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Based on the provided documents, here is a comprehensive English translation of the **China Airlines B747-200F (B-198) Accident Investigation Report.**

The report is issued by the **Civil Aeronautics Administration (CAA), Republic of China**, date of release in April 1996.

One, Factual Information

1. History of Flight

On December 29, 1991, China Airlines aircraft B-747-200, registration B-198, was piloted by a two-man flight crew (one acting as Captain, one as First Officer), accompanied by one Flight Engineer and two Aircraft Mechanics (one on duty, one positioning). Flight CI-358 was a scheduled cargo mission flying from Taipei to Anchorage, with a flight plan to maintain Flight Level 290. However, approximately four minutes after takeoff, around 15:01, the separation of two engines in mid-air caused the aircraft to crash into a hill in Wanli, resulting in a total fire; all five crew members on board perished. (No ground injuries occurred), resulting in a severe accident.

According to Air Traffic Control records, at 14:37, CI-358 received clearance from Ground Control Tower to start engines and push back; approximately 4 minutes later, it obtained taxi clearance to Runway 05L (taxiing crew received ATC clearance and read it back correctly); at 14:46:57, it obtained instructions to contact the Tower; approximately 1 minute later, the Tower approved it to hold short of Runway 05L; at approximately 14:50, it obtained clearance to enter the runway and wait, expecting to obtain separation from other aircraft. At 14:52:18, the Tower cleared it for takeoff, reporting wind direction 080 degrees, 16 knots/gusting to max 24 knots, and approved takeoff. (The Cockpit Voice Recorder data indicates the First Officer was the Pilot Flying).

At 14:53:23, the First Officer called out "V2". CI-358 lifted off from Runway 05L. After climbing through 1,400 feet, it contacted Departure Control, and Departure Control informed the flight it was identified on radar and cleared it to climb to Flight Level 290 at "high speed" and maintain that altitude. The CVR indicates that at 14:57:21, there was a sound of "two bumps/vibrations" followed by two distinct noises. Located on the extension of the departure runway, ground eyewitnesses on the coast claimed they saw two or three large black objects fall into the sea; at a distance of approximately 800 to 1,000 meters from the beach, they also saw small white objects and large black objects fall into the water four or five seconds later.

The CVR recorded the crew speaking, indicating an engine malfunction, but it was unclear whether it was a two-engine failure or a Number 2 engine failure; it also recorded a decrease in aircraft altitude, a request for return guidance, the aircraft straightening out, and the retraction of wing leading edge flaps. 14:57:59 CI-358 called Departure Control stating: "Number 2 engine is, ah, failure," and subsequently requested vectors to return to CKS Airport for landing.

During the conversation with the Departure Controller regarding the return, the controller stated that because CI-358's radar data block indicated its altitude was 5,600 feet, he permitted it to maintain 6,000 feet, fly heading 050, and "radar vector to Runway 05L approach course". CI-358 reported its altitude was 5,500 feet; the controller then permitted it to maintain 5,000 feet. At 14:58:47, Departure Control cleared CI-358 to turn left to heading 270 and maintain 5,000 feet; the crew repeated the heading instruction, but within the cockpit, the First Officer said he could not maintain altitude, and regarding this, the Flight Engineer said "Add more power," and the First Officer said he could not manipulate the aircraft, and that he had "used full control inputs," and the second Aircraft Mechanic said, "Used full power".

To this, the First Officer said "Okay," and regarding the inability to turn left, the use of power, the unceasing loss of altitude, and the inability to stop the aircraft from turning right, there was urgent conversation; the speech became extremely urgent, making the CVR tape difficult to verify and impossible to transcribe fully.

At 14:59:47, the First Officer spoke to Departure Control in Chinese (hereinafter referred to as the radio communication between Control and CI-358): "I have a two-engine failure, I cannot turn left, I am maintaining heading 150". The controller instructed the aircraft to maintain 5,000 feet and turn right to 270 degrees. 15:00:03 The aircraft repeated its heading and altitude.

CVR recording shows the crew discussing "Shutting down the engine," 15:00:20 The Captain made a confirmative response, and a click sound was heard in the cockpit, followed by the Captain saying "Right turn 270," to which the second mechanic said "Bank angle do not be too large". Following this, the Captain and mechanic both pointed out the bank angle was too large and the aircraft would stall. 15:00:42 The control column stick shaker sound appeared for two seconds, the second mechanic and the First Officer both yelled "Pull it up". 15:00:35 One of the CI-358 crew members called out "Pull up" "Pull up" "Pull up" "Pull up" (The last radio transmission from CI-358 was to Departure Control; this was the last time the radio was keyed. CI-358 crashed into the side of a hill in the Wanli area at an elevation of 1,548 feet, the terrain being mountainous and forested, and the crew all perished.

Eyewitnesses in Wanli said the aircraft came from the direction of the sea, maintaining a right turn, continuing to turn to the right, the engine sound was abnormal, and claimed the aircraft nose was pointing down, and there was fire visible before it hit the ground.

2. Injuries to Persons

Injury	Crew	Passengers	Others	Total
Fatal	5	0	0	5
Serious	0	0	0	0
Minor	0	0	0	0
None	0	0	0	0
Total	5	0	0	5

3. Damage to Aircraft Crashed into the mountain and caught fire; the aircraft was completely destroyed.

4. Other Damage No other property damage.

5. Personnel Information The crew performing the CI-358 flight mission; all five individuals held valid Civil Aviation Regulations and company operations procedure qualifications and licenses. According to training records, all passed the required skills and route checks and received all required ground training.

