AA2016-6

AIRCRAFT ACCIDENT INVESTIGATION REPORT

ALL NIPPON AIRWAYS CO., LTD.
JA610A

July 28, 2016

Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board and with Annex 13 to the Convention on International Civil Aviation is to determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

Kazuhiro Nakahashi
Chairman,
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

AIRCRAFT ACCIDENT INVESTIGATION REPORT

AIRCRAFT DAMAGE CAUSED BY HARD LANDING
ALL NIPPON AIRWAYS CO., LTD.
BOEING 767-300, JA610A
NARITA INTERNATIONAL AIRPORT
AT ABOUT 13:23 JST, JUNE 20, 2012

July 8, 2016

Adopted by the Japan Transport Safety Board

Chairman	Kazuhiro Nakahashi
Member	Toru Miyashita
Member	Toshiyuki Ishikawa
Member	Sadao Tamura
Member	Keiji Tanaka
Member	Miwa Nakanishi

SYNOPSIS

<Summary of the Accident>

On June 20 (Wednesday), 2012 at about 13:23 Japan Standard Time (JST: UTC +9hrs, all times are indicated in JST on a 24-hour clock), a Boeing 767-300, registered JA610A, operated by All Nippon Airways Co., Ltd. as a scheduled Flight 956, experienced a bounce when attempting to land at Runway 16R of Narita International Airport and had a damage to the Aircraft by a strong impact.

There were a total of 193 persons on board, consisting of the Captain, nine crews and 183 passengers, and four cabin attendants suffered minor injuries.

The Aircraft sustained substantial damage, but there was no outbreak of fire.

<Probable Causes>

It is highly probable that this accident occurred by the damage to the aircraft is a result of the hard landing of the nose landing gear after its bounce when attempting to land at Runway 16R of Narita International Airport.

It is probable that the hard landing of the nose landing gear was caused because the Captain could not notice the bounce of the aircraft and controlled it to take a nose down position in order to make early touch-down of the nose landing gear.

It is probable that the continued landing with the aircraft being in an unstable posture caused by a crosswind with gust which occurs when there is a strong southwest wind around the airport contributed to the occurrence of the accident.

Abbreviations used in this report are as follows:

AOM :Airplane Operations Manual
AOR :Airplane Operations Reference
AP :Auto Pilot
AT :Autothrottle
BRK :Brake
CAS :Computed Air Speed
CCP :Control Column Position
CFIT :Controlled Flight Into Terrain
CG :Center of Gravity
CVR :Cockpit Voice Recorder
CWP :Control Wheel Position
DA :Decision Altitude
FAF :Final Approach Fix
FCTM :Flight Crew Training Manual
FD :Flight Director
FDR :Flight Data Recorder
FL :Flight Level
GPWS :Ground Proximity Warning System
ILS :Instrument Landing System
MAC :Mean Aerodynamic Chord
MDA :Minimum Descent Altitude
PF :Pilot Flying
PM :Pilot Monitoring
RA :Radio Altitude
REV :Reverse
RWY :Runway
SPD :Speed
STA :Body Station
UTC :Coordinated Universal Time
VREF :Reference Landing Speed

Unit Conversion Table

1 ft :0.3048 m
1 in :2.54 cm
1 nm :1,852 m
1 lb :0.4536 kg
1 kt :1.852 km/h (0.5144 m/s)
1 atm :29.92 inHg :1,013 hPa

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1. PROCESS AND PROGRESS OF THE AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident

On Wednesday June 20, 2012 at about 13:23 Japan Standard Time (JST: UTC + 9hrs, all times are indicated in JST on a 24-hour clock), a Boeing 767-300, registered JA610A, operated by All Nippon Airways Co., Ltd. as a scheduled Flight 956, experienced a bounce when attempting to land at Runway 16R of Narita International Airport and had a damage to the airframe by a strong impact.

