862, can we line-up?								
171914 171915	T - E	Affirm sir, line-up OIL								
171916 171916	E - T	Roger								
172049 172052	T - E	El Al 1862 is cleared take-off OIL								
172052 172055	E - T	Cleared for take-off OIL, rolling								
172055 172055	T - E	Roger								
172251 172253	E - T	El Al 18 eh .. 62 changing to departure								
172254 172255	T - E	Bye bye El Al								
172255 172255	E - T	Good day								
172259 172303	E - A	Departure, El Al 1862, good eve .. eh .. afternoon, passing 2000								
172304 172306	A - E	El Al 1862, good afternoon, climb flight level 90								
172307 172308	E - A	90, roger								
172541 172544	A - E	El Al 1862 contact Amsterdam on 124.87								

172545 172546	E - A	124.87. good day																	
172546 172546	A - E	Bye																	
172552 172556	E - O	Amsterdam El Al 1862, good evening, pas- sing 4300																	
			172553 172559	A - O	Kan je de KLM 237 zo hebben in verband met die El Al, want die klinkt voor geen meter die El Al? [Can you accept KLM 237 this way, regard- ing the El Al, because this El Al climbs like a brick]														
			172559 172600	O - A	Ne, maar da's geen probleem [No, but that's no problem]														
			172600 172601	A - O	Oké dan krijg je er [Okay, you'll get it]														
172602 172605	O - E	El Al 1862, hello, climb to flight level 210																	
172606 172607	E - O	210, roger																	
172618 172622	KLM- O	Amsterdam, goedenavond, KLM 237 climbing flight level 90 [Amsterdam, good evening, KLM 237 climbing flight level 90]																	
172623 172626	O - KLM	Goeeavond KLM 237 and eh .. climb to flight level 210 [Good evening KLM 237 and eh ... climb to flight level 210]																	
172627 172630	KLM- O	Climbing flight level 210, KLM 237																	
172634 172637	O - BAV	Speedbird 943, climb to flight level 280																	
172637 172640	BAV- O	Flight level 280, Speedbird 943																	
172645 172648	O - BAV	Speedbird 51 2 , descend to flight level 100																	
172649 172651	BAV- O	Descend flight level 100, Speedbird 51 2																	
172700 172701	O - KLM	KLM 237, direct to Germinghausfen																	
172702 172704	BAV- O	Direct Germinghausfen, KLM 237, thank you																	
172720 172723	O - KLC	City 057, contact Düsseldorf 129.17, good day																	
172724 172727	KLC- O	129.17 good day, City 057																	

172750 172753	O -BAW	Speedbird 943, climb now (flight level 310									
172754 172756	BAW- O	310, Speedbird 943									
172756 172759	E - O	El Al 1862, mayday, mayday, we have an emergency									
172800 172804	O - E	El Al 1862 roger, break, KLM 237 turn left heading 090									
172804 172806	KLM- O	Turn left 090, KLM 237									
172806 172808	O - E	El Al 1862 do you wish to return to Schiphol?	172806 172806	A - Po	Ja [Yes]						
			172807 172811	Po - A	El Al die gaat ..eh met een mayday terug ... die is nu aan 't zakken [El Al is returning ..eh with a mayday ... it is descending right now]						
172809 172811	E - O	Affirmative, mayday, mayday, mayday									
172811 172817	O - E	Turn right heading 260, field eh .. behind you eh .. in your to the west eh .., distance 18 miles									
			172812 172812	A - Po	Check						
172817 172821	E - O	Roger, we have fire on engine number number 3, we have fire on engine number 3									
172822 172823	O - E	Roger, heading 270 for downwind									
172824 172825	E - O	270 downwind									
172831 172834	O - E	El Al 1862, surface wind 040 at 21 knots				172831 172833	A - T	El Al 1866 komt terug met een mayday [El Al 1866 is returning with a mayday]			
172835 172835	E - O	Roger									
172835 172839	O -BLB	Luftbansa 5594, contact Amsterdam 123.85									
			172836 172836	A - Po	Ja [Yes]			172836 172836	At - Ap	Ja [Yes]	
			172836 172841	Po - A	Wij heeft een engine on fire, draait nu naar .. eh .. downwind voor de 06 [It's got an engine on fire, it's now turning .. eh .. downwind for the 06]						
						172837 172837	T - A	Wat zeg je nou? [What do you say?]	172837 172839	Ap - At	Ik weet nog niet wat ie heeft precies eigenlijk, die El Al [I don't know yet what's exactly the matter with this El Al]

