AA2004-2

AIRCRAFT ACCIDENT INVESTIGATION REPORT

NIPPON CARGO AIRLINES FLIGHT 62
BOEING 747-200F, JA8191
NEW TOKYO INTERNATIONAL AIRPORT, NARITA, JAPAN
OCTOBER 22, 2003

July 30, 2004

Aircraft and Railway Accidents Investigation Commission
Ministry of Land, Infrastructure and Transport

The investigation for this report was conducted by Aircraft and Railway Accidents Investigation Commission, ARAIC, about the aircraft accident of Nippon Cargo Airlines Boeing 747-200F in accordance with Aircraft and Railway Accidents Investigation Commission Establishment Law and Annex 13 to the Convention of International Civil Aviation for the purpose of determining cause of the aircraft accident and contributing to the prevention of accidents and not for the purpose of blaming responsibility of the accident.

This English version report has been published and translated by ARAIC to make its reading easier for English speaking people those who are not familiar with Japanese. Although efforts are made to translate as accurate as possible, only the Japanese version is authentic. If there is difference in meaning of the texts between the Japanese version and the English version, texts in the Japanese version are correct.

Junzo Sato,

Chairman,

Aircraft and Railway Accidents Investigation Commission

AIRCRAFT ACCIDENT INVESTIGATION REPORT
NIPPON CARGO AIRLINES FLIGHT 62
BOEING 747-200F, JA8191
DAMAGE TO AIRCRAFT BY AFT FUSELAGE CONTACT WITH GROUND
NEW TOKYO INTERNATIONAL AIRPORT, NARITA, JAPAN
AT ABOUT 21:57 JST, OCTOBER 22, 2003

July 7, 2004

Decision by the Aircraft and Railway Accidents Investigation Commission (Air Sub-committee Meeting)

Chairman	Junzo Sato
Member	Yukio Kusuki
Member	Susumu Kato
Member	Sumio Matsuura
Member	Yukiko Kakimoto
Member	Akiko Matsuo

1. PROCESS AND PROGRESS OF THE ACCIDENT INVESTIGATION

1.1 Summary of the Accident

On Wednesday October 22, 2003, at around 21:57, a Boeing 747-200F of Nippon Cargo Airlines (NCA), registration JA8191, took off from New Tokyo International Airport (Narita Airport) as scheduled cargo flight 62. During the takeoff, the aircraft's aft fuselage contacted the runway surface and the aircraft sustained moderate damage, but continued its takeoff and became airborne. Thereafter, the aircraft returned to Narita Airport and landed.

None of the four persons, including the captain, on board flight 62 was injured.

The aircraft sustained moderate damage, but there was no fire.

1.2 Outline of the Accident Investigation

1.2.1 The Organization of the Investigation

On October 23, 2003, the Aircraft and Railway Accidents Investigation Commission (ARAIC) assigned an investigator-in-charge and two investigators.

1.2.2 Accredited representative and adviser by Foreign Authorities

ARAIC forwarded the notification of the accident to the United States, the state of design and manufacture of the accident aircraft. However, the United States did not designate any representative or Adviser to participate in the investigation.

1.2.3 The Implementation of the Investigation

The investigation proceeded as follows.

October 23, 2003	Aircraft inspection and interviews with crew
October 24, 2003	On-site investigation and interviews with crew
January 16, 2004	Flight test using flight simulator

1.2.4 Hearings from Persons relevant to the Cause of the Accident

Hearings were held.

2. FACTUAL INFORMATION

2.1 Flight History

On October 22, 2003, a Boeing 747-200F of Nippon Cargo Airlines, registration JA8191, took off as scheduled cargo flight 62 from Narita Airport to Anchorage International Airport in the U.S.A. at around 21:57 (JST).

The flight plan of the aircraft submitted to the Tokyo Airport Office of the Civil Aviation Bureau (CAB) was as follows:

FLIGHT RULES: IFR, DEPARTURE AERODROME: New Tokyo International Airport, TIME: 21:30, CRUISING SPEED: 490kt, CRUISING ALTITUDE: FLIGHT LEVEL 290, ROUTE: GUPPY–OTR8–KAGIS–A590–AMOTT–J511–ANC, DESTINATION AERODROME: Anchorage International Airport, TOTAL EET: 6 hours 20 minutes, ENDURANCE: 7 hrs 31 minutes, PERSONS ON BOARD: 4.

In the cockpit, the captain assumed the duties of Pilot Flying (PF) from the left pilot seat, while a foreign pilot training for first officer assumed Pilot Not Flying (PNF) duties from the right pilot seat and the flight engineer (FE) was seated on the flight engineer's seat. The first officer occupied the left observer's seat (jump seat).

Based on the recordings of the aircraft' Digital Flight Data Recorder (DFDR), air traffic control voice recordings and the statements of the crew, an outline of the progress of the flight from the time of push back is as follows.

2.1.1 Flight History based on DFDR and Communications Recorder

The aircraft pushed back from the spot 209 at Narita Airport at around 21:40 and the engines were started from 21:41 to 21:42.

The aircraft taxied toward runway 34L and at 21:54 was instructed by Narita Airport Control (Narita Tower) to taxi into position and hold on runway 34L. At 21:55, the aircraft was cleared for take off.

2156:03: The thrust levers started to be advanced.

2156:12: The aircraft began its takeoff roll.

2156:24: The N1 (Note 1) values of the No. 1 and No. 4 engines reached the target value of 107%. However, the indicated N1 values of the No. 2 engine (84.4%) and No. 3 engine (97.8%) were below target, and thereafter remained the same.

2156:43: Computed Air Speed (CAS) was 123kt.

2156:44: CAS increased to 129kt.

2156:46: CAS reached 133kt, and the aircraft started to be rotated as the control columns were pulled back 2.3 degrees. The pitch angle at the time was minus 0.5 degrees Aircraft Nose Up. After the start of the rotation maneuver, the aircraft's acceleration decreased.

2156:51: CAS was 146kt, pitch angle was 5.4 degrees.

2156:52: The control columns were pulled back to 6.1 degrees, pitch angle was 8.0 degrees, and CAS was 148kt.

2156:53: The control columns were pulled back to 6.8 degrees, pitch angle was 10.6 degrees, and CAS was 149kt.

2156:54–55: Pitch angle indicated its maximum value of 11.9 degrees while the AIR/GROUND (AIR/GRD) sensor was in GROUND mode.

2156:54: The control columns were pulled back to 7.5 degrees, the maximum value reached in the accident. The aircraft was approximately 1,620m from the start of the takeoff roll.

2156:55: The control columns returned to 5.8 degrees. The aircraft was approximately 1,690m from the start of the takeoff roll, and CAS was 153kt.

2156:56: CAS was 158kt, the control columns were pulled back to 6.6 degrees and pitch angle was 11.5 degrees. The AIR/GND sensor was in GROUND mode.

2156:57: The AIR/GRD sensor changed to AIR mode, and it was 11 seconds after the start of the rotation. CAS was 160kt, radio altitude was 9ft, the control column was pulled back to 6.7 degrees and pitch angle was 11.5 degrees.

2156:59: CAS was 157kt, radio altitude was 13ft and pitch angle was 12.3 degrees.

2157:00: CAS was 163kt, radio altitude was 17ft and pitch angle was 13.2 degrees.

2157:02: The gear lever indication changed from DOWN to NOT. CAS was 163kt, radio altitude was 35ft and pitch angle was 14.5 degrees.

2157:40: While passing through a barometric altitude of 1,300ft, the aircraft informed Narita Departure that it was climbing to 7,000ft.
Thereafter, the aircraft continued to climb at a CAS of 160–175kt with the flaps at 10 degrees.

2159:52: The aircraft reached a barometric altitude of 3,000ft and started to right turn. Three seconds later, pitch angle decreased and CAS started to increase.

At 2206:23, the aircraft made its first contact with Tokyo Air Traffic Control Center and requested to climb to FL150 rather than the planned altitude and asked permission to dump fuel. After that, the aircraft stated its intention to return to Narita Airport and requested radar vectors to the ARIES (reporting point) to dump fuel there.

After dumping fuel, the aircraft flew via the COSMO (reporting point) and landed at Narita Airport on runway 34L at around 22:49.

(Note 1) N1 indicates the rotation speed of the low-pressure turbine, and is indicated as a percentage with 3,432.5 rpm corresponding to 100%. It is used as an index for setting engine thrust.

2.1.2 Statements of the Flight Crew

(1) The Captain

"We completed the onboard preflight preparations and at around 21:35, I received the final weight and balance data and asked the FE to prepare the takeoff data card ("data card" below). At around 21:39, I received the data card from the FE and set the airspeed bugs (reference markers set on the airspeed indicator which the crew to indicate certain key values) according to the card. I had not memorized the standard value of airspeed corresponding to our takeoff weight. Our departure was around 10 minutes late, and so we soon received push back clearance. Everything was carried out according to normal procedures.

"While taxiing, we completed the Taxi and Takeoff Checklist, during which we set and cross checked the bugs again to thoroughly confirm there was no discrepancy between the bugs and the takeoff data.

"We began the takeoff after receiving takeoff clearance, and I started the rotation when the PNF called V_R (**Note 2**). The wind was almost 4 to 5 kt headwind. I pulled the column back at the standard rotation rate and the aircraft became airborne, but I felt that the liftoff took slightly longer than normal. Because it was bad weather and at night, I don't remember clearly whereabouts on the runway we lifted off from. Also, I don't exactly remember the pitch attitude on rotation since I was concentrating on the speed, but think it was around 12 degrees.

"After that, we retracted the gear in a normal climb and climbed mostly at V_2 (**Note 3**) + 20kt. While we were passing 3,000ft, Narita Departure instructed us to turn right, and as we started to turn, the stall warning stick shaker activated. I quickly responded by reducing pitch, and asked the FE to recheck the takeoff data. As a result of the recheck, we realized that the V_2 value we were using was around 28kt less it should have been. I reset the bug to the correct speed and retracted the flaps in accordance with the flap schedule.

"Although I confirmed cabin pressurization was normal, since we started the rotation at a lower speed than we originally should have, and considering that the lift off was later than normal, I felt that we might have had a tail strike at lift off and I felt uneasy about continuing a high altitude long distance flight over the ocean. After retracting flaps, I discussed with the crew, and eventually decided to turn back.

"We dumped fuel for around 20 minutes from 22:13, then returned to Narita Airport and landed at 22:49. After arriving at the ramp at 22:53, a check by a mechanic found abrasions on the lower part of the aft fuselage. I had not felt any shock that might be thought to be due to a tail strike between rotation and liftoff.

"I did not know the exact value of pitch angle at which a tail strike will occur on the B747-200F."

(2) The Trainee Pilot

"After leaving the ramp, we completed the Taxi and Takeoff Checklist while taxiing and cross checked the takeoff data. I contacted Narita Tower at about the time a Boeing 747 that had been taxiing in front of us started its takeoff. We taxied into position on runway 34L and received takeoff clearance.

"The captain increased power, set the auto-throttle and called [takeoff]. The aircraft accelerated normally during the takeoff roll. The captain rotated the aircraft smoothly according to my calls of 'V_1' (**Note 4**), 'V_R' and 'Rotate 16 degrees'. For about five or six seconds I suppose, it seemed we were having trouble getting airborne. It's hard to express, but I felt that the aircraft lifted off momentarily, then we stopped accelerating and the main gear touched down again.

"After that, the aircraft lifted off and at last the altimeter and vertical speed indicator started to show we were climbing. I called 'Positive climb' (climbing normally) and retracted the gear when instructed by the captain. As we were passing through 1,000ft, Narita Tower told us to contact Narita Departure. Our airspeed at that time was V_2 + 20kt.