- **Captain:** Jin Zhi-ping, 53 years old, held Airline Transport Pilot License No. 10714, Multi-engine, Land Aircraft Rating, and B707, B747 Type Ratings. On November 12, 1991, he passed his First Class Physical; required to wear corrective lenses when performing flight duties. He had 12,678 hours of flight experience, of which 2,207 hours were on the B747. In the past 90 days and 30 days, he flew 194.6 and 74.3 hours respectively; on December 29, 1991, at 12:30 when he reported for duty, prior to the duty period, he had approximately 48.8 hours of rest; at the time of the accident, he had been on duty for 3 hours and 31 minutes, of which 8 minutes were flight time. The member received Crew Resource Management (CRM) instructor training at Flight Safety International (FSI) in the US. (In August 1991, China Airlines signed a contract with FSI for FSI to train China Airlines personnel as CRM instructors. After completing "FSI" training, China Airlines began its CRM training program in March 1992.)

- **First Officer (PF):** Niu Zheng-pu, 46 years old, held ATP Land Multi-engine License No. 10883, B737, B747 Type Ratings. He passed his First Class Physical on December 4, 1991, required to "Hold Airline Transport Pilot License, wear corrective lenses when exercising privileges". The member had 9,510 hours of flight experience, of which 1,943 hours were B747 time. In the past 90 days and 30 days, he flew 195.7 and 74.3 hours respectively; at 12:30 on December 29, 1991, when he reported for duty, prior to the duty period, he had approximately 72.7 hours of rest; his duty time and flight time were the same as the Captain.
- **Flight Engineer:** Wang Jun-jun, 47 years old, held Senior Commercial Pilot License No. 20977. On November 8, 1991, he passed his First Class Physical, without limitations. The member had 7,543 hours of flight experience, of which 1,795.8 hours were on the B747. In the past 90 days and 30 days, his flight times were 224.9 and 78.7 hours respectively. At 12:30 on December 29, 1991, when he reported for duty, prior to the duty period, he had 38.2 hours of rest; the duty time and flight time on that day were the same as the Captain.
- **Aircraft Mechanic:** Zhu Zheng-ji, 48 years old, held Aircraft Mechanic License No. 90162, and B747 rating. On August 1, 1991, he passed his First Class Physical, required to "Carry Airman Certificate, hold corrective lenses for use". The member had 15,786 hours of flight experience, of which 10,435 hours were B747 time; in the past 90 days and 30 days, his flight times were 224.9 and 78.7 hours respectively; at 12:30 on December 29, 1991, when he reported for duty, prior to the duty period, he had 38.2 hours of rest; duty time and flight time were the same as the Captain.
- **Positioning Aircraft Mechanic:** Xie Wen-chang, 39 years old, held Aircraft Mechanic License No. 90219, and B747 rating. On July 11, 1991, he passed his First Class Physical, required to "Carry Airman Certificate, need to wear corrective lenses". The member had 7,297.9 hours of flight experience, of which 6,974 hours were B747 time; in the past 90 days and 30 days, his flight times were 247.4 and 82.6 hours respectively; on December 29, 1991, when he reported for duty, he had 51.4 hours of rest; the duty time and flight time on that day were the same as the Captain.

6. Aircraft Information The aircraft registration number was B-198, a Boeing 747-200F model aircraft, production serial number 482, serial number 22390. It was originally delivered to Cargolux on October 10, 1980; China Airlines purchased it on June 9, 1985, and until the time of the accident, it was used for cargo missions. The aircraft was equipped with four P&W JT9D-7R4G2 engines and suitable instruments and equipment for flight; until the time of the accident, the cumulative flight time of the aircraft was 45,868 hours, with 9,094 landings; according to the Boeing Company's original design for the BOEING-747, the estimated economic life was 60,000 flight hours, 20,000 landings, and a service life limit of 20 years.

China Airlines carried out maintenance operations on the aircraft in accordance with the Continuous Airworthiness Maintenance Program approved by the Civil Aeronautics Administration; the most recent significant checks were a "C CHECK" completed on December 23, 1991, and a "B CHECK" completed on October 10, 1991. These records show no significant defects; during the implementation of these checks, the engine pylon sections were inspected. The takeoff weight of CI-358 on December 29, 1991, was calculated to be 828,634 pounds (Maximum Allowable Takeoff Weight 833,001 pounds), and the Center of Gravity was 18.3% MAC (Allowable Center of Gravity position is 12.5 - 19% MAC).

According to the loading supervisor at the CKS station, the last cargo loaded onto the forward lower cargo hold was a pallet containing 64 boxes of clothes; these boxes were wrapped in nylon and secured with ropes; the total weight of the pallet and boxes was 1,714 kg (3,771 pounds); the loading supervisor said there were no difficulties closing the cargo door after loading was completed.

No. 3 Engine The No. 3 engine serial number was 725326; since being installed on the aircraft on February 7, 1990, the accumulated operating time was 8,800 hours, with 1,464 landings; there were no items related to the No. 3 engine pylon structure in the maintenance records.

7. Meteorological Information At 15:00, the surface observation recorded at CKS station was as follows: Wind 060 degrees at 15 knots, gusting to 25 knots; Visibility 6 km or more; Clouds 1/8 Cumulus at 1,600 feet, 5/8 Stratocumulus at 3,200 feet, 7/8 Stratocumulus at 5,000 feet; Temperature 10 degrees C, Dew Point 4 degrees C; Altimeter setting 30.32 inches Hg.