172840 172840	DLM- O	123.85, bye bye						172840 172841	At - Ap	EI Al 1862 komt terug? [EI Al 1862 is returning?]
172841 172843	O -BAY	Speedbird 943, contact Naastricht 127.62						172841 172842	Ap - At	Ja [Yes]
								172842 172844	At - Ap	Oké, ik ga gelijk de inspectie, hij heeft een mayday-call geplaatst? [Okay, I will immediately the inspection, he did make a mayday-call?]
172843 172843	BAY- O	127.62								
			172844 172845	A - Po	Oké, that's copied [Okay, that's copied]					
172845 172849	E - O	EI Al 1862 lost number 3 and number 4 engine, number 3 and number 4 engine						172845 172845 172845 172846	Ap - At At - Ap	Ja [Yes] Oké .. voor 06 .. [Okay .. for 06 ..]
			172846 172846	Po - A	Bij komt nu bij jullie .. [It will be transferred to you right now]					
			172847 172847	A - Po	Ja, is goed .. [Yes, that's okay ..]					
			172848 172850	Po - A	.. Oh eh bij heeft number 3 en number 2 engine verloren [..oh eh and it has lost number 3 and number 2 engine]					
172850 172850	O - E	Roger 1862								
			172851 172852	A - Po	Number 3 en 2 verlo... [Lost number 3 and 2]					
			172852 172852	Po - A	Ja [Yes]					
			172852 172852	A - Po	Oké [Okay]					
			172853 172854	Po - A	Dus geef maar alarm denk ik [So, I think you had better give an alert]					
172854 172856	E - O	What will be the runway in use for me at Amsterdam?						172854 172856	Ap - At	Number 2 and number 3 engine doen 't niet [Number 2 and number 3 engines are inoperative]
			172855 172855	A - Po	Eh .. doen we [Eh .. we'll do that]					
								172856 172857	At - Ap	Runner ... 06? [Number ... 06?]
172857 172901	O - E	Runway 06 in use sir, surface wind 040 at 21 knots, QNH 1012								

								172858 172858	Ap - At	Ja [Yes]
								172858 172858	At - Ap	Oké [Okay]
172902 172904	E - O	1012, we request 27 for landing								
			172904 172905	B - Gc	Met de Brandveer [Fire-brigade]					
172905 172906	O - E	Roger, can you call Approach now 121.2 for your line-up?	172905 172913	Gc - B	Brandveer, .. eh .. Jumbo komt terug van 06 met twee uitgevallen motoren, u volgt .. eh .. verder bericht eh .. volgt nog [Fire-brigade, .. eh .. Jumbo is returning from 06 with two engines inoperative, you follow .. eh .. additional information eh .. will follow later]					
172908 172908	E - O	121.2, bye bye								
172908 172908	O - E	Bye								
			172913 172914	B - Gc	O .. eh .. baan 06? [O .. eh .. runway 06?]					
172914 172917	EIW- A	Amsterdam Approach, Shearock 606								
			172915 172915	Gc - B	Baan 06 [Runway 06]					
			172916 172917	B - Gc	Oké, we komen d'r aan [Okay, we're on our way]					
			172917 172917	Gc - B	Dank u wel [Thank you]					
172918 172923	A - EIW	Shearock 606 descend to 3000 feet on QNH 1012, you can expect delay due to an emergency coming in								
172924 172929	EIW- A	(.. Unreadable ..)								
172925 172930	E - A	Schiphol, El Al 1862, we have an emergency, eh .. ve're number t.. eh .. 3 and 4 engine inoperative (.. badly readable .., probably: "intending" or "returning") landing	172925 172926	T - A	Vaar zit ie nu? [What's it's position now?]					
			172928 172931	A - T	Kijltje of .. eh .. 12 uit [About .. eh .. 12 miles out]	172928 172929	At - Aa	Airport 1, Tower [Airport 1, Tower]		
						172930 172930	Aa - At	Toren, Airport 1 [Tower, Airport 1]		