"When we started to right turn according to the Standard Instrument Departure (SID), the stick shaker activated briefly. The captain lowered the nose to increase the speed, and ordered the FE to check the takeoff speed data. As the result, V_2 was found to be around 30kt less, and we reset the bugs to the correct V_2. After that, the captain, first officer and FE talked in Japanese, so I couldn't understand the conversation. After I had advised that we might have scraped the tail on rotation, the captain finally decided to turn back.

"We requested radar vectors for ARIES, and dumped fuel while holding over ARIES. After dumping fuel we made a radar-vectored approach and landed on runway 34L.

"Unlike in my home country, where I flew before coming to Japan, pounds are used here as the unit of a weight instead of kilograms, so I couldn't immediately grasp the mistake in numbers when hearing them. Furthermore, in the simulator training I received since coming to Japan, the aircraft weight was always the same, 530,000lbs, and since the speed computed by the FE at the time was not much different from the one in simulator training, I didn't notice the mistake. Moreover, in my home country both the FE and the first officer independently work out and then mutually check the calculations, but because what we did at the time was standard procedure at NCA, I did not do the calculations myself."

(3) The First Officer

"I went to the assistant dispatcher's desk five minutes before the 20:00 show-up time. Because the trainee pilot was undergoing route training for first officer, I was getting extra logs as a safety co-pilot (a first officer on board who can take over from a trainee pilot if necessary), and because it's a route we generally fly, I checked whether there were anything different from usual as well as the necessary items. From the log, the planned takeoff weight was around 750,000lbs, and I noticed that this was quite heavy for an NCA flight. Our departure was slightly delayed. I carried out my checks as safety co-pilot, and I checked that the trainee pilot hadn't missed anything he was supposed to have done. Because I could hardly see the captain's side (left pilot seat) from the jump seat (left rear seat), I concentrated mainly on checking the [instruments and switches on the] co-pilot's-side (right pilot seat). I don't think there was anything missed off the checklists.

"The captain received the weight and balance and other papers, and told the FE to prepare the data card. The captain and the trainee pilot set the bugs on their airspeed indicators according to the data, and after cross checking we started to push back. The captain conducted the takeoff briefing during taxi. I confirmed the Taxi and Takeoff Checklist, but I found no errors in setting the takeoff data and no discrepancies between left and right.

"After the V_1 call, we started pitching up slowly as the rotation call was being made, and although PNF confirmed that the aircraft was airborne and called 'positive climb', the positive climb call was very late.

"After that, the aircraft climbed at airspeed of about $V_2 + 20$kt. When we started to turn right following the SID, the sick shaker activated. I though this was unusual so I released my shoulder harness and looked forward. The FE rechecked the takeoff data and found that V_2 was around 30kt less than the correct value. As rotating the aircraft at such a low speed constitutes an early rotation and carries a risk of tail strike, the FE carried out the Tail-Strike on Takeoff checklist.

"Although I confirmed that the cabin pressurization was normal at the time, because the pressurization would be used near its limits during the high altitude flight to Anchorage, I felt uneasy about continuing this flight, so I advised the captain 'let's go back'. The captain seemed to be wavering about deciding to turn back. Because Narita Airport operates until 23:00, I thought we wouldn't be able to return to Narita if we did not request clearance to return soon, so I strongly expressed to the captain that we go back to Narita. The captain decided to return at around 22:08. After that, we made holding at ARIES and dumped fuel, then made a radar-vectored approach and landed on runway 34L."

(4) The Flight Engineer

"After a routine briefing with the assistant dispatcher, and I filled in the necessary items on the flight engineer record (a document the FE uses during flight) and went to the aircraft.

"The nose cargo door is normally closed while loading cargo, but since it was open this time, I thought they might be speeding up the cargo loading. I entered the cockpit and checked the log, and then went round the outside of the aircraft doing the external checks before going up to the cockpit again. The preflight checks were carried out as normal.

"Loading of the lower aft cargo compartment was running a little behind schedule. The load planner brought the weight and balance manifest to the cockpit at around 21:35. The captain checked it, and then I received it and prepared the data card. Although there are no spaces for entries in the flight engineer record, I noted down the zero fuel weight of 552,700lbs and the estimated landing weight on arriving Anchorage of 579,800lbs in the margin for my reference. Our takeoff weight was 745,000lbs, and although I should have noted down the data in the chart for a weight of 750,000lbs of V_1 156kt, V_R 168kt, V_2 175kt, and ATT12 (Note 5), in fact I looked at the values in the row for 550,000lbs below the chart and wrote V_1 124kt, V_R 132kt, V_2 146kt and ATT16. I think it was because the zero fuel weight of 552,700lbs had stuck in my head.

"As a habit I normally recheck the data by reverse lookup (reading the takeoff weight from the speeds), but because I was somewhat bothered that we were delaying than schedule I failed to recheck it this time. I think I would have found the mistake had I rechecked as usual. I felt it was because we had always left on time.

"I handed the completed data card to the captain and he set the bugs on his airspeed indicator according to the data. We received push back clearance at 21:39. After pushing back, we started to taxi and carried out the Taxi and Takeoff checklist. At that time, we only checked that the values on the data card agreed with the bug settings, and we did not check whether the data itself was correct or not.

"On aircraft that carry an FE, that FE prepares the takeoff and landing data cards. Some captains and first officers carry simple charts or computers, but since preparing the data card is ultimately the FE's duty, it did not concern me whether the captain or first officer went over the calculations or not. The trim setting value was correct because I looked at the 750,000lbs value when writing it.

"When we reached V_1 after starting the takeoff, I felt our speed was slow. After that, power was reduced from takeoff power to climb thrust at 1,500ft. During a right turn the stick shaker activated and I was directed by the captain to recheck the takeoff data. I only realized the mistake in the takeoff data when I rechecked, and reported this to the captain and told him the correct value. Since there was a chance we had had a tail strike at takeoff, the captain decided to return to Narita Airport.

"I computed the quantity of fuel to dump, and after dumping fuel we received clearance and landed on runway 34L at 22:49. After arriving at the ramp, a mechanic checked the aircraft and found what appeared to be scratches on the tail section.

(Note 2): V_R (rotation speed) is the speed at which the pilot starts increasing the aircraft's angle of attack to increase the lift coefficient for the aircraft to lift off. It is set according to takeoff weight and flap angle.

(Note 3): V_2 (take off safety speed) is the speed at which the aircraft can takeoff and climb safely with one engine inoperative and clear an altitude of 35ft with the required climb gradient. It is set according to takeoff weight, flap angle, outside air temperature and barometric altitude.

(Note 4): V_1 (takeoff decision speed) is the speed by which the pilot must decide whether to continue or abort takeoff if one engine fails during the takeoff roll. It is set according to takeoff weight, flap angle, runway condition and thrust.

(Note 5): ATT (attitude) is the climb attitude with one engine inoperative. In normal takeoff operation, the pilot pulls the aircraft up to this attitude in a continuous motion during rotation.

(See Figures 1, 2, 4, 5, 6, 7, 8, 9-1 and 9-2)

The aircraft landed at Narita Airport at around 22:49. The accident occurred at around 21:57 on the 'A' runway of Narita Airport.

2.2 Deaths, Missing Persons and Injuries

There were no casualties.

2.3 Damage to the Aircraft

2.3.1 Extent of Damage

Moderate damage.

2.3.2 Damage to the Aircraft by Part

As a result of the investigation, the main damages were found to be as summarized below:

(1) Aft lower Fuselage

① Abrasions estimated as being damage caused by the tail contacting the runway were found on the aft lower fuselage skin for around 14m from stations (Note 6) 2231 to 2775. The abrasions became increasingly conspicuous moving aftwards.

② Deformation of the lower frames was found at Sta. 2484, 2598 and 2658, and cracks were found in some of these. Part of a lower stringer that passes through these stations was bent inwards.

(2) Horizontal Stabilizer Actuator Access Door

Abrasions were found.

(3) APU Battery Access Door

Abrasions, dents and cracks were found.

(4) APU Access Door

Abrasions and cracks were found.

(5) Tail Cone

Abrasions, dents and cracks were found on the bottom of the tail cone.

(Note6): In this report, STA expressed the distance measured along aircraft longitudinal axis toward aft from the point of Zero setting as a datum at forward of aircraft, and indicated its position in unit of inch to fore and aft direction of aircraft.

(See Fig. 4 and photo 1)

2.4 Damage to Other than the Aircraft

None

2.5 Crew Information

(1) Captain: Male, aged 55

Airline Transport Pilot License (Airplane)	Issued February 25, 1986
Type Ratings	
Airplane multiengine (land)	Issued May 18, 1973
Boeing 747	Issued July 9, 1984
Class 1 Airman Medical Certificate	
Term of Validity	Until October 31, 2003
Total flight time	13,965 hours 47 minutes
Flight time during the previous 30 days	51 hours 04minutes
Total flight time on Boeing 747	7,345 hours 57 minutes
Flight time during the previous 30 days	51 hours 04 minutes

(2) Trainee Pilot: Male, aged 43

Airline Transport Pilot License (Airplane)	Issued September 5, 2003
Type Ratings	
Boeing 747	Issued September 5, 2003
Class 1 Airman Medical Certificate	
Term of Validity	Until March 15, 2004
Total flight time	9,836 hours 17 minutes
Flight time during the previous 30 days	27 hours 55 minutes
Total flight time on Boeing 747	5,365 hours 45 minutes
Flight time during the previous 30 days	27 hours 55 minutes

(3) First Officer: Male, aged 35

Airline Transport Pilot License (Airplane)	Issued July 30, 2002
Type Rating	
Airplane multiengine (land)	Issued February 23, 1993
Boeing 747	Issued August 8, 2000

Class 1 Airman Medical Certificate	
Term of Validity	Until January 15, 2004
Total flight time	4,859 hours 37 minutes
Flight time during the previous 30 days	63 hours 19 minutes
Total flight time on Boeing 747	1,401 hours 12 minutes
Flight time during the previous 30 days	63 hours 19 minutes

(4) FE: Male, aged 59

Flight Engineer License (Airplane)	Issued December 11, 1971
Type Rating	
Airplane multiengine (land)	Issued December 11, 1971
Boeing 747	Issued May 25, 1992
Class 1 Airman Medical Certificate	
Term of Validity	Until November 29, 2003
Total flight time	15,849 hours 33 minutes
Flight time during the previous 30 days	39 hours 19 minutes
Total flight time on Boeing 747	5,987 hours 13 minutes
Flight time during the previous 30 days	39 hours 19 minutes

2.6 Aircraft Information

2.6.1 The Aircraft

Type	Boeing 747-200F
Serial Number.	24576
Date of Manufacture	October 16, 1990
Certificate of Airworthiness	Tou-10-408
Term of validity	Until valid date of NCA Maintenance Program Manual from September 14, 1998
Category	Airplane Transport(T)
Total flight time	53,848 hours 08 minutes
Flight time since scheduled maintenance	
"C" Check on January 8, 2003	116 hours 46 minutes

(See Figure 3)

2.6.2 The Engines

Type: General Electric CF6-50E2

	Serial No.	Date of manufacture	Total time in service
No.1	517191	July 9, 1976	82,634 hours 22 minutes

No.2	530236	November 19, 1984	74,050 hours 59 minutes
No.3	530269	July 19, 1985	70,864 hours 01 minutes
No.4	530210	August 3, 1984	68,421 hours 05 minutes

2.6.3 Weight and Center of Gravity

The weight of the aircraft at the time of the accident is estimated to have been approximately 744,500lb, with the center of gravity at 23.3% MAC. Both these values were within the allowable limits (maximum takeoff weight 781,800lb, with an allowable center of gravity range corresponding to the weight at the time of take off of 11.2–32.1% MAC).

2.6.4 Fuel and Lubricating Oil

The fuel on board was JET A-1. The lubricating oil was BP Turbo Oil 2380.