The flight plan for CI-358 at 12:00 CKS time had the following contents regarding surface weather: Wind 040 degrees at 15 knots, gusting to 25 knots; Visibility 6 km or more; Clouds 2/8 Cumulus at 1,600 feet, 4/8 Stratocumulus at 3,000 feet, 7/8 Stratocumulus at 4,000 feet. Taipei Meteorological Center performed upper air wind observations at 08:00 and 20:00: **08:00 Observation:** 4,000 feet: Wind 70 degrees 10 knots, Temperature 5 degrees C. 5,000 feet: Wind 330 degrees 5 knots, Temperature -1.5 degrees C. 6,000 feet: Wind 240 degrees 10 knots, Temperature -2.9 degrees C. **20:00 Observation:** 4,000 feet: Wind 70 degrees 15 knots, Temperature -1 degrees C. 5,000 feet: Wind 30 degrees 5 knots, Temperature -1.5 degrees C. 6,000 feet: Wind 300 degrees 5 knots, Temperature -2.4 degrees C.

8. Aids to Navigation Navigation aids were not related to this investigation and were not inspected.

9. Communications There were no reports of communication difficulties between ATC and the flight crew due to equipment problems.

10. Aerodrome Information CKS Station is located approximately nine miles west of Taipei, elevation 107 feet, with three runways 05L/23R 12,008 feet long, 05R/23L 9,029 feet long; 06/24 10,991 feet long, the longer two runways are 150 feet wide.

11. Flight Recorders The aircraft was equipped with a Digital Flight Data Recorder (FDR) manufactured by Lockheed Aircraft Service Company, Model 209, Serial Number 50999, and a Cockpit Voice Recorder (CVR) manufactured by Lockheed Aircraft Service Company, Model A-100A, Serial Number 877. Both recorders were recovered from the wreckage and sent to the National Transportation Safety Board (NTSB) in the United States; in the laboratory where the playback was conducted, it was determined that the recording tape inside the FDR was severely burned and the recorded data was insufficient. The recording mechanism of the CVR was not destroyed and was fully transcribed.

Based on the identification of the flight crew voices, the CVR working group determined the positions of each flight crew member in the aircraft; the Captain sat in the left seat (Pilot Flying), the senior Flight Engineer sat in the right seat performing First Officer duties, the senior Flight Engineer sat at the flight engineer panel, and the junior Flight Engineer sat in the observer seat behind him; this seating arrangement conforms to company procedures.

CVR transcript data indicates the flight start was partly normal; approximately 3 minutes and 58 seconds after starting the rotation for takeoff (R+03:58), there was a recording of "two bumps" and "one vibration sound"; at R+04:15 the Flight Engineer said "Two engines failure". One call followed; thereafter, other crew members told the pilot flying not to turn, "This is a mountain area," and to maintain altitude; the pilot flying in the air said he could not stop the aircraft from turning and said he had used full rudder but it was ineffective. R+04:27 FE called out "Slats, slats are down," R+05:00 FE called out "Leading edge is down," etc., for me to see," except for 6 seconds later when the Pilot Flying instructed "Retract the leading edge," there were no further statements regarding slats. R+05:20 The Pilot Flying said: "Disengage autopilot," 6 seconds later there is a recording (sound of autopilot disengage); thereafter, the crew had difficult conversations regarding maintaining heading and altitude; the First Officer informed the Pilot Flying saying "Altitude continues to be lost," the Pilot Flying said "I cannot control the aircraft".

R+06:14 The First Officer suggested "Try reducing power a bit, how about that," the Pilot Flying replied "The aircraft won't stop turning right". R+06:26 The First Officer said: "Bank angle too large," R+06:41 The Mechanic asked "We shut down the engine right!" The FE repeated the question once, R+06:52 The Pilot Flying said "It's shut down," 1 second later there was a recording (Click sound) R+07:14 (The Pilot Flying yelled out, two seconds later the recording stopped).

12. Wreckage and Impact Information Wreckage was discovered in two areas, one area was below the aircraft flight path, approaching the aforementioned CVR location where the sounds were heard; the other area was the crash site and the flight path before the crash. The first area was near shallow water, its coordinates roughly North Latitude 25 degrees 16' 25" to 26", East Longitude 121 degrees 28' 14". It was a seabed with a depth of 25 to 80 feet; local fishermen discovered some main parts of the No. 3 engine and the cowling of the No. 4 engine floating on the sea surface, and handed them over to the Civil Aeronautics Administration within days of the accident. Some honeycomb structure fragments were washed onto the beach and were also recovered; underwater fragments were searched for by contracted divers and divers, and mapped and positioned for recovery. In this area, parts of the No. 3 and No. 4 engines and engine pylons/struts were found and recovered. (Right Wing) #19 leading edge slat was also found. Those parts found but not recovered included some iron pieces, (including No. 4 engine cowling), sonar search in that area found no other parts deemed valuable, and due to difficult working conditions in the sea, causing risks to other aircraft, no further search was conducted.

The second area (the main wreckage site) is located in the Wanli mountainous area north of Taipei (25 degrees 10' 21" N, 121 degrees 40' 04" E). The elevation is approximately 472 meters; the area is 60 meters long, 30 meters wide, and 15 meters deep; traces of impact show its direction was magnetic heading 315. Located on the saddle of relatively high mountains to the north, the impact site is naturally northeast; burnt fragments were scattered over a distance of approximately 1,000 meters; the surface was covered by soft vegetation; digging downward revealed many large rocks.