172932 172938	A - S	El Al 1862, roger copied about your emergency, contact 118.4 for your line-up	172932 172932	T - A	Check	172932 172942	At - Aa	Rijnbeer .. eh .. we hebben zojuist doorgekregen een El Al, die zojuist gestart is, komt terug, motor 2 en 3 zijn uitgevallen, heeft een mayday-call geplaatst, we hebben de Brandveer reeds gevaarschuld [Sir, .. eh .. we just got the message that an El Al, that has just departed, is returning, engines 2 and 3 are inoperative, he made a mayday-call, we already informed the fire-brigade]			
172939 172940	S - A	118.4, bye									
			172941 172941	A - O	Ja [Yes]						
			172941 172941	O - A	Heb je 'm [Have you got it?]						
			172942 172942	A - O	Ja [Yes]						
			172942 172942	O - A	Oké [Okay]						
						172943 172945	Aa - At	Oké, ik ga .. (... unreadable ..) [Okay, I'm going .. (... unreadable ...)]			
172949 172957	S - Ar	Schiphol, El Al 1862, we have an emergency, number 3 and number 4 engine inoperative, request 27 for landing									
			172952 172952	Ap - At	Ja [Yes]						
			172953 172953	At - Ap	Momentje [One moment]						
			172953 172953	Ap - At	Ja [Yes]						
172958 173008	Ar - S	Yon request 27, in that case heading 360, 360 the heading, descend to 2000 feet on 1012, wind the wind is 050 at 22									
			173002 173006	At - Ap	Schrijf jij het op of moet ook nog dingen ik heb de inspecteur gevaarschuld en de brandveer is gevaarschuld [Will you write this down or do have things also I've already informed the inspector and the Fire-brigade as well]						
			173006 173006	Ap - At	Oké [Okay]						
			173007 173008	At - Ap	Schrijf jij dat even op? [Will you write this down?]						
			173008 173009	Ap - At	Ja, ik schrijf het vel op [Yes I'll write it down]						

			173009 173009	At - Ap	Olé [Okay]						
			173009 173009	Ap - At	Hoi [Bye]						
			173009 173009	At - Ap	Bedankt [Thanks]						
173010 173011	E - Ar	Roger, can you say again the wind please									
173012 173013	Ar - E	050 at 22									
173014 173016	E - Ar	Roger, what heading for runway 27?									
173016 173025	Ar - E	Heading 360, heading 360 and then give you a right turn on, to cross the localizer first and you've got only 7 miles to go from present position									
173025 173027	E - Ar	Roger 36, copied									
									173032 173038	A - T	Nij gaat naar 27 de EI A1 1862 dus ik weet nu niet precies hoeveel mijl die gaat vliegen [It's going to 27 the EI A1 1862, so I don't know exactly how many miles it will cover]
									173038 173041	T - A	Nee check, waar zit je voor mij op de scope, pal vest 15 mijl? [No check, what's its position for me on the scope, due west 15 miles?]
			173040 173040	At - Ap	Konentje [One moment]						
			173041 173042	Ap - At	Ja, dat had je nee, 27? [Yeah, did you copy, 27?]				173041 173048	A - T	Nee, hij gaat door de outer marker 27 nu bijna; dus je starts rechtson moet je even eh ... coördineren [No, it's about to cross the outer marker 27; so you have to eh ... coordinate your departures to the right]
			173042 173043	At - Ap	Ja [Yes]						
			173043 173043	Ap - At	Huhh						
								173044 173050	At-Aa/B		Airport 1 en Brandweer, hier de toren, de desbetreffende kist gaat naar baan 27, ik herhaal baan 27 [Airport 1 and Fire-brigade, this is the tower, the aircraft concerned will head for runway 27, I repeat runway 27]
									173048 173050	T - A	Oh, ik rol nu met de 217 [Oh, the 217 is rolling now]