2.7 Meteorological Information

The aviation routine weather reports (METAR) and aviation selected special weather reports (SPECI) for Narita Airport around the time of the accident were as follows:

Time of Observation	21:30 JST	21:41 JST	22:00 JST
Wind Direction	340 degrees	340 degrees	320 degrees
Wind Speed	11 kt	11 kt	10 kt
Visibility (Prevailing)	7,000 m	4,500 m	3,000 m
Weather	light rain	light rain, haze	light rain, haze
Cloud amount	1/8	1/8	1/8
Cloud type	Stratus	Stratus	Stratus
Height of cloud base	200 ft	200 ft	100 ft
Cloud amount	5/8	5/8	5/8
Cloud type	Stratus	Stratus	Stratus
Height of cloud base	400 ft	400 ft	300 ft
Cloud amount	7/8	7/8	7/8
Cloud type	Stratocumulus	Stratus	Stratus
Height of cloud base	1,000 ft	800 ft	500 ft
Temperature	17°C	17°C	17°C
Dew point	16°C	16°C	16°C
Altimeter Setting (QNH)	29.70 inHg	29.69 inHg	29.69 inHg

2.8 Information on Digital Flight Data Recorder (DFDR) and Cockpit Voice Recorder (CVR)

The aircraft was equipped with a Lockheed Aircraft Service DFDR (Part Number: 209F/10077A500) and a Fairchild CVR (Part Number: 93-A100-80).

2.8.1 DFDR

All data recordings during the time from when the aircraft started to taxi from parking spot 209 at Narita Airport until it stopped after landing remained on the DFDR.

2.8.2 CVR

Since the CVR records only voices and sounds in the cockpit on a 30-minute endless tape loop until it stops operating, all recordings on the CVR from around the time of accident had been overwritten.

2.9 The Accident Site

Based on DFDR recordings, at the time the aircraft pitch angle reached 11.9 degrees, the aircraft was around 1,620–1,690m from the point at which the takeoff started. Assuming that the start of the takeoff was around 150m inside from the threshold of the runway 34L, there ought to have been abrasion marks caused by the aircraft around 1,770–1,840m from the approach end of runway 34L; however, no marks that could be thought to have been made by the aircraft were found.

(See Figure 2.)

2.10 Cargo Loading

At NCA, for loading a cargo onto an aircraft, a load planner decides the locations where the cargo is to be loaded and a loadmaster supervises the loading work. A supervisor in charge of cargo has overall responsibility for cargo loading. Fuel loading is done by a responsible mechanic.

Based on the statements of the load planner, the loadmaster and the responsible mechanic, the cargo and fuel loading were completed normally.

Furthermore, after the aircraft had arrived at Narita Airport after turning back, the loadmaster and the supervisor in charge of cargo at NCA re-checked that the cargo had been loaded appropriately according to instructions.

2.11 Data Card

2.11.1 Points concerning Data Cards

(1) The NCA Operations Manual (OM) contains descriptions of the roles and responsibilities of the captain, first officer and FE, but does not describe who should prepare or who should confirm data cards.

Regarding data card preparation, a paragraph COCKPIT PREPERATION-F/E in the NORMAL PROCEDURES section of the Airplane Operations Manual (AOM) has a description "Takeoff Data Card …: COMPLETED", but it is not clear from this description that the data card should be prepared by the FE, and there is no description as to who should confirm the data card.

(2) Section 8-3-4 "ESTABLISHING SPEEDS" of the AOM describes how to determine

the speeds for each flight phase, and states that takeoff speeds are shown in the section 8-6-2 TAKEOFF SPEED Table.

(3) The procedures for preparing a takeoff data card are explained in detail in section 8-6 “OPERATIONAL DATA” of the AOM.

The AOM states that the necessary data for takeoff are read from the AOM. The four items V_1, V_R, V_2 and ATT, which are particularly significant for the takeoff maneuver, appear boxed with a heavy solid line. For V_1, V_R and V_2, the AOM states to “Enter the speeds found in the TAKEOFF SPEED Table”, and for ATT it states to “Enter the 3ENG Climb Attitude value indicated in the TAKEOFF SPEED Table”.

(4) The TAKEOFF SPEED Chart (“chart” below) for the RTG-II (Note 7) takeoff thrust setting and 10-degree flap setting used at takeoff in the accident was printed in section 8-6-2 TAKEOFF & LANDING of the AOM.

(Note 7): RTG-II is the one of the takeoff thrust settings determined by takeoff weight, runway length, noise abatement, etc. There are four types of takeoff thrust setting: MAX, RTG-I, RTG-II and RTG-II-2. MAX is the maximum permitted takeoff thrust of the installed engines. RTG-I is a thrust of 4% lower than MAX, and RTG-II is 10% lower than MAX. RTG-II-2 is the thrust obtained by subtracting 2% of the takeoff N1 from RTG-II, and is 4% lower than RTG-II.

(See Figures 5 and 6.)

2.11.2 Preparation and Verification of Data Cards

(1) Before Flight Crew Boarding

According to the 19:02 data used when the flight crew was briefed by the assistant dispatcher, the planned take off weight was 750,500lbs, and RTG-II thrust and 10 degrees of flap were to be used, but no speed data were mentioned.

At that time, the flight crew neither prepared the data card nor discussed the speeds for takeoff.

(2) Between the crew boarding and push back for departure

At around 21:35, the captain received the final weight and balance manifest and the load instruction sheet from the load planner, and then instructed the FE to prepare the data card.

The FE prepared the data card referring to the charts in the AOM he carried and handed it to the captain.

The captain set the bugs on the left side airspeed indicator based on the values of V_1 124kt, V_R 132kt, and V_2 146kt recorded on the data card. The trainee pilot set the bugs on the right side airspeed indicator while checking each value recorded on the data card with the bugs on the left airspeed indicator set by the captain.

The first officer on the left observer’s seat was checking to see that these procedures were carried out correctly.

(3) From push back for departure until the start of the takeoff

While taxiing to runway 34L, the crew carried out the final checks before takeoff using the Taxi and Takeoff Checklist, during which the captain and trainee pilot checked that the bugs on their respective airspeed indicators agreed with the speed data on the data card.

2.11.3 Entries on the Data Card

On the data card used at the time of the accident, instead of the data for the correct takeoff weight of 745,000lbs of V_1 156kt, V_R 167kt, V_2 175kt and ATT 12, the data for an incorrect takeoff weight of 550,000lbs of V_1 124kt, V_R 132kt, V_2 146kt and ATT 16 were entered.

(See Figure 6)

2.12 Control from the start of takeoff

(1) The aircraft took off using the Normal Takeoff Method (Note 8).

(2) The aircraft's speed at the start of rotation was approximately 133kt, close to the 132kt value recorded on the data card at the time of the accident. However, this speed was 34kt less than the 167kt value at which the rotation should have been started based on the takeoff weight and takeoff thrust used at the time of the accident.

(3) Around 11 second elapsed from the start of rotation until the DFDR recordings show the AIR/GRD sensor changing to AIR mode.

(Note 8): In the Normal Takeoff Method, the thrust levers are advanced to around 70%N1 with the brakes applied at the starting point of the takeoff roll, and after engine thrust stabilizes, the takeoff roll is started and takeoff thrust is set by the time airspeed reaches 80kt.

2.13 Other Relevant Information

2.13.1 Stall Speed, etc.

According to the AOM, the aircraft's stall speed (V_S) at a takeoff weight of 745,000lbs and with flaps setting at 10 degrees was 146kt, and the speed at which the stick shaker activate was 163kt.

The minimum control speed (V_{MCA} in flight) with the critical engine inoperative when using RTG-II takeoff thrust is 107.5kt.

2.13.2 Relationship between Takeoff Weight and Takeoff Speeds

According to the AOM, the four normally used thrust settings are MAX, RTG-I, RTG-II and RTG-II-2, in decreasing order of thrust. Regarding the relationship between takeoff weight and the V_1, V_R, and V_2 speeds used at takeoff, although the speeds for

MAX takeoff thrust are lower than for the other three thrust settings due to the use of 20 degrees of flap when using MAX thrust, the speeds for the other three thrust settings, for which 10 degrees of flap is used, tend to agree.

The V_1, V_R, and V_2 takeoff speed values for all four thrust settings at the aircraft's takeoff weight at the time of the accident of 745,000lbs are for the most part between 150kt to 180kt.

(See Figure 7)

2.13.3 Relationship between Takeoff Weight and ATT

In the AOM, the ATT value depends on takeoff weight, is greater for lighter takeoff weights and smaller for heavier weights, and lies within a range of a maximum of 17 and a minimum of 11.

The ATT16 used at the time of the accident is appropriate for a takeoff weight of 560,000lbs and MAX, RTG-I, or RTG-II thrust settings, and a takeoff weight of 520,000lbs if RTG-II-2 is used.

For the 745,000lb takeoff weight at the time of the accident, ATT is 12 or 13 for all four thrust ratings.

(See Figure 8)

2.13.4 Flight Simulator Investigation

Two pilots conducted takeoffs at a thrust setting of RTG-II. The test conditions and corresponding results are shown in the following table and described below.

An investigation was carried out using a Boeing 747-200F simulator with sophisticated visual and motion systems approved as a level 'D' device (the highest level of simulation fidelity) by the Civil Aviation Bureau, Ministry of Land, Infrastructure and Transport.

The bottom line of the table below shows data read out from DFDR recordings at the time of the accident.

Thrust Rating	Aircraft Gross Weight	Lift off Pitch (deg.)	Rotation Rate (deg/s)	Acceleration before/after Rotation (kt/s)	Initial Target Pitch (deg.)	Time until Lift off (sec)
RTG-II	Light	9.1	2.30	5.3/4.6	16	6
	Heavy	9.1	1.90	3.6/2.5	11	7
RTG-II	At the Accident	11.9	1.55	4.0/2.1	16	11

(1) The rotations were made smoothly starting at V_R. The rotation rate was 2.3 deg/sec at a light aircraft weight, and 1.9 deg/sec at a heavy weight. During the rotations, the AIR/GRD sensor switched to AIR mode at 9.1 deg., before pitch angle reached the

initial target pitch.

(2) Acceleration decreased by 0.7–1.1kt/s after starting the rotation compared to before rotation. There was a difference in acceleration of 1.7–2.1kt/s between lighter and heavier aircraft weights.

(3) The time from the start of rotation until the AIR/GRD sensor switched to AIR mode and the aircraft lifted off was around 6 seconds at light aircraft weight and around 7 seconds at heavy weight.

Pilots can recognize lift off by the sound of the gear lever safety relay switching off.

(4) In both cases (light and heavy weights) the gear lever safety relay sound occurred after V_2 was achieved.

2.13.5 B747 Airplane Operations Reference

The B747 Airplane Operations Reference (AOR) contains reference material issued by the Boeing Co. that supplements and explains the contents of the Boeing 747 AOM.

Pitch control, etc. during takeoff was described in the AOR as follows:

7-2-1-15 Pitch control during takeoff, Target pitch attitude, and reference N1 during takeoff/approach.

1. Introduction

This AOR provides you with supplementary explanation about pitch control during takeoff as an aid for achieving proper takeoff rotation. In addition this AOR provides you with Target Pitch Attitude and Reference N_1 during takeoff/approach phase to prevent Climb Speed Low and Pitch Low Landing.

2. Pitch Control during Takeoff

During takeoff roll, keep light forward pressure on control column and when approaching V_R, reduce the forward pressure to make it neutral at V_R.

－ Control the aircraft not to make pitch up attitude.

Initiate rotation at V_R.

－ Initiation of rotation means start of back pressure application on control column, and not the beginning of airplane's nose up motion.

－ Do not make a rotation before V_R. Early rotation may cause a tail contact.