The main wreckage distribution was one mile southeast of the flight path start; in this area, right wing assemblies were found, such as the slat track fairing tail cone, and the main part of the #2 spoiler; these two parts were found individually in a farm field. Aside from the shallow water vicinity and the parts CI-358 dropped along its flight path into the water which were not recovered, all other aircraft parts and fragments were found near the main impact site, identifying approximately 50% of the wing structure, 10% of the empennage structure, and 90% of the flight controls and main landing gear parts.

(1) Engines and Pylons: The No. 1 and No. 2 engines and their cowlings, pylons, etc., were found at the main wreckage site, partially damaged by fire. The anti-skid plates (rub strips) of both engines had deep friction marks, concentrated on the upper part of the engines, indicating high speed rotation of the blades. According to the factory engine experts and the US National Transportation Safety Board's opinion, this friction appears to be sudden stoppage before hitting the ground, caused by the engine suffering immense rotational force, or aerodynamic load. Additionally, the high pressure compressor sections of both engines also revealed blade damage and casing damage, mostly slight damage to the leading edges of the blades.

The No. 3 engine and its blade disk were found in the shallow water, North Latitude 25 degrees 16' 23", East Longitude 121 degrees 28' 12". Recovered from the sea, and recovered on July 18, 1992, after six months of corrosion in seawater, the entire engine had marine life growing on it; many assemblies were damaged by salt corrosion; the cowling suffered an inward dent on the left side, according to the investigation team's inspection, the low pressure compressor blades had friction marks rubbing to the right and into the inlet tract, caused by strong aerodynamic load; the rubbing produced by the engine nose lifting to the right was similar; other engines did not reveal such rubbing marks; the inspection of the engine exterior did not show any impact damage.

The No. 4 engine was recovered one month after the accident, at North Latitude 25 degrees 16' 19", East Longitude 121 degrees 27' 52" in the sea, and recovered on March 1, 1992; the engine and its main assembly were together; the blade disk and tooth gear box had separated from the engine; only using video tape to observe its condition on the sea floor, and it was not recovered; the entire cowling suffered an inward impact on the inboard side; the low pressure compressor blades showed evidence of hard object damage, similar to damage from foreign objects sucked in during high speed rotation; all low pressure compressor blades were bent and the direction of rotation was opposite.

(2) Airframe Structure: Fuselage: The landing gear, including left and right wing gears and body gears, nose gear, were all found at the crash site in their correct relative positions; the Auxiliary Power Unit (APU) was found approximately 14 meters from the nose gear and excavated approximately 30 feet underground; the main deck cargo door and latch were found in the burned wreckage area; one forward cargo door and two aft cargo doors were found in the wreckage pit.

Wings: Broken pieces of the left and right wings and flaps were recovered approx 30 feet away; eight slat tracks (seven in the main wreckage pit), another No. 3 left wing inboard slat track was found in the impact area; the right wing outboard flap was found in the pit, the left wing inboard flap was found approximately 20 meters from the pit.

Empennage: Inside the main wreckage area, the horizontal stabilizer and an approximately 25-foot section of horizontal stabilizer skin were found; inside the pit, parts of the vertical stabilizer and connected rudder actuators were found.

(3) Systems: Fragments of all primary and secondary flight control systems were found at the scene; no evidence of failure prior to impact was found. The positions of hydraulic actuators could not be determined at the scene; other hydraulic system assemblies were identified, and their relative positions to the impact site were recorded on the wreckage distribution map. CVR and FDR were found near the APU tail cone; no other electronic equipment was identified from the crash site data.

13. Medical and Pathological Information It was determined that the cause of death for the five crew members was severe impact force; additionally, because the five bodies were severely burned, samples could not be taken for dissection.

14. Fire Fire occurred after the aircraft hit the ground; charred structures and burnt wreckage were found surrounding the impact area; no evidence of fire prior to impact was discovered.

15. Survival No survivors.

16. Tests and Research Using wood to build a right wing model, set up at Songshan Airport, aircraft assemblies found were installed on the model, or their relationship positions placed beside the model; the names of the assemblies and where they were found are listed below:

- Large parts of No. 3 and No. 4 engine inlet cowlings and honeycomb structure fragments found by local fishermen floating on the edge of the sea.
- A section of leading edge slat recovered from the sea.
- A section of slat skin and No. 7 slat drive gear assembly recovered from the flight path prior to impact.
- No. 3 and No. 4 engine pylons and wing lower attachment fittings recovered from the wreckage pit.
- No. 3 and No. 4 engines recovered from the sea (No. 3 engine recovered March 1, 1992, No. 4 engine recovered July 18, 1992).