									173051 173051	A - T	Runway heading
									173052 173053	B - At	Begrepen van Brandveer 1, Toren {Tower, Fire-brigade 1 understood}
									173053 173053	T - A	Runway heading...
			173054 173057	Ar - T	(naam) Ik heb die El Al en die heeft een mijl of 10 te gaan voor 27 [(name) I have got the El Al and it has about 10 miles to go for runway 27]						
									173055 173056	B - At	Begrepen Rijk {Understood, Rijk}
									173057 173058	Aa - At	Toren, Airport 1 {Tower, Airport 1}
			173058 173100	T - Ar	Ja check, we zetten het licht aan, Brand- veer is gevaarschuld (naam) [Yes check, we'll switch on the lights, the Fire-brigade has been alerted, (name)]						
			173100 173101	Ar - T	Oké {Okay}						
									173116 173117	Aa - At	Toren, Airport 1 {Tower, Airport 1}
173117 173119	Ar - E	El Al 1852 what is the distance you need to touchdown?							173117 173117	At - Aa	Airport 1, Toren {Airport 1, Tower}
									173119 173120	Aa - At	Is het de vrachtkist van El Al? [Is it the El Al freighter?]
									173120 173121	At - Aa	Inderdaad {Indeed}
									173123 173126	Aa - At	En heeft ie verder nog iets gezegd, behal- ve 2 motoren uit? [And did he report anything else, except 2 engines out?]
173127 173129	E - Ar	12 miles final we need for landing									
									173128 173128	At - Aa	Niet bekend {Unknown}
173130 173134	Ar - E	Yeah, how many miles final .. eh correcti- on .. how many miles track miles you need?									
173140 173142	E - Ar	... Flap one .. we need .. eh .. a 12 miles final for landing									
173143 173145	Ar - E	Oké, right right heading 100, right right heading 100									
173146 173147	E - Ar	Heading 100									
			173158 173200	T - Ar	Beeft ie nog meer ellende (naam)? [Does it have any additional trouble (name)?]						

			173200 173202	Ar - T	Motor 3 en 4 heeft ie niet [It hasn't got engines 3 and 4]					
			173203 173205	T - Ar	Die zijn gewoon uit en verder geen extra ellende? [They are just out and no extra trouble on top?]					
			173206 173207	Ar - T	Niet dat ik weet [Not as far as I know]					
			173207 173209	T - Ar	Check, ga je dat nog even informeren? [Check, can you check this, please?]					
						173208 173209	Aa - At	Toren, Airport 1, hoeveel mijl uit? [Tower, Airport 1, how many miles out?]		
			173209 173209	Ar - T	Ja [Yes]					
						173211 173217	At - Aa	... 1 rechts, u rijdt op de 1 rechts nu, Ja's begrepen Airport 1, ik hoor zojuist dat bij motor 3 en 4 uit heeft staan [... 1 right, you're now driving on the 1 right, that's understood Airport 1, I just heard that engines 3 and 4 are shut off]		
173215 173220	Ar - B	El Al 1862, just to be sure, your engines number 3 and 4 are out?								
						173218 173220	Aa - At	3 en 4 uit, hoeveel mijl uit is ie? [3 and 4 out, how many miles out?]		
173220 173224	B - Ar	Number 3 and 4 are out and we have .. eh .. problems with our flaps								
						173223 173225	At - Aa Momente wordt geteld, ... 12 mijl [.....One moment, they're counting, ... 12 miles]		
173225 173227	Ar - B	Problem with the flaps, roger								
						173226 173228	Aa - At	12 mijl, is begrepen .. eh .. [12 miles, that's understood .. eh ..]		
			173227 173228	Ar - T	And flapproblems					
			173229 173230	T - Ar	En flapproblems? [And flapproblems?]	173229 173230	Aa - At	Ik ben vrij van OIR [I'm clear of OIR]		
			173230 173231	Ar - T	Yes					
						173231 173233	At - Aa	U bent vrij van de OIR, bedankt Airport 1 [You're clear of the OIR, thanks Airport 1]		
173237 173238	B - Ar	Heading 100, El Al 1862								
173239 173240	Ar - B	Thank you 1862								