Make a rotation smoothly and continuously at pitch up rate of 2～3 deg/sec. During the process of rotation at an appropriate pitch up rate, airplane will lift off and its pitch attitude will be about 11～18 deg. (Note 1) and Airspeed will be V_2 + 10kt or more when reaching 35ft. Those parameters depend to the takeoff thrust settings and/or gross weight.

– The airspeed of this stage: V_2 + 10kt is a result of appropriate rotation and liftoff, and not an object to be realized by the control from rotation to climb out. The maneuver aiming to realize this airspeed in the process of takeoff may result in an over rotation and cause a tail strike.

– Do not make an aggressive and rapid pitch up toward FD's [flight directors] command bar. The nose up toward the command bar should also be made at the appropriate rate.

Note 1: These values are climb attitude displayed on takeoff data card and based on 3 engines condition. Therefore they are just a reference at the early stage of takeoff and do not necessarily realize an adequate airspeed thereafter. Adjust pitch attitude to maintain an adequate airspeed.

Do not make early rotation, rapid (excessive pitch up rate) rotation and over rotation to avoid tail strike.

2.13.6 Relationship between Aircraft Attitude and Tail Contact

Based on data from the aircraft's manufacturer, the Boeing Co. of the U.S.A., the following table shows the point on the fuselage at which tail contact will occur depending on the aircraft's attitude, the state of compression of the body gear oleos, and the body gear tilt.

Body gear oleo compression	Body gear tilt	Aircraft Pitch Angle (deg.)	Fuselage point of Contact (STA : in)
Normally Compressed	0 tilt: all tires on the runway	11.1	2,060
Maximally Extended	0 tilt: all tires on the runway	12.6	2,750
Maximally Extended	Full tilt: Aft tires on the runway	13.1	2,750

2.13.7 Stick Shaker Activation

The flight crew stated that the stick shaker activated when the aircraft first started to turn at an altitude of 3,000ft. Furthermore, agreeing with the captain's statement that he "… quickly responded by reducing pitch", based on the DFDR recording, at that time airspeed showed signs of increasing, then suddenly increased by 10kt as pitch attitude decreased, and the aircraft descended momentarily. N1, which indicates engine thrust, did not increase.
(See Figure 9-2)

3. ANALYSIS

3.1 Analysis

3.1.1 The captain, the trainee pilot, the first officer and the FE had valid aircrew proficiency certificates and valid aircrew medical certificates.

3.1.2 The aircraft had a valid certificate of airworthiness, and had been maintained and inspected properly as specified by the applicable regulations.

It is estimated that cargo was loaded onto the aircraft according to the instructions described in 2.10, and did not contribute to this accident.

As described in 2.1.1, low values of N_1 for engines 2 and 3 were recorded after 21:56:24. However, since the N_2 (Note 9) values for all engines during this time were within the range 101.8–103.1%, and each fuel flow for all engines was within the range 17,200–18,000lb/hr, it is estimated that the low values of N_1 for No. 2 and 3 engines at takeoff are errors in the recording, and that those engines also attained around 107% N_1.

Moreover, considering that none of the crew mentioned abnormal engine thrust in their statements, it is estimated that the instrument indications were around 107% for all four engines.

(Note 9) N_2 indicates the rotation speed of the high-pressure turbine, and is indicated as a percentage with 9,827rpm corresponding to 100%.

3.1.3 It is estimated that the weather conditions at the time of the accident had no influence on the accident.

3.1.4 Based on the data card used in the accident and the statement of FE, when the FE prepared the data card, since the actual takeoff weight was 745,000lbs he should have taken the airspeed and ATT values from the rows in the chart for 750,000lbs and 740,000lbs and used the middle of these values. However, it is estimated that the airspeed and ATT values from the row corresponding to the zero fuel weight of 550,000lbs were read and recorded on the data card. As the result, instead of the correct data of V_1 of 156kt, V_R of 167kt, V_2 of 175kt and ATT 12 being recorded on the data card, incorrect data of V_1 124kt, V_R 132kt, V_2 146kt and ATT 16 were recorded. Furthermore, because FE did not verify the data, he did not notice the error.

3.1.5 Problems with Data Card Preparation and Verification

3.1.5.1 During briefing with the Assistant Dispatcher

As described in 2.11.2 (1), according to the data used at the pre-departure briefing with the assistant dispatcher, the flight crew had confirmed that the planned takeoff weight was 750,500lbs, and that RTG-II and Flap 10 deg were to be used for the takeoff. However, there was no mention of takeoff speeds in the data, and it is estimated that the crew did not prepare a data card at that time.

If the crew had prepared a data card during the pre-departure briefing and in doing so investigated the takeoff speeds, they could have known the approximate takeoff speed values so that when the FE later prepared the erroneous data card after receiving the weight and balance manifest, they might have noticed the error by comparing with the previous estimates and corrected it.

Comparing the takeoff data for the planned takeoff weight of 750,500lbs and the final gross weight of 745,000lbs on the weight and balance manifest, there was a 1kt difference between the V_R values, while V_1, V_2 and ATT were the same.

3.1.5.2 The Data Card Preparation

(1) The captain received the final weight and balance manifest from the load planner in the cockpit and after checking it, he handed it to the FE and asked him to prepare the data card, but he did not also ask the trainee pilot as PNF and the first officer on the jump seat. It is estimated that the captain instructed only the FE to prepare the data card because this was the practice at NCA.

When preparing the takeoff data card, an FE considers the takeoff weight and runway condition from the chart in the airplane operations manual carried on board, prepares the data card using the values of V_1, V_R, V_2, and ATT corresponding to the takeoff weight, and then performs a reconfirm. However, when the FE carries out the reconfirm himself, it is possible that he may repeat the same actions and thereby overlook a mistake. Consequently, in addition to the FE himself reconfirm the data card which he has prepared, it is considered that it would be effective to avoid errors if either the PNF also checked the data card, or if the FE and PNF both independently prepared data cards and used the values if they agreed or corrected them if they were inconsistent.

(2) It is estimated that the FE prepared the data card according to the zero fuel weight because he had written it on the flight engineer record sheet and so it had remained in his mind. Furthermore, because the FE was in a rush as the departure was behind schedule, he neglected to reconfirm the data card and so did not realize his mistake.

An error such as mistakenly using a previously-remembered value to prepare the data card might happen to anybody, and it is considered that measures such as the following will be effective to prevent this kind of error: as described in 3.1.5.1, the flight crew should prepare a data card based on the planned takeoff weight during the pre-flight briefing with the assistant dispatcher and so consider takeoff speeds; and as described in (1) above, several crewmembers should prepare the final data card based on the weight and balance manifest.

The aircraft's departure had fallen behind schedule because it had arrived late at Narita Airport when operating as a previous flight, and it started to push back at 21:40, ten minutes later than the schedule departure time of 21:30. Given that NCA's rules treat departures within 15 minutes of the scheduled time as being on schedule, it is estimated that the flight was on schedule.

While it is important for operators to keep to the schedule for scheduled flights, it goes without saying that ensuring flight safety is the highest priority. Therefore, it is necessary that flight crews should carry out their normal crosschecks and safety procedures positively and without omission in any event.

Although it is estimated that FE had omitted reconfirming the takeoff data due to being under time pressure, it is thought that he would not have omitted the reconfirmation if he had followed standard operating procedures calmly. Further, it is considered that since the reconfirmation does not take much time, there was ample time available to carry it out.

3.1.5.3 From after the Data Card Preparation until Push Back

(1) It is estimated that the captain set the bugs on the left panel airspeed indicator according the values of V_1 124kt, V_R 132kt and V_2 146kt on the data card prepared by the FE without feeling any uncertainty about them. It is considered that the trainee pilot acting as PNF also set the bugs on the right panel airspeed indicator and checked that they agreed with both the values recorded on the data card and the airspeed bugs on the airspeed indicator set by the captain without any doubts regarding the values. In addition, the first officer on the left jump seat observed that these procedures had been performed correctly, but it is considered that he did not doubt the values on the data card and did not check them.

It is considered that if all four crew members were sufficiently experienced with the aircraft type, and if they had recognized the relationship between takeoff weight and speed described in section 2.13.2, because that values of V_1, V_R and V_2 for a takeoff weight of 745,000lbs are in the range 150–180kt, they would have recognized that the speeds recorded on the data card prepared by FE were abnormally low.

(2) As described in section 2.13.3, ATT is specified as 12 deg. at a takeoff weight of 745,000lbs using RTG-II thrust, but the value of ATT recorded on the data card was 16 deg. Although this value is applicable at light takeoff weights below 560,000lbs., and ATT never reaches 16 deg. at a takeoff weight of 745,000lbs, it is considered that the flight crew had no doubts about the value of ATT.

Since the value of ATT is found on the same row as the speed data in the charts, it is thought that if the ATT value had been regarded as suspect, the FE's mistake in the data card preparation might have been realized.

3.1.5.4 From the start of Taxiing until Takeoff

At performing the Taxi and Takeoff Checklist while taxiing towards runway 34L, the captain and the trainee pilot each confirmed that the bugs set on their airspeed indicators agreed with the speed values recorded on the data card, but it is estimated that they did not check whether the speed values themselves were correct at this time. This is the final check before takeoff, and it is estimated that if they had wanted to confirm whether the speed values themselves were correct and had checked, they could have detected the erroneous values.

It is also estimated that the FE, who prepared the data card, was himself unaware that the speed values were in error.

3.1.5.5 Regulations in the NCA Operations Manuals

As described in 2.11.1, NCA's OM specifies procedures for data card entry and the roles of the captain, the first officer and the FE, but although from the descriptions in the manual it can be interpreted that the FE prepares the data card, there is no actual mention in the manual of who should check the data card. It is estimated that as a result, only the FE prepared the data card, and the trainee pilot took no part in its preparation as PNF.

The preparation and checking of particularly important items for operation such as data cards should never depend on only one crewmember. It is thought necessary that either item prepared by one crewmember (the FE in the accident) should be checked by another crewmember, or that several crewmembers should independently prepare and then crosscheck those items.

Although it is thought that the crew would not have ordinarily supposed that a simple mistake such as with the data card preparation would occur, sch mistakes can be made even by well-experienced persons. Since the correct preparation of data cards is an essential item that has a direct bearing on flight safety, it is necessary that flight crews should carry out their duties considering the possibility that this sort of mistake might be made.

3.1.6 Control during the Takeoff

(1) The captain began the takeoff based on the incorrect takeoff data, and flew the takeoff according to normal takeoff procedure. He operated the aircraft according to the normal takeoff method and the aircraft started to accelerate. As shown in the row "RTG-II at the accident" in the table in section 2.13.4, the average acceleration prior to rotation was 4kt/sec. And, according to the flight simulator tests, such a value is not particularly low compared to normal acceleration.

When the aircraft reached V_1, the FE felt that the speed was slower than normal but because the other crewmembers did not mention anything about this, it is thought that the other crewmembers did not feel the takeoff condition was different from normal. It is therefore thought that the crew couldn't recognize the erroneous speed values at this time.

(2) After the captain began the rotation, the acceleration of the aircraft became 2.1kt/sec. Although this is slightly lower than the acceleration of 2.5kt/sec. at a heavy gross weight described in 2.13.4(2), it is estimated that the captain continued the takeoff.

(3) The aircraft lifted off around 11 seconds after the captain started the rotation, a longer time than usual as described in 2.13.4(3). It is estimated that this was because the aircraft had not attained adequate speed for liftoff. The four crewmembers recognized that the liftoff took longer than usual, but because they did not feel that this was abnormal, they continued the takeoff in that condition.

(4) During the time from when the captain initiated rotation until the aircraft lifted off, the aircraft's speed reached the incorrect V_2 takeoff data value. As described in 2.13.4(4), based on the flight simulator tests, the aircraft would have reached V_2 before liftoff even if the correct value of V_2 had been used, so this condition during takeoff did not differ from the normal case and so it is considered that consequently, the crew did not sense anything abnormal.