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Using the model to assist in determining the sequence of events leading to the aircraft breakup. Inspection of the No. 3 engine pylon, wing lower attachment engine mounting structure, and blade protection, proved consistent with the engine breaking away downwards and outwards. Detailed inspection of the recovered No. 3 and No. 4 engines showed no evidence indicating engine seizure or blade separation failure. Both engines suffered impact damage before hitting the sea surface; No. 4 engine showed it had suffered a similar impact from a hard physical body. The fan blades of the No. 3 engine and the blade rotation spinner showed marks of mutual collision with an object of similar size. The inner and outer mid-spar fittings of the No. 3 engine pylon were recovered from shallow water and sent to the US National Transportation Safety Board for metallurgical inspection in May 1993. The inspection showed: The two lugs of the outer fitting head (FITTING) were intact; the inner lugs of the outer fitting (FUSE PIN) section were recovered; the remaining parts of the fuse pin were not recovered; the outer lugs of the outer fitting were twisted and bent outwards. The distance between the two lugs of the fitting head had increased; inspection of the inner bore of the outer fitting's inner lugs revealed fracture surfaces, showing evidence of overload fracture, but no fatigue phenomena. The two lugs of the inner fitting broke evenly; each lug had about 2 inches of area; of the four fracture surfaces from the upper section of the inner fitting, microscopic inspection examined the two upper fracture surfaces; each lug had one, showing fatigue cracks originating from the lug bore (LUG BORES) (connection to the WING FITTING) extending upwards toward the center of the lug. Inspection of the lower fracture surfaces of the two lugs showed each lug had one, showing overload causing failure. The fatigue fracture on the upper part of the inner fitting's inner lug was large; on the inboard lug it was 0.53 inches X 0.29 inches, on the outboard lug it was 0.31 inches X 0.27 inches. The main fatigue on the inboard lug fracture began at the outer edge of the lug bore, while the main fatigue on the outboard lug fracture began at the inner edge of the lug bore. Along the bore surface (BORES SURFACE) of each lug, secondary fatigue origins could be observed. The remaining fracture areas showed failure due to overload stress. The thickness of the No. 3 pylon inner mid-spar fitting lug measured 0.618 inches on the inboard side and 0.615 inches on the outboard side. The outboard lug thickness was lower than the design requirement of 0.617 inches to 0.627 inches, specifically 0.002 inches (0.617 - 0.615 = 0.002), but these measurement results are uncertain because the surface condition of the lugs was poor and greatly reduced. The installed shim (connection modification installation base) met the drawing requirements for material heat treatment and surface shot peening. The mid-spar fuse pin (BULK HEAD STYLE) (second generation) installed on the No. 3 pylon was installed in December 1986 per Service Bulletin 747-54-2063 (SB installation), and inspected for corrosion prevention according to the requirements of the 7th revision of the SB in December 1980. The fatigue cracks within the inboard installation lug bore were consistent with previous reports of pylon installation lug fatigue cracks, and were within the ultrasonic inspection range required by SB 747-54-2100. This mid-spar pylon installation fitting had not undergone the modification of SB 747-54-2100, but according to records, at 9,349 hours, 1,561 landings, ultrasonic inspection had been performed. Prior to the accident, China Airlines followed Civil Aeronautics Administration Airworthiness Directive (AD) 74-747-048 (FAA AD 85-22-07) regarding SB 747-54-2100) to perform ultrasonic inspections on the No. 3 pylon mid-spar installation fitting lugs twice, once on December 30, 1986, at 24,201 hours 4,925 landings; another time on December 12, 1989, at 36,495 hours 7,534 landings; both inspections were completed, and there were no reports of cracks discovered within the prescribed time limits.

17. Other Information (1) China Airlines Flight Procedures: After takeoff speed reaches V2, maintain V2+10 climb, usually continue using takeoff power to 1,500 feet. Flap retraction procedure is deduced based on the set V2 speed; if using 20 degrees flaps for takeoff, the flight director commands V2+20 knots, retract flaps to 10 degrees; at V2+40 knots retract flaps to 5 degrees; flap retraction to 5 degrees, reduce engine thrust from takeoff power to climb power; V2+60 knots retract flaps to 1 degree; V2+80 knots retract all flaps; to save engine life, the pilot can choose to select climb power earlier in the sequence.

(2) B747-200 Flight Performance Data The following B747-200 performance data is based on a gross weight of 820,000 pounds, flaps and landing gear retracted as follows: The Airplane Flight Manual approved by the Federal Aviation Administration defines the stall speed on the chart; at this weight, the aircraft configuration is flaps and slats retracted, stall speed is 206 KIAS. Boeing 747 flight crew training manual, stall warning stick shaker activates, and airframe initial buffeting speed map, shows aircraft initial aerodynamic buffeting speed is 234 KIAS; stick shaker activation is 228 KIAS. At sea level altitude 5,000 feet with only two engines operating, the minimum aircraft maneuver speed is 254 KIAS; this minimum speed refers to the two engines maintaining takeoff power, capable of maintaining the aircraft's directional control.

(3) B-747-200 Emergency Procedures According to the B747 Operations Manual checklist, in the event of an engine fire, severe damage or separation: Requires crew members, upon discovering the engine failure, to call out "X Number Engine Failure"; following this, the crew closes the throttle, pulls the start lever to the "Cutoff" position; if a fire warning occurs, complete fire fighting related appropriate procedures. The "Two Engine Failure" except for completing the engine failure checklist, continues to require the crew to complete a "One or Two Generator Failure Checklist," and if necessary, execute fuel dumping in the air, to provide "Maximum Landing Weight required for landing" performance.