						173255	At - Aa	.. Airport 1, we krijgen zojuist ook door dat ie ook nog flapprobleem heeft, dus het wordt waarschijnlijk heel de baan [And Airport 1, we just got the information that it has flapproblems as well, so it will probably need the total runway-length]		
						173300				
173300 173304	E - Ar	Okay, heading .. eh .. 120 .. and turning eh .. maintaining								
						173302 173306	Aa - At	Dat is begrepen Toren, .. eh .. ik rij na de landing even achter de machine aan [Tower, that's understood, .. eh .. I will follow the aircraft after landing]		
173305 173307	Ar - E	Roger 1862, your speed is?								
						173306 173308	T/At-Aa	Dat is begrepen, Airport 1 [That's understood, Airport 1]		
173310 173310	E - Ar	Say again								
173312 173312	Ar - E	Your speed?								
173313 173314	E - Ar	Our speed is .. eh .. 260								
173315 173321	Ar - E	Okay, you have around 13 miles to go to touchdown, speed is all yours, you are cleared to land runway 27								
173321 173322	E - Ar	Cleared to land 27								
			173324 173325	Ar - T	Dat heb ik 'n maargegeven tenminste [He has been given that at least]					
173327 173343	Ar - E	SI Al 1862 a right right turn heading 270 adjust on the localizer, cleared for approach								
173344 173345	E - Ar	Right right 270								
						173352 173352	Aa - T	Toren, Airport 1 [Tower, Airport 1]		
						173353 173354	T - Aa	Airport 1		
						173355 173357	Aa - T	(Naam), heeft ie een emergency ge-declared, of dat niet? [(Name), did he declare an emergency, or did he not?]		
						173357 173358	T - Aa	Hij heeft mayday geroepen [He called mayday]		
						173400 173400	Aa - T	Mayday geroepen? [Called mayday?]		

					173401 173401	T - Aa	Ja [Yes]		
173414 173427	Ar - B	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							
								173420 173425	Aa - B Brandweer 1 van Airport 1, het is bij deze intern alarm vliegtuig [Fire-brigade 1 from Airport 1, from now on it's internal emergency aircraft]
								173426 173429	B - Aa Eh .. intern alarm vliegtuig, begrepen van Brandweer 1 [eh .. internal emergency aircraft, understood from Fire-brigade 1]
173428 173429	E - Ar	Roger 290							
173448 173452	Ar - B	El Al 1862 further right, heading 310, heading 310							
173452 173452	E - Ar	310							
					173454 173455	Aa - T	Toren, Airport } [Tower, Airport 1]		
					173455 173456	T - Aa	Airport 1, Toren [Airport 1, Tower]		
					173457 173459	Aa - T	Het is intern alarm vliegtuig [It's internal emergency aircraft]		
173458 173502	Ar - B	El Al 1862 continue descent 1500 feet, 1500							
					173500 173504	T - Aa	Intern alarm vliegtuig, bedankt, wij houden al het uitgaande verkeer vast [Internal emergency aircraft, thanks, we're grounding all outbound traffic]		
173503 173505	E - Ar	1500 and we have a controlling problem							
					173504 173505	Aa - T	Dat is begrepen [That's understood]		
173506 173508	Ar - B	You have controlling problems as well, roger							
			173511 173514	Ar - T			Hij zit dik dik dik in de problemen, nou ook met z'n controls [He's in deep deep deep trouble, now with his controls as well]		
			173515 173517	T - Ar			Dus ook problemen met z'n controls, check [So problems with his controls as well, check]		
			173518 173518	Ar - T			Ja [Ye..]		