As described in section 2.1.1, at 21:56:54 the control columns had been pulled back to 7.5 deg., but returned to 5.8 deg. at 21:56:55, at which time the aircraft pitch angle is estimated to have been 11.9 deg. At 21:56:56 pitch angle was 11.5 deg. and the control columns were at 6.6 deg., then at 21:56:57 pitch angle was 11.5 deg. and the control columns moved to 6.7 deg., and it is estimated that the aircraft lifted off at this time. Regarding these actions and changes, the captain stated that he rotated "at the standard rotation rate and the aircraft became airborne", but at around 21:56:53, when the pitch angle exceeded 11 deg., the lower surface of the aft fuselage was already in contact with the runway surface and this started to prevent pitch angle from increasing further. Pitch angle increase was thus restricted, and when it stabilized at around 11.9 deg. at 21:56:54, it is thought that the captain, unaware that tail contact had taken place, controlled the aircraft so as not to exceed that pitch attitude. While these actions were too late to avoid a tail strike, pitch angle reduced by around 0.5 deg. for approximately 2 seconds as a result, and this reduced the extent to which the aft fuselage was pressed onto the runway surface. While unintentional, it is considered that consequently the damage to the lower aft fuselage by the tail contact was minimal. After the aircraft had lifted off at a pitch angle of 11.5 deg., it is considered that the captain pulled the control column back again.

(5) If the rotation had been performed by smoothly raising the pitch angle to ATT

when the airspeed reached V_R, the aircraft would have lifted off at a pitch angle of around 9.1 deg., the transition point of control, as described in 2.13.4(1). However, since the captain did not suspect the values on the data card prepared by FE, and because he was unaware of the exact pitch angle at which the tail would contact the ground, even though the aircraft had not lifted off, as described in 2.13.6, it is estimated that the captain did not stop the rotation before the aircraft reached a pitch angle of 11.1 deg. and wait for the aircraft to lift off. It is considered that as a result of this, pitch angle increased to an angle at which the lower surface of the aft fuselage contacted the runway.

3.1.7 Aircraft Attitude and Time at Aft Fuselage Contact

Based on the table in section 2.13.6, it is estimated that the lower surface of the aft fuselage would not have contacted the runway surface before 21:56:53, when the aircraft's pitch angle had not yet reached 11.1 deg.

At 21:56:54 and 21:56:55, pitch angle reached 11.9 deg. and CAS was 151kt and 152kt respectively. These airspeeds are more than 15kt slower than the 168kt V_R corresponding to the takeoff weight and thrust, and since the aircraft had therefore not yet attained sufficient airspeed to lift off, the body gear would have been at zero tilt and the oleos would have been in a compressed state. Based on the table in section 2.13.6, it is therefore estimated that the lower part of the aircraft's aft fuselage was in contact with the runway surface, and had started to be damaged by abrasion as described in section 2.3.2 as a result.

3.1.8 Stall Speed and Takeoff Data

As described in section 2.11.3, the speeds recorded on the data card used at the time of the accident were V_1 124kt, V_R 132kt, and V_2 146kt. Furthermore, as described in section 2.13.1, the aircraft's stall speed corresponding to its weight at takeoff was 146kt, and the stick shaker operating speed was 163kt.

The correct V_R at the takeoff weight in this accident was 168kt, and although the captain should therefore have rotated at 168kt, it is estimated that he started the rotation when the speed passed 132kt because a V_R value of 132kt had been recorded on the data card. Since the airspeed was below the 146kt stall speed even at the start of rotation, the aircraft could not lift off within usual 6–7 seconds as described in section 2.13.4, but eventually lifted off around 11 seconds later when its speed reached around 160kt. Consequently, it is estimated that the liftoff in this accident occurred at a speed with no stall margin.

Since the V_2 of 146kt recorded on the data card was the same as the stall speed of 146kt corresponding to the takeoff weight in this accident, it is estimated that the aircraft could not have lifted off at this speed. After the aircraft had lifted off, its airspeed passing 35ft altitude was 163kt, considerably below the correct V_2 of 175kt. Further, the climb out after takeoff should be flown at V_2 + 10–25kt, so the aircraft should have climbed at a speed of 185–200kt (175 + 10–25kt) based on the correct value of V_2 corresponding to the takeoff weight in the accident. However, in the accident it is estimated that the aircraft climbed out at a speed of around 166kt (=146 + 20kt) based on the value of V_2 recorded on the data card.

While turning right at around 3,000ft, it is estimated because the aircraft was in a right roll, the speed at which the stall warning stick shaker activates increased by 5kt to around 168kt, and was therefore more easily triggered during the turn. Because of this, it is estimated that the stick shaker operated when the aircraft's speed dropped momentary below 168kt.

In consideration of the above, the aircraft's airspeed during takeoff and climb out had only small margin over the stall speed. Generally, it is thought that an aircraft is exposed to further risk when flying under such conditions because aircraft attitude changes or a change in wind direction or speed can lead to a loss of CAS and a stall.

3.1.9 The Crew's Response to the Stick Shaker Operation

At the time the stick shaker is thought to have operated, when the aircraft had reached an altitude of around 3,000ft and had started its first turn, its rate of climb appeared to decrease and its airspeed momentary increased by around 10kt, but this was still only to 175kt, around 20kt lower than the 195kt the climb speed should have been originally. It is estimated that the captain did not increase thrust at this time. In this case, it is considered that would have been safer to affect stall recovery procedures such as advancing the thrust levers to increase thrust together with reducing aircraft pitch angle, as is practiced in training.

3.1.10 Considerations for Engine Failure

In the accident, an failure of one engine before reaching the correct V1 takeoff decision speed of 156kt should have resulted in the takeoff being aborted. However, because the takeoff decision speed was mistakenly set to 124kt, if one engine had failed before reaching 156kt but after exceeding 124kt, the takeoff would have been continued. If the takeoff had continued under these circumstances, because acceleration would have been reduced due to the failed engine, it would have taken time to gain enough speed for takeoff, and there could have been risk due to marginal runway length and obstacles under the flight path beyond the runway.

However, since Narita Airport's runway 34L had a sufficient length of 4,000m, it is considered that there were none of the risks described above.

4. PROBABLE CAUSE

In this accident, while the aircraft was taking off from Narita Airport, it is estimated that liftoff was delayed due to rotation being initiated at lower than the appropriate speed, and that the lower surface of the aft fuselage contacted the runway surface, causing it to be damaged.

It is estimated that the following factors were involved in the rotation being started at lower than an adequate speed:

(1) When the FE prepared the data card, he did so reading the takeoff speeds and target pitch attitude from the chart corresponding to the aircraft's zero fuel weight instead of its takeoff weight by mistake and further, because he did not reconfirm, he did not realize his mistake.

(2) The captain, the trainee pilot acting as PNF, and the first officer had no doubts about the speed values on the data card prepared by the FE.

(3) The preparation of data cards at NCA is done solely by the FE, and other crewmembers are not involved in their preparation or reconfirmation.

5. OPINION

In this accident, despite all the flight crew — the captain, trainee pilot, first officer and FE — having ample experience on the aircraft type, the aircraft took off without their recognizing erroneous data on the takeoff data card, and the lower surface of the aft fuselage contacted the runway surface.

Because the rotation was started more than 30kt lower than the appropriate speed corresponding to its takeoff gross weight and takeoff thrust, and its speed during climbout was more than 30kt below the appropriate climb speed, it is considered that the aircraft was in a situation where it would have been exposed to farther danger in the event of changes in attitude or wind speed or direction.

Based on the above, it is considered that when conducting the pre-flight briefing with the assistant dispatcher, items essential for flight operations such as the takeoff data card should be prepared for the planned takeoff weight and the flight crew should note the approximate values, and furthermore, when preparing the takeoff data card in the cockpit based on the final takeoff weight, it is essential that the preparation and checking of the card should not be carried out by a single crewmember, but that a system of checking that involves several crewmembers should be established.

Furthermore, in the accident, since an experienced crewmember mistook the row he should have read in the data tables, and he further omitted to reconfirmation since he was in a rush due to the departure being delayed, all crewmembers should recognize the potential for anyone to commit such a mistake or oversight, and it is essential that operating procedures and checks necessary for safety should be positively carried out regardless of the circumstances.

Further, it is necessary for aircraft operators to take appropriate further steps to ensure flight safety, and to thoroughly instill such knowledge as the above in flight crews in order to prevent the recurrence of this type of accident.

6. MATTERS FOR REFERENCE

As the result of this accident, NCA issued a bulletin on December 12, 2003 involving the following as a measure to prevent recurrence, and thoroughly disseminated this to all flight crews.

Regarding the takeoff data card prepared by FE, the applicable section of normal operating procedures will be revised to add the confirmation by PNF. Confirmation by the PNF will also be added for the landing data card.