(4) B747 AC Electrical System and Hydraulic System The B747's AC power source (AC) is provided by AC generators driven by the four engines; each generator supplies one bus bar; then via BUS TIE BREAKERS connected for synchronized grid operation; if one generator cannot supply power, its bus bar can be supplied by other generators via the synchronized grid; generator voltage and frequency must be within limits; for system protection, it can prevent the generator and synchronized bus bar from connecting, simultaneously preventing unstable power sources from generating a connection. Important 115v AC bus bars are usually supplied by the No. 4 generator bus bar but can be supplied by other generators via flight crew operation. The B747 aircraft flight control system provides power via four independent hydraulic systems; normally supplied by the No. 1 and No. 3 hydraulic systems, providing 2, 3 system failure conditions. Ailerons, elevators, and rudder can still rely on 1 and 4 hydraulic systems for operation. However, their operating efficiency is relatively reduced, (due to control system backup, dual hydraulic system supply, power design, plus control surface size, requiring immense power to begin operation, resulting in the artificial feel system, spoiler and rudder ratio changer providing aircraft roll control; when low speed slats are extended, inboard ailerons, and flight spoilers produce action, utilizing roll control; when flaps are retracted to position 1 or above, outboard aileron power "locks"]. When the control wheel movement exceeds 8 degrees, flight spoiler 1-5 panels actuate.

Two, Analysis

1. General: The CI-358 flight crew all received professional training in accordance with civil aviation regulations, passed examinations, held licenses, and there is no evidence indicating medical or fatigue factors affected their work performance. Aircraft equipment and maintenance were all operated according to legal procedures, held airworthiness certificates, and dispatch documents for this flight indicate gross weight and center of gravity were within limits; prior to this flight there were no: aircraft fuselage, flight control system, and power part failures, or reports of failure. Evidence shows the No. 3 and No. 4 engines separated from the aircraft right wing 3 minutes before the crash, and within the No. 3 engine pylon outboard mid-spar installation fitting lugs, fatigue cracks were found, and this report has analysis below. Investigation of the causes of this accident did not discover factors related to air traffic control. Weather report at CKS Station, the condition one minute before the accident: Visibility greater than 6 miles, Clouds 1/8 Cumulus 1,600 feet, 5/8 Stratocumulus 3,200 feet, 7/8 Stratocumulus 5,000 feet; based on this condition, it is assessed that the separation of engines 3 and 4 from the aircraft right wing likely happened while the aircraft was in clouds, but there were no reports of turbulence, nor were there any other relevant weather conditions that could cause crew distraction. Pilot recording (CVR) recorded normal flight operations; from the start of the takeoff roll, the First Officer called out "V2", after 3 minutes 58 seconds, when the CVR recorded two bump/vibration sounds, the sounds were short and distinct, and the origin could not be identified. 3 minutes 18 seconds later, the crew tried to figure out what happened; approximately 1 second after the vibration, the flight engineer face, engine fire, etc., "Wait a moment," "Wait a moment," followed by "Two engines," "Two engines failure (lost effectiveness)". CVR shows the crew could not determine if No. 3 engine, or No. 4 engine failed, or if two engines failed; the Pilot Flying spoke out, since full rudder had been used, the aircraft did not respond, flying straight ahead, the mechanic instructed to lower the nose; regarding this, the Pilot Flying said he could not "turn," after which he disengaged the autopilot. The aircraft maintained a right turn at 5,000 feet; CVR recording ended 30 seconds before, the crew agreed to "Shut down" one engine, but could not confirm in the conversation which engine it was, nor could actual physical evidence show that engine was shut down. Evidence shows No. 1 and No. 2 engines, upon impact with the ground, because observation of the main blades showed severe damage, both at the high pressure compressor (HPC) section, and mostly blade damage was at the leading edge, this type of situation can only occur during high speed rotation at impact, so it is inferred that both engines were rotating at high speed upon impact. The investigation team considered the lower cargo door, opened during flight, hitting the No. 3 and No. 4 engines causing foreign object damage; Boeing company personnel and US government personnel, at Seattle performed matching of the doors, actual inspection, showing that upon hitting the ground, the doors were in the locked position. Accident conditions show the No. 3 engine and pylon separated from the aircraft outboard first, followed by the No. 3 engine and No. 4 engine colliding, causing the No. 4 engine to also separate from the aircraft right wing; although the aircraft lost two engines, it could still continue flying, but because the crew could not maneuver the aircraft and crashed in the mountain area, the investigation team hopes to determine what cause led to the separation of two engines on the right wing, causing the aircraft to lose control. Only because of the impact and fire, making FDR recorded data completely damaged, therefore flight crew regarding how to maneuver the aircraft, how the flight path was? No data available for investigation. There is no evidence showing the No. 3 engine had a seizure or major failure; the investigation team therefore focused the investigation on the cause of the No. 3 engine and pylon separating from the aircraft right wing.

2. Aircraft Wreckage and Structure Failure Analysis

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(1) Engine Wreckage: Examination of all four engines' results showed no evidence indicating a pre-existing failure condition; for example, the imbalance of the rotor, rotor seizure or external fire. The conclusion is that all damage found on the engines was caused by the No. 3 engine moving from its position under the right wing outwards causing the collision; evidence shows the No. 3 engine moved outwards from the aircraft when separating, turning normally, then hitting the No. 4 engine, causing the No. 4 engine to separate from the aircraft right wing, and both engines fell into the sea. The No. 1 and No. 2 engine blades remained on the aircraft; when the aircraft hit the ground, both engines were still rotating; inspection of No. 1 and No. 2 engine blade rotors, No. 2 engine's some blades were straight, while No. 1 engine's parts blades showed compression forcing rotation in the opposite bending, this is due to the blades receiving impact during high speed rotation and penetration forces, damaging the No. 2 engine low pressure turbine (LPT) shaft; consistent with the impact still pushing under rotation, this finding shows the No. 2 engine LPT shaft fracture happened early in the impact sequence, causing the blades to lose driving torque, causing reverse rotation bending; due to the fracture, blades separated from the drive turbine, causing blade LPT non-rotation. The No. 1 engine LPT shaft also broke, but occurred after the blades suffered damage in the impact sequence, causing both engines shaft fracture parts cause was bending load, because the precise time of shaft fracture cannot be determined, so IPC blade anti-skid strip condition, served as No. 1 and No. 2 engines appearing to be in high power condition at aircraft ground impact as comparatively reliable evidence.