						173520 173524	At - Aa	Airport 1, Toren, d'r komt steeds weer bij, hij heeft ook problemen met de controls [Airport 1, Tower, it's getting worse, he's having problems with the controls as well]			
173525 173541	B - Ar	TARIN ET KOL RAFLAPS, ET KOL RAFLAPS TA-KIN, TORID ET RAGGAR Going down 1862, going down, going down copied going down [RAISE ALL THE FLAPS, ALL THE FLAPS RAISE, LOWER THE GEAR Going down 1862, going down, going down copied going down]									
						173527 173528	Aa - At	Dat is begrepen Toren [Tower, that's understood]			
									173538 173539	Aa - B	Brandveer 1, van Airport 1 [Fire-brigade, from Airport 1]
									173540 173540	B - Aa	Brandveer [Fire-brigade]
									173541 173543	Aa - B	Machine na de landing volgen [Follow the aircraft after landing]
			173545 173545	T - Ar	't Is gebeurd [It's over]				173545 173546	B - Aa	Ja, da's begrepen van Brandveer [Yes that's understood from Fire-brigade]
173547 173548	Ar - B	Ja ... El 11 1862 your heading [Yes ... El 11 1862 your heading]				173547 173549	At - Aa	Airport 1, ziet u daar het vuur in 't oosten? Hij is gecrashed [Airport 1, do you see the fire in the east? It has crashed]			
			173550 173551	T - Ar	't Heeft geen zin, hij is gecrashed (naam) [It's no use, it has crashed (name)]						
			173552 173552	Ar - T	Heb je 'm gezien? [Did you see it?]	173552 173553	Aa - At	Ja, da's begrepen [Yes, that's understood]			
			173553 173554	T - Ar	Één grote rookvolk boven de stad [One big cloud of smoke over the city]						
									173554 173555	Aa - B	(.. Unreadable ..) van Airport 1 [(.. Unreadable ..) from Airport 1]
			173555 173557	Ar - T	Sjees, net bij VP inside [Gee, just inside VP]						
									173556 173556	B - Aa	Airport 1
									173557 173600	Aa - B	Machine is in het verlengde van baan 27 gecrashed [The aircraft has crashed in the extended centre-line of runway 27]
			173601 173601	T - Ar	Bij VP? [Wear VP?]						
			173602 173604	Ar - T	1 mijl vest van VP [1 mile vest of VP]				173602 173606	B - Aa	Eh ja is er .. eh .. van de Toren, is er ook bekend waar ie precies ligt? [Eh yes is there .. eh .. from the Tower, do they know its exact position?]

									173607 173610	T - B	1 mijl vest van VP, 1 mijl vest vest van Veesp [1 mile vest of VP, 1 mile vest vest of "Veesp"]
									173612 173613	B - T	1 mijl vest van Veesp, bedankt [1 mile vest of "Veesp", thanks]
			173613 173615	T - Ar	1 mijl vest van Veesp zei je (naam)? [Did you say 1 mile vest of "Veesp" (name)?]						
			173616 173617	Ar - T	1 mijl vest van VP, ja [Yes, 1 mile vest of VP]						

Verder geen relevante R/T
[No further relevant R/T]

APPENDIX 4.2

TRANSCRIPT OF TELEPHONE COMMUNICATION

BETWEEN ATC AND COAST GUARD

R E C O R D E R V E R S L A G

Bandnummer : A-2

Kanaal : 23 (inductie telefoonlijn met Kustwacht IJmuiden)

Frequentie :

Betreffende: Kontakt met RCC IJmuiden

Datum : 04-10-1992

Tijd (UTC)	Van	Aan	A = Algemene verkeersleiding (ACC) R = RCC IJmuiden
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Begintijd

173137	A	R	Algemeen verkeer (naam), goedenavond
	R	A	(naam), IJmuiden goeienavond.
	A	R	Daag
	R	A	Weet je iets van een vliegtuig met problemen in de buurt van Hilversum Naarden ?
	A	R	Eh.. is bekend bij ons ja
	R	A	D'r is een motor afgerold of zoiets ?
	A	R	Ja eh.. ik weet weet niet precies wat er is, maar het is eh..'t is bij ons onderkend en eh.. ze staan in kontakt met ons in ieder geval
	R	A	Dus die kist die is nog eh..airborne ?
	A	R	Ja hij was net airborne, ik dacht dat het 'n eh.. een El Al was
	R	A	Niet ge-crashed dus of zo ?
	A	R	Nee nee nee nee,
	R	A	Oké
	A	R	Maar we weten ervan
	R	A	Goed zo,
	A	R	Zeg bedankt, hoi

Eindtijd

173204	A	R	Hoi.
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