Figure1　Estimated Flight Route

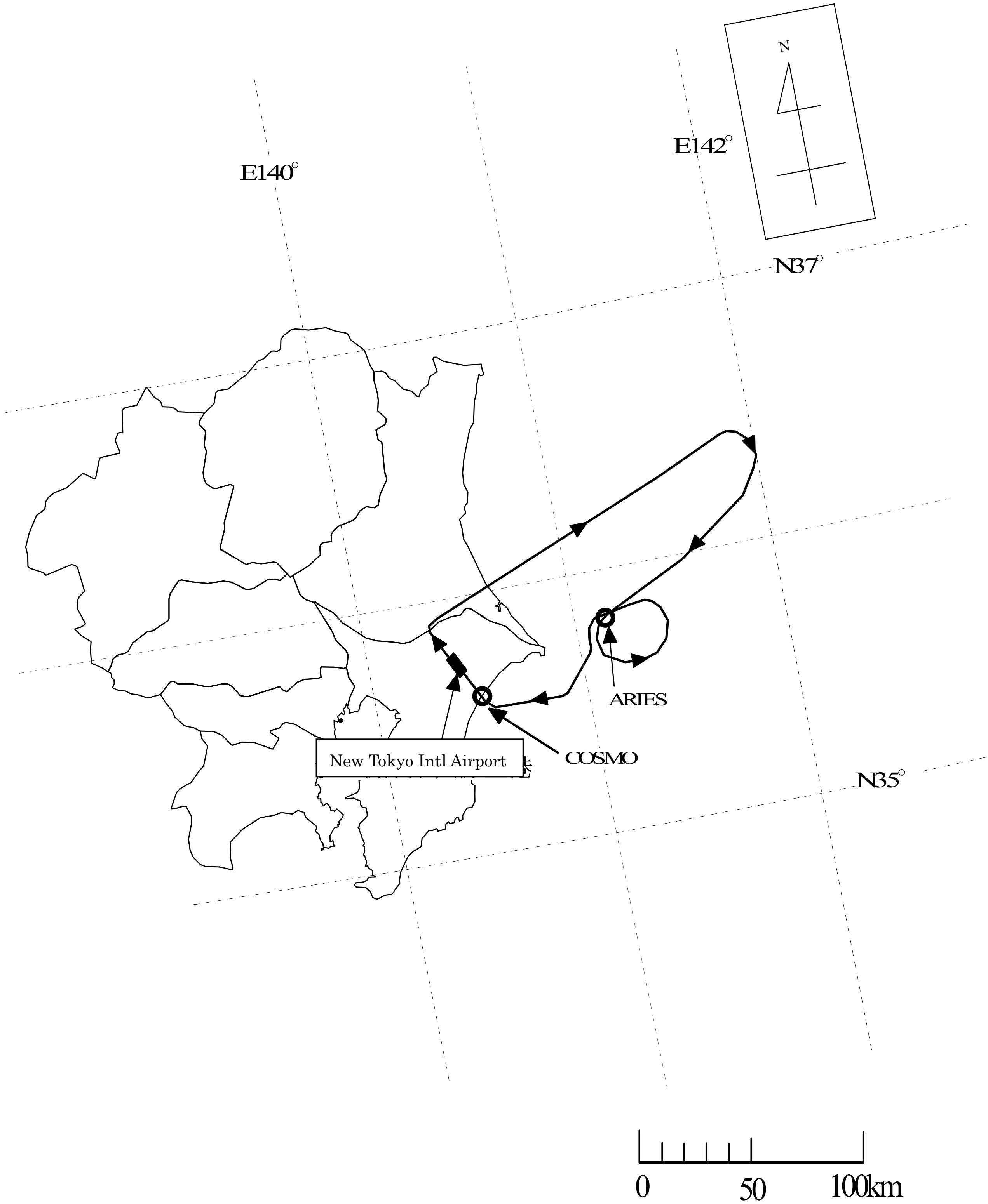


Figure2 Estimated tail contact point

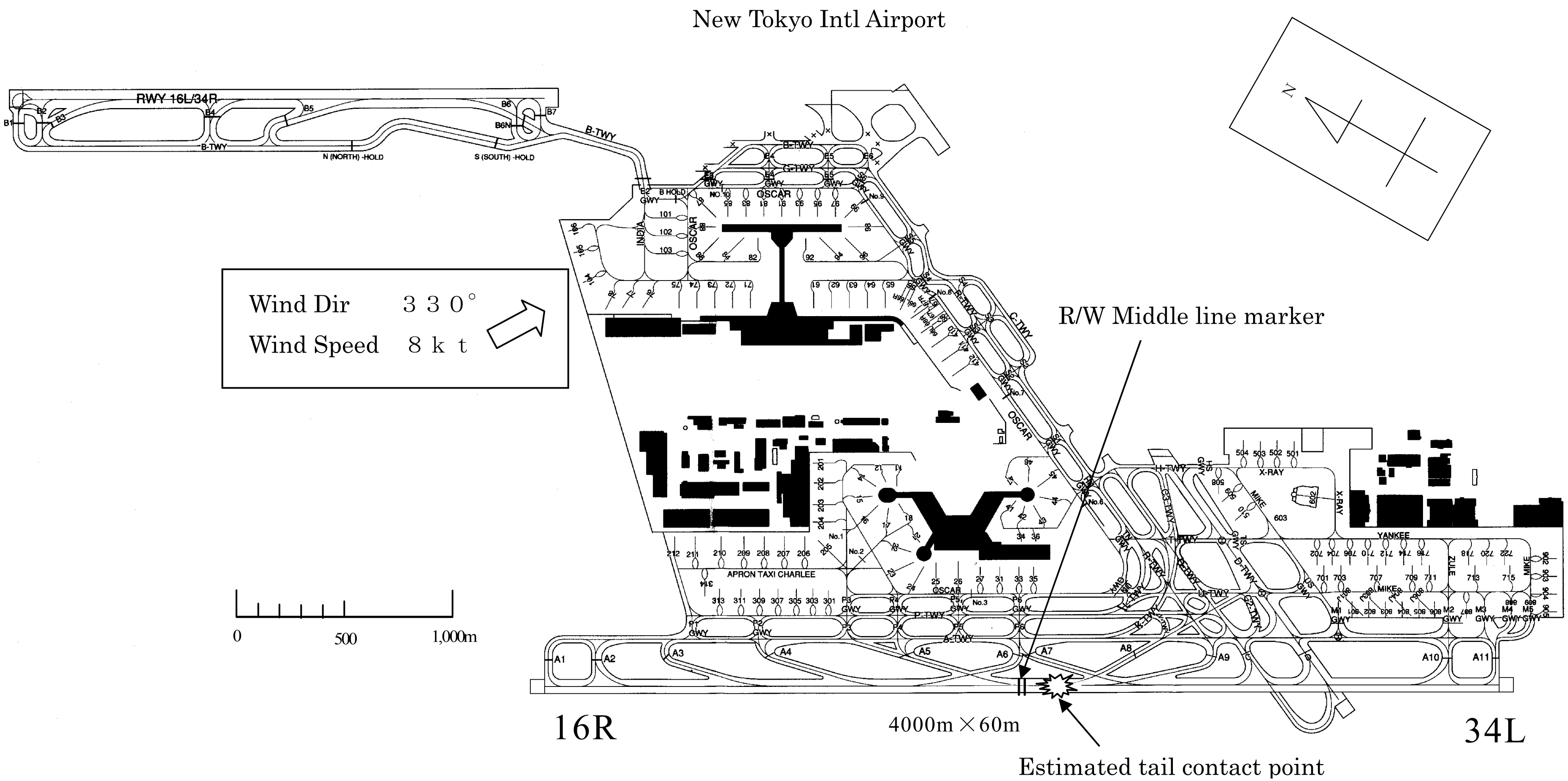


Figure 3　 Three angle view of Boeing 747-200F

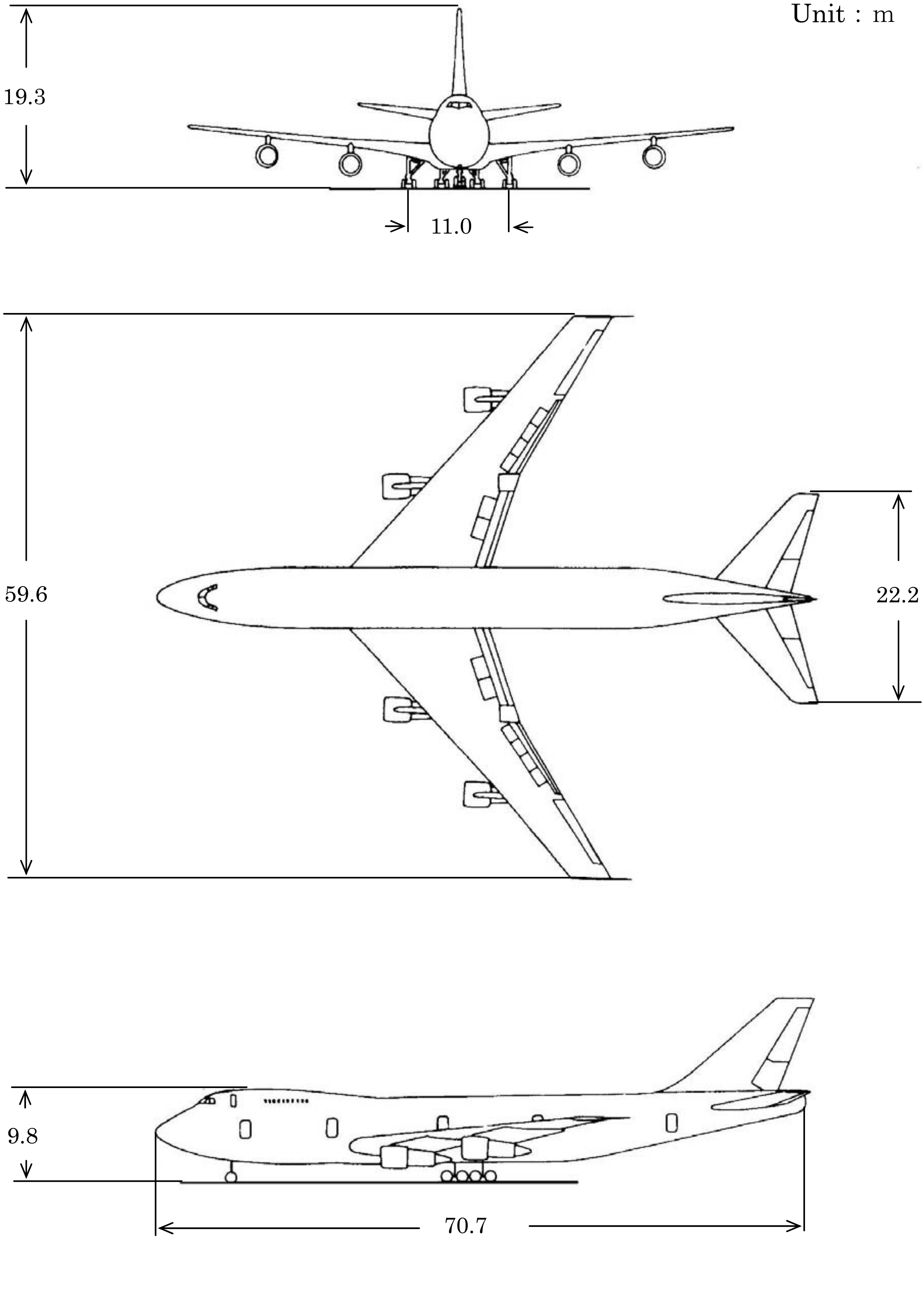
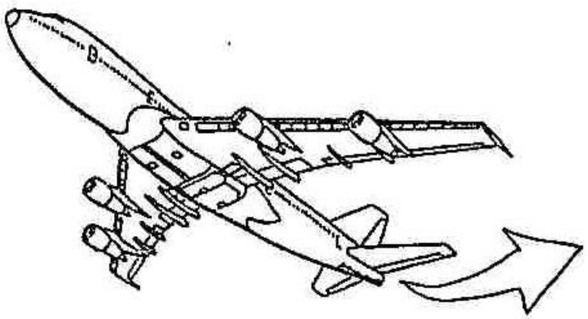


Figure 4　Damage Station



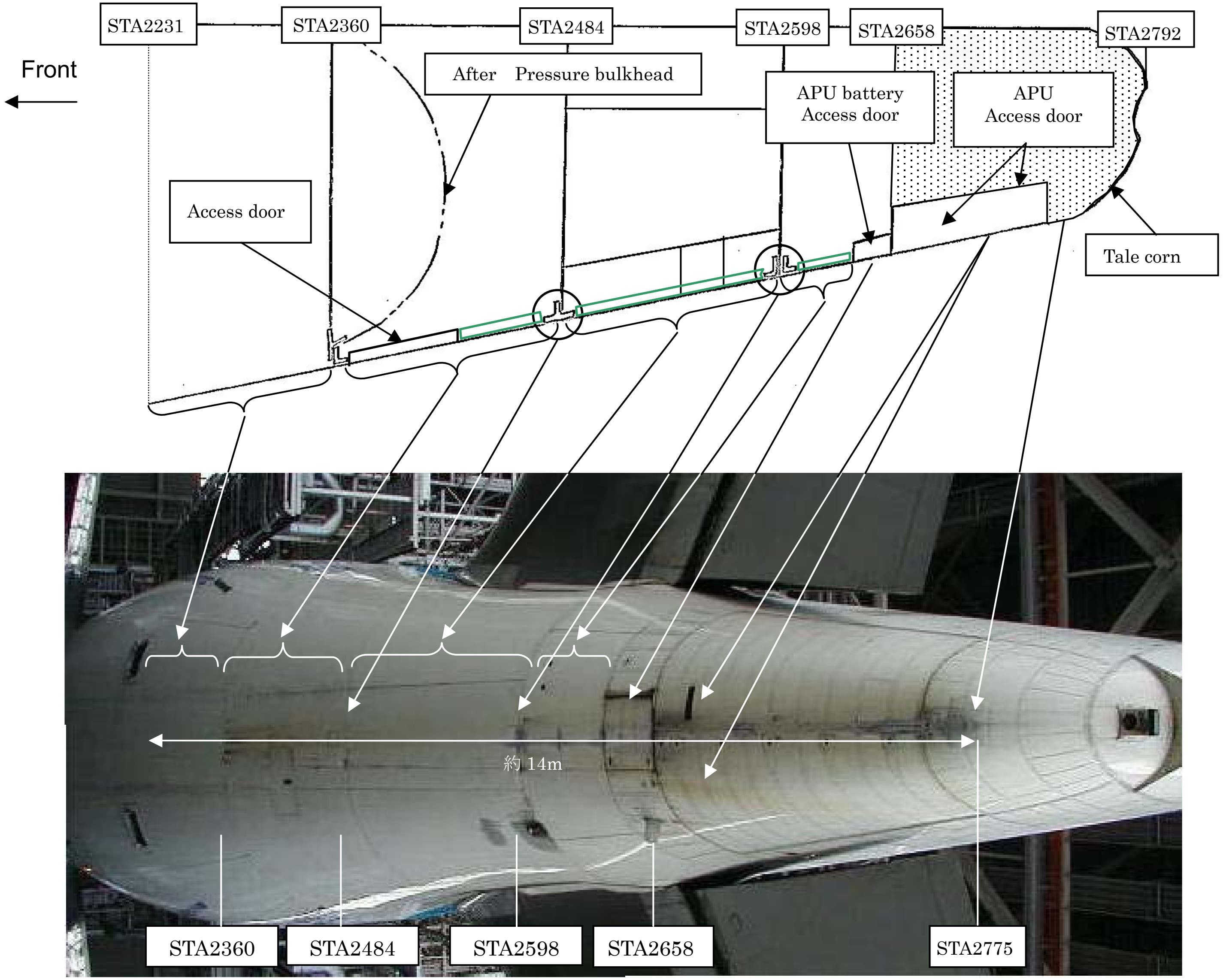


Figure 5 Data list that the FE used

TAKEOFF SPEED
DRY/WET
SNOW/ICE/SLUSH/FLDD
(NORMAL RANGE)

NOTE: SHADED AREA SHOWS V_1 AND/OR V_R IS LIMITED BY V_{MCG}.