(2) No. 3 Pylon Wreckage: Inspection of the No. 3 engine pylon mid-spar installation fitting, showed the outboard installation fitting's two lugs were intact, but parts of the pin remained within the inner lug bore; the rest of the safety pin could not be found; the outboard installation fitting's outboard lug was twisted outward, creating a gap between the installation fitting's two lugs; the inboard installation fitting's two lugs both had fractures, each had approximately 20 inches (Wait, text likely implies size or area, previous text said 2 inches area); from the upper break of the rear two parts (one for each lug), microscopic inspection revealed metallurgical fatigue characteristics, determining fatigue cracks, starting at the two inboard installation fitting lugs, and expanding.

(3) Engine Separation Sequence: The fatigue crack started at the lug bore's inboard side (near the wing fitting) and expanded upward toward the lug's centerline, and existed for several years; but these high strength steel parts, long immersed in sea water, with marine organisms growing on them, and without clear data available for inspection, analysis of the two lower fracture surfaces showed overload fracture, and no fatigue phenomenon. Inspection of the engine pylon and wing structure failed to provide clear separation sequence physical evidence; most likely leading to the sequence of events of the No. 3 and

No. 4 engines separating from the aircraft as follows: The No. 3 pylon inboard mid-spar U-shaped installation fitting separated; due to the outboard edge of the inboard lug and the inboard edge of the outboard lug of the pylon, fatigue cracks started, and after an unclear period of time, the fatigue cracks expanded to severe length, at high altitude climb bearing typical loads, and causing the final lug fracture. The load passed through the dynamic movement and distributed to the outboard mid-spar installation fitting, and this force was large enough to cause the outboard mid-spar installation fitting U-shaped lug, and pylon to separate from the wing. The No. 3 pylon and engine quickly moved outboard, (firewall strip receiving blade damage gyroscopic effect can prove), possibly the No. 3 engine's remaining thrust and drag combined, causing the engine to move outboard and run to the original position forward, until colliding with the No. 4 engine. Inspection of the No. 3 and No. 4 engines' damage fits the situation of No. 3 engine hitting No. 4 engine; the force of the collision caused the No. 3 engine blades to break off, its occurrence time and No. 4 engine and pylon separating from the wing were simultaneous.

(4) Design Changes Due to Accident Although the analysis of the No. 3 engine structure assembly components was not until May 1993, these parts were recovered from the sea and inspection began; but because on October 4, 1992, an El Al 747 crashed in Amsterdam, and had P&W engine pylon mid-spar lug fatigue crack service report, causing Boeing on December 23, 1992, to issue an Alert Service Bulletin (ASB) 747-54-A2152 (this announcement supplements SB 747-54-2100 data), requiring all operators to execute mid-spar installation fitting lug inspections, and listing inspection plans, hoping to discover early pylon installation fitting lug cracks. The report has already begun for all 747 engine pylons to carry out a structural modification plan, to strengthen pylon and wing connection structure, adding multiple backups, to meet the load bearing capacity of said pylon, and wing connection endurance; on all engine pylons, adding two stainless steel fittings, some parts replaced with stronger assemblies, all pylons will install larger mid-spar installation fittings; stronger diagonal braces and connections; this mechanism wing modification, to ensure new pylon design, still can protect fuel tanks, when receiving ground external object damage to avoid rupture; additionally also avoids separation in flight. Boeing's goal is to execute these structural modifications to comply with all FAA airworthiness directives, (these modifications include all 747 aircraft). On May 12, 1994, at a briefing held by Boeing, the company distributed to all B747 operators a document, which included completing the structural modification plan schedule, completing all JT9D-3 and JT9D-7 engine B747 aircraft, modification completed, within three to five years, based on aircraft age, completing modifications on all equipped aircraft. The latest SB regarding the short pylon structural modification plan is 747-54A2156, 2157, 2158 and 2159 related ADs including the February 1, 1995 issued 92-24-51, 93-03-14, 93-17-07, 94-10-05 and 94-17-17; these ADs are investigations based on the October 4, 1992 El Al 747-

200F aircraft accident in Amsterdam, and issued. This investigation discovered regarding B747 pylon design issues, Boeing Company guaranteed to adopt a correction plan. The Civil Aeronautics Administration also paid attention to US Code of Federal Regulations (CFR) 14 Part 25, stipulating manufacturers regarding determining structural response under multiple limit loads, obtaining separate analysis of each axis G load, and not requiring structural design to bear simultaneous multi-directional limit loads, Boeing engineering report, pylon bearing maximum lateral load occurs during taxi, so Boeing's B747 pylon structural modification, did not have significantly increased structural lateral load bearing capacity.

(5) Loss of Control: The aircraft began to descend continuously from 5,000 feet from approximately 320 KIAS to 270 KIAS, during this time, the flight crew cockpit conversation showed the crew could not stop the aircraft from turning right, at aircraft speed dropping to approximately 270 KIAS, loss of lateral control, causing the aircraft to descend rapidly to the right. Factors for loss of control may be due to: structural damage creating large drag, and producing large rolling and yawing moments. Maintaining large thrust to compensate for large drag. Hydraulic system damage causing flight control system energy reduction. High altitude air load reducing small aircraft maneuverability. The Captain failed to reduce power (causing torque unable to reduce) and failed to trade altitude for speed (to exchange for maneuverability) this situation made minimum maneuver speed increase. Regardless of landing at the airport or on water, it was unavoidable.

Three, Conclusions:

1. Findings:

(1) The aircraft's dispatch, equipment and maintenance, all complied with regulations and procedures.

(2) The flight crew accepted checks according to civil aviation regulations; based on their duties, appropriate certification and checks were qualified; there is no evidence indicating the flight crew's performance was affected by medical or fatigue factors.

(3) The aircraft operated in accordance with civil aviation regulations and company procedures.

(4) Weather generally matched the forecast and was not related to the accident.

(5) ATC services were appropriate and not related to the accident.

(6) Flight was normal, until 3 minutes 58 seconds after takeoff, CVR recorded two sounds followed by one vibration.

(7) The crew failed to distinguish if it was one or two engines losing thrust; nor did they discover two engines separated from the right wing.

(8) The flight crew turned to return to CKS Airport for landing; when instructed to turn left, the pilot flying said he could not turn left, since he had already used full left rudder.

(9) The Pilot Flying decided to disengage the autopilot.

(10) Approximately 30 seconds before hitting the ground, the crew agreed to shut down one engine, but the conversation did not specify which engine; although physical evidence was not discovered indicating one engine was shut down, inspection of No. 1 and No. 2 engines revealed both engines were still rotating upon hitting the ground.

(11) Inspection of the No. 3 engine pylon inboard mid-spar installation fitting showed fatigue cracks; the starting point was the inboard edge of the inboard lug and the outboard edge of the outboard lug; under high speed climb, the force received by the pylon caused the lug to break.

(12) The No. 3 engine pylon broke, causing the load to redistribute to the outboard mid-spar installation fitting, and that load was large enough to cause the outboard installation fitting's outboard lug to separate, and the pylon and wing structure disconnected.

(13) The No. 3 engine pylon separated from the wing structure, and moved outboard, until colliding with the No. 4 engine.

(14) No. 3 engine and No. 4 engine collided, causing both engines to separate from the aircraft right wing.

(15) Structural damage increased aircraft drag.

(16) Hydraulic system suffered damage; combined with high aerodynamic load, caused maneuverability reduction.

(17) The pilot failed to reduce the power of the two engines on the left wing, or reduce altitude to maintain speed, causing flight at minimum maneuver speed or below, resulting in unavoidable loss of control.

(18) Aircraft speed was below minimum control speed (Vmc), causing loss of control.

2. Probable Causes Leading to the Aircraft Accident: Fatigue failure of the No. 3 engine pylon inboard mid-spar installation fitting lugs. This caused the No. 3 engine pylon to separate from the wing; and move outboard, until colliding with the No. 4 engine, causing the No. 4 engine to separate; separation of the No. 3 and No. 4 engines from the aircraft right wing caused a major impact. The aircraft after No. 3 and No. 4 engines separated, maintained altitude, but suffered drag, speed loss, and flight crew reporting inability to maneuver the aircraft to turn left and start a right turn return to the airport, aircraft airspeed dropped to minimum maneuvering speed required, aircraft stalled, rolled to the right and descended rapidly, crashing into the ground approximately 3 minutes after the engines separated.

Four, Improvement Recommendations:

To improve B-747 series aircraft engine pylon structures, enhance their structural strength, to increase operational reliability, China Airlines and EVA Airways should follow the airworthiness directives issued by the Civil Aeronautics Administration to replace related components.

1. Issued on June 2, 1995, CAA AD 84-747-237 (FAA AD 95-10-16) limiting P&W JT9D engines: To be completed before February 21, 2000 (Those who have not executed SB must be completed before February 21, 1998).

   (1) China Airlines

   i. B-1862 May 02 1995-29 Jul 1995 Executed Completed
   ii. B-1886 03 Sep 1995-19 Oct 1995 Executed Completed
   iii. B-1880 19 Nov 1995-17 Dec 1995 Executed Completed
   iv. B-1864 26 Dec 1995-13 Feb 1996 Executed Completed
   v. B-1866 08 Mar 1996-28 Apr 1996 Executed Completed

   (2) Scheduled implementation

   i. B-1894 04 before Sep 1996
   ii. N4522 03 before Nov 1996
   iii. N4508 03 before Nov 1997
   iv. B-1888 03 before Nov 1997
   v. B-160 03 before Nov 1999

2. Issued on July 28, 1995, CAA AD 84-747-240 (FAA AD 95-13-06) for installed GE CF6-80C2 and PW4000 series engines, improved before January 28, 2002.

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(1) China Airlines

i. B-161 before Jan 28 2002
ii. B-162 before Jan 28 2002
iii. B-163 before Jan 28 2002
iv. B-164 before Jan 28 2002

(2) EVA Airways

i. N-405 Jun 1998
ii. B-16462 Apr 1998
iii. B-16463 Oct 1998
iv. B-16465 Oct 1998
v. N403 Oct 2001
vi. B-16461 Dec 2001
vii. B-16401 Apr 2001
viii. B-16402 Jun 2001

(3) The Civil Aeronautics Administration will check the execution status separately upon the due dates.