V_1 ADJUSTMENT (V_1 MUST NOT BE LESS THAN V_{MCG})	WIND	−2KT/5KT TAIL
	SLOPE	−2KT/1% DOWN

P. ALT (−1000FT TO 999FT)
OAT (−54°C TO 32°C) (−65°F TO 90°F)

V1										GROSS WT ×1000 LB	VR	V2	CLM ATT	
15 / 11mm					35 / 25 mm	70 / 50 mm	WET		DRY					
G	MG	M 2mm SLUSH	MP	P	6mm SLUSH FLDD	12mm SLUSH	NG	G					3 ENG	4 ENG
158	156	153	149	144	148	155	159	163	168	833	182	188	11	14
157	155	152	148	143	147	154	158	162	167	830	181	187	11	14
155	153	150	146	141	145	152	157	161	166	820	180	186	11	14
153	151	148	144	139	143	150	155	159	164	810	178	184	11	14
151	149	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	158	163	800	176	183	12	14
149	147	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	157	162	790	174	181	12	14
148	145	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	156	161	780	173	180	12	15
146	143	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	155	159	770	171	178	12	15
144	141	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	154	158	760	170	177	12	15
142	139	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	152	156	750	168	175	12	15
140	137	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	151	155	740	166	174	[illegible]	15
138	135	132	128	123	127	135	145	149	153	730	164	172	12	15
136	133	130	126		124	133	143	148	152	720	163	171	13	16
134	131	128	123		123	131	141	146	150	710	161	170	13	16
132	129	126				129	140	145	149	700	159	169	13	16
130	127	123				126	138	143	147	690	157	167	13	16
128	125					124	136	141	146	680	156	166	13	16
126	123					123	134	139	144	670	154	164	13	16
124							132	138	143	660	152	162	14	16
123							130	135	141	650	150	160	14	16
							128	133	139	640	149	159	14	17
							126	131	137	630	147	157	14	17
							124	129	136	620	145	156	14	17
							124	127	134	610	143	154	14	17
							123	125	132	600	142	153	15	17
								124	130	590	140	151	15	17
								123	129	580	138	150	15	17
									127	570	136	149	15	17
									126	560	134	148	16	18
									124	550	132	146	16	18
									123	540	131	145	16	18
										530	129	144	16	18
										520	127	144	16	18
										510	125	143	16	18
123	123	123	123	123	123	123	123	123	123	500 & BELOW	124	143	16	19
VMCG=123Kt														

The correct number that was adapted. Between 750 & 740.

Wrong number that the FE used.

RTG II FLAP 10

Figure 6 Takeoff Data Card

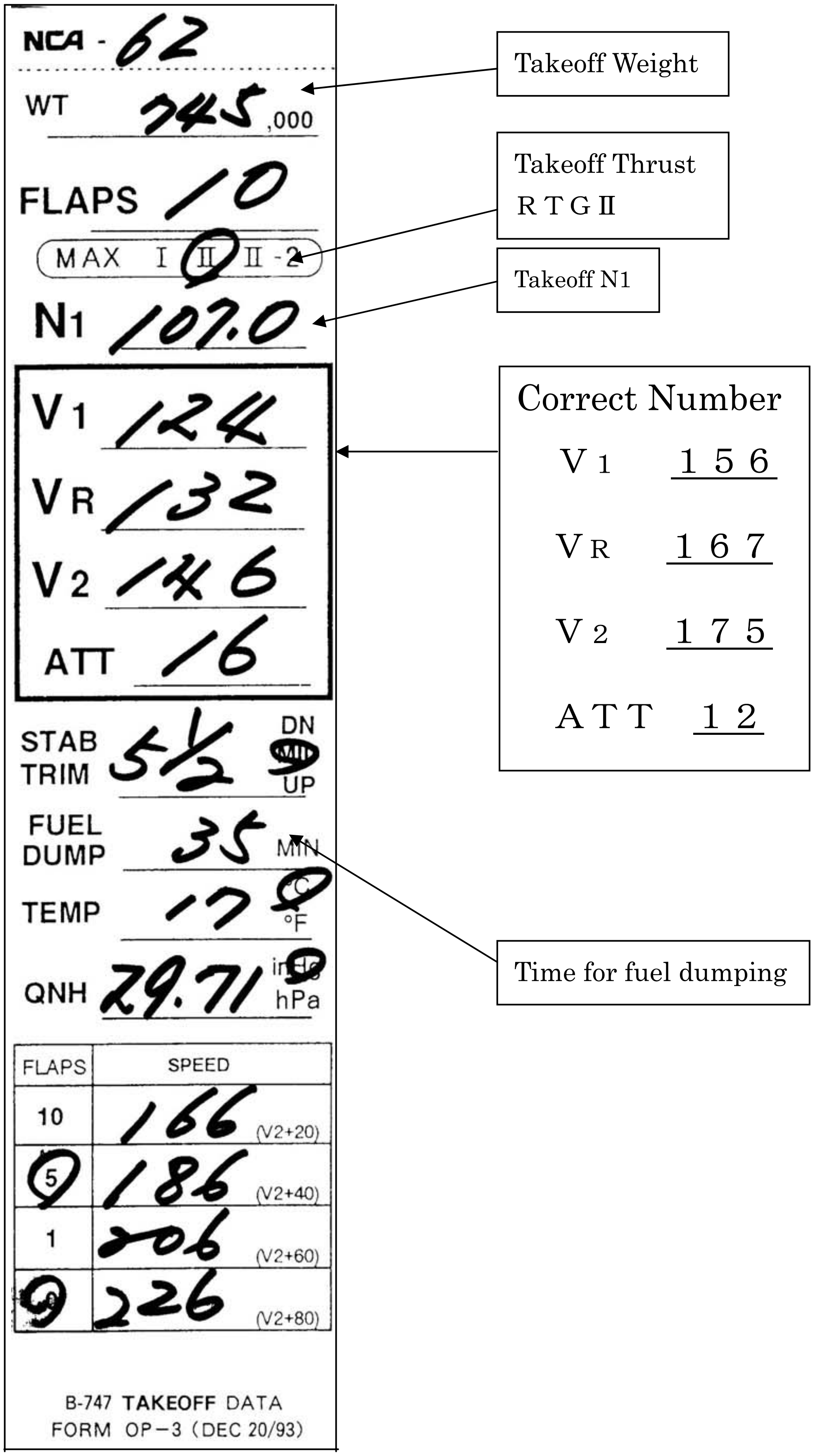


Figure7 Relations between Take-off weight and V1, V2,VR

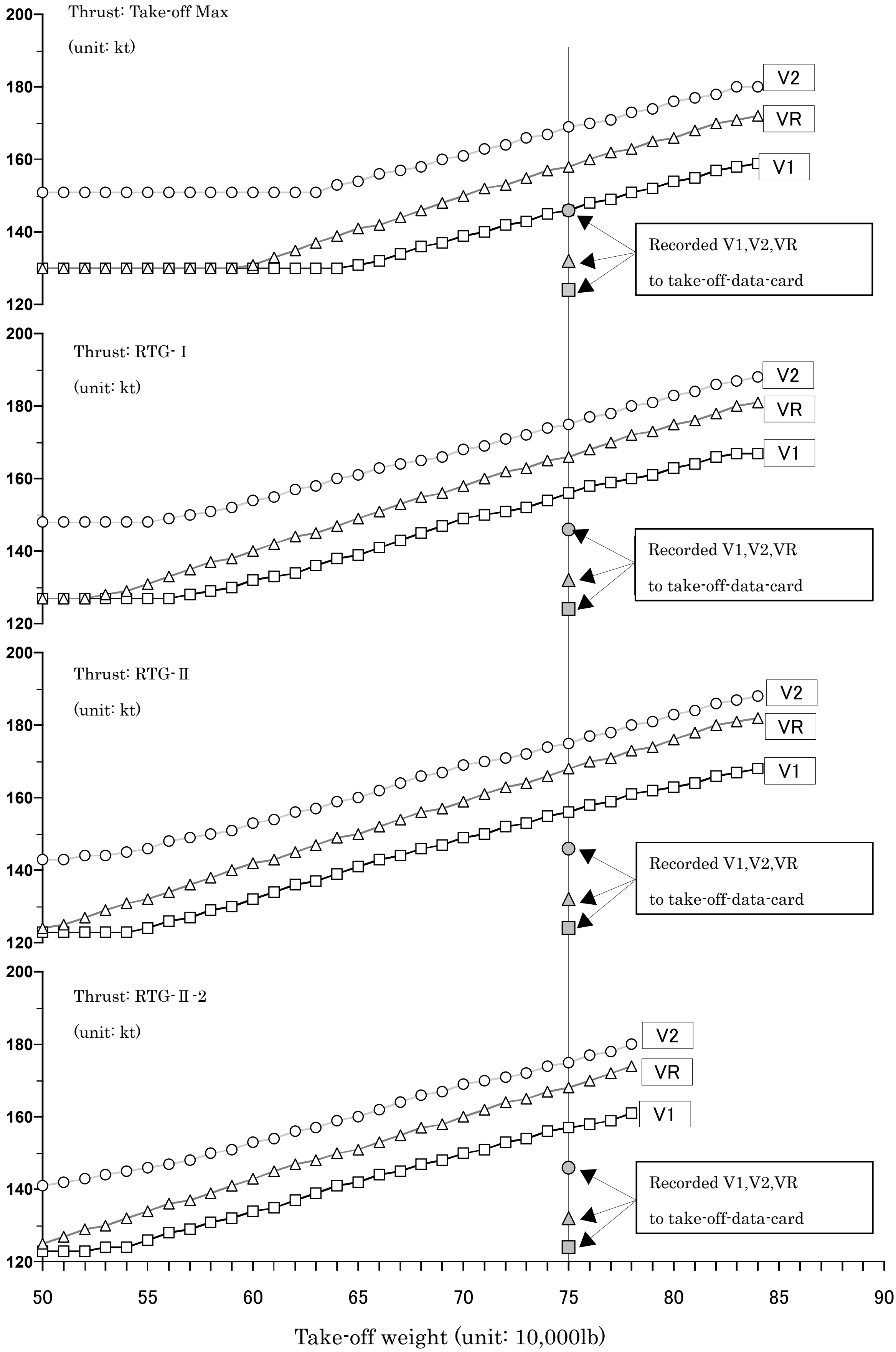


Figure8 Relations between Take-off Weight & ATT

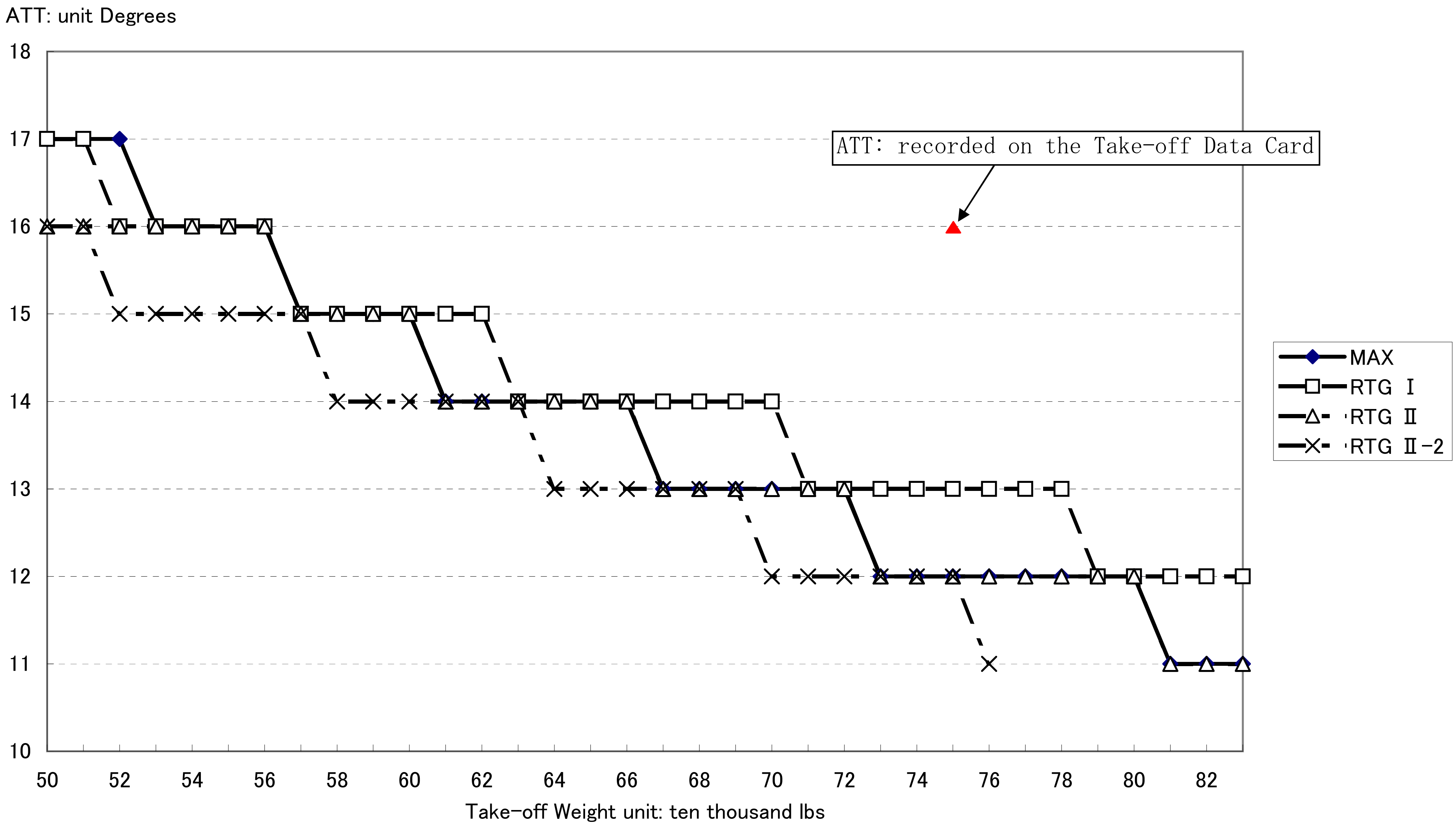


Figure9-1　DFDR Recording-1

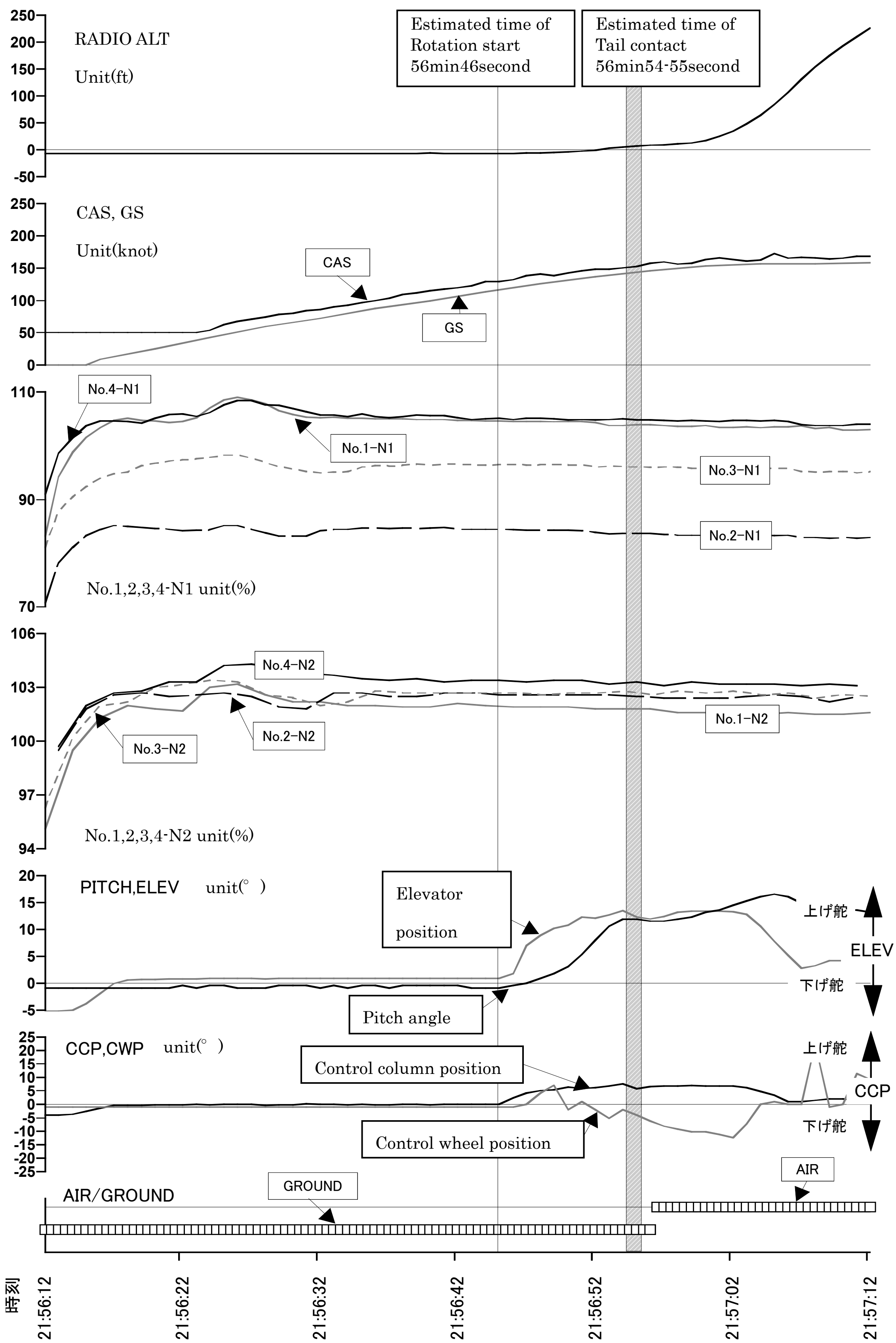
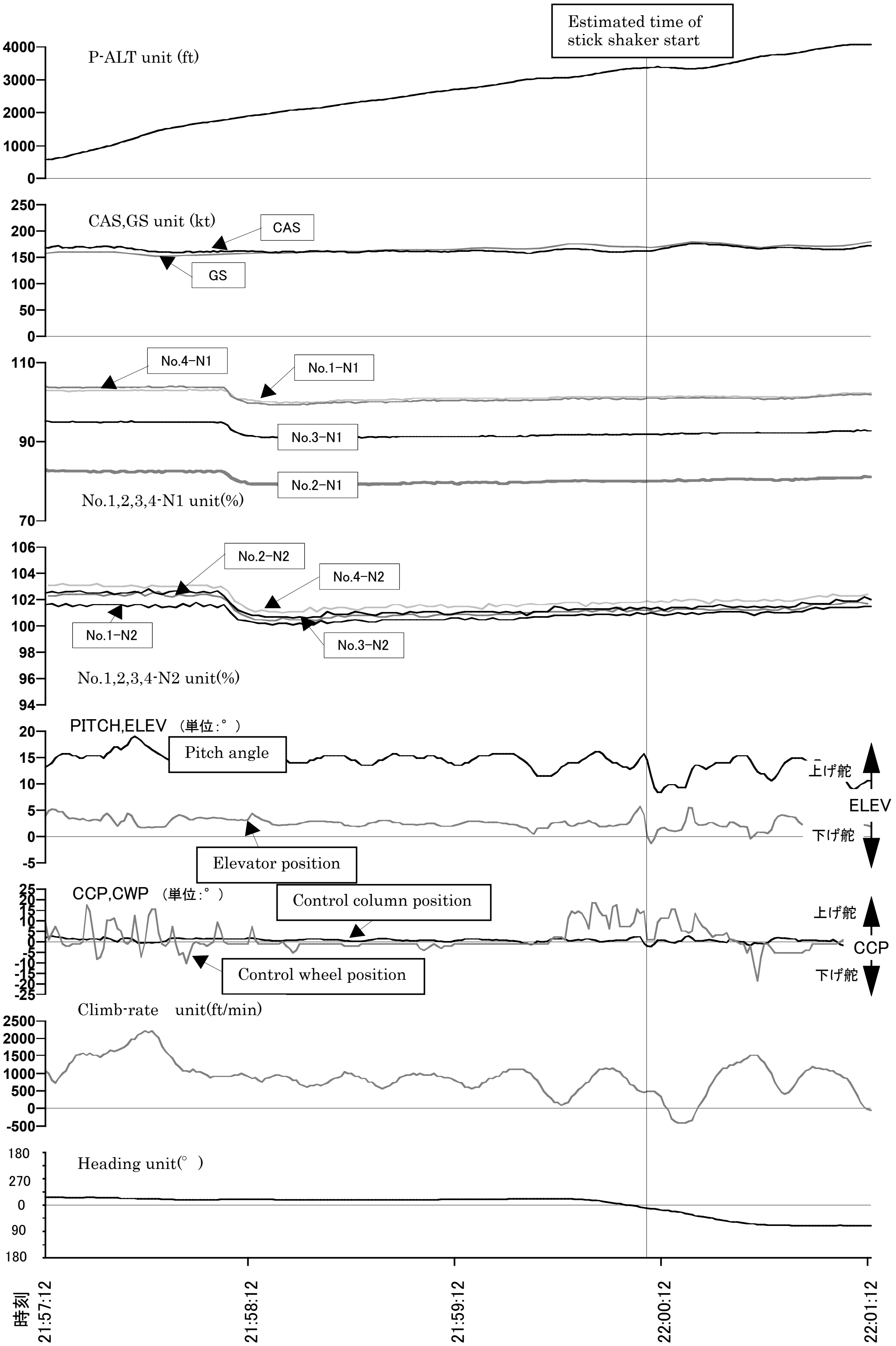


Figure9-2 DFDR Recording-2



Photograph 1　Damage of the tail corn