There were a total of 193 persons on board, consisting of the Captain, nine crew members and 183 passengers, and four cabin attendants suffered minor injuries.

The aircraft sustained substantial damage, but there was no outbreak of fire.

1.2 Outline of the Accident Investigation

1.2.1 Investigation Organization

(1) On June 20, 2012, the Japan Transport Safety Board designated an investigate-in-charge and two investigators to investigate this accident.

(2) Two expert advisers were appointed for the investigation of the following technical matters with respect to this accident by the Board on August 3, 2012.

(i) Investigation on airframe structure
Atsushi Kanda
Structure Research Group, Aeronautical Technology Directorate
Japan Aerospace Exploration Agency (JAXA)

(ii) Investigation on airframe kinetics
Daisuke Kubo
Flight Research Group, Aeronautical Technology Directorate
Japan Aerospace Exploration Agency (JAXA)

(3) Fracture surface analysis of the fuselage damaged part was entrusted to National Institute of Material Science (NIMS).

1.2.2 Representatives from the Relevant State

An accredited representative of the United States of America, as the State of Design and Manufacture of the aircraft involved in this accident, participated in the investigation.

1.2.3 Implementation of the Investigation

June 20, 2012: Interviews
June 21, 2012: Interviews and aircraft examination
June 28, and July 23 and 24, 2012: Aircraft examination
August 7 through September 6, 2012: Fracture surface analysis of damaged part
August 8 and 9, 2012: Teardown investigation of nose landing gear
August 31, 2012: Aircraft examination
September 13, 2012: Teardown investigation of nose landing gear wheel
October 3, 2012: Investigation of operating company

June 7, 2013:	Progress meeting for investigation matters
August 29, 2012 through September 24, 2015:	Structural and kinetic analyses

1.2.4 Comments from the Parties Relevant to the Cause of the Accident

Comments were invited from the parties relevant to the cause of the accident.

1.2.5 Comments from the Relevant State

Comments on the draft report were invited from the relevant State.

2. FACTUAL INFORMATION

2.1 History of the Flight

On June 20, 2012, the Boeing 767-300, registered JA610A operated by All Nippon Airways Co., Ltd. (hereinafter referred to as “the Company”) departed as its scheduled Flight 956 from Beijing Capital International Airport at 10:26 (hereinafter indicated in JST on a 24-hour clock unless specifically noted), headed for Narita International Airport (hereinafter referred to as “Narita Airport”)

In the aircraft, the Captain sat in the left seat as PF (Pilot Flying: pilot mainly in charge of flying) and the First Officer sat in the right seat as PM (Pilot Monitoring: pilot mainly in charge of duties other than flying).

The outline of the flight plan of the aircraft was as follows:

Flight rules: Instrument flight rules
Departure aerodrome: Beijing Capital International Airport
Estimated off-block time: 00:30 (UTC)
Cruising speed: 865 km/h
Cruising altitude: S1070
Route: Omitted - A597 (airway) – LANAT (position reporting point) - Y51 (RNAV route) - SAMON (waypoint) - Y517 (RNAV route) - LIVET (waypoint) - Y303 (RNAV route) - SWAMP (position reporting point)
Cruising speed: 480 kt
Cruising altitude: FL 350, Route: Y30 (RNAV route) - MELON (waypoint)
Destination aerodrome: Narita Airport
Total estimated elapsed time: 3 hours 3 minutes
Fuel load expressed in endurance: 5 hours 7 minutes
Alternative aerodrome: Tokyo International Airport

According to the air traffic control communication records, the records of the flight data recorder (hereinafter referred to as “the FDR”), and the records of the cockpit voice recorder (hereinafter referred to as “the CVR”) as well as the statements from the flight crew members, the history of the flight up to the time of the accident is as outlined below.

2.1.1 History of the flight based on the air traffic control communication records and records of FDR and CVR

About 12:33 to 12:37 While the aircraft was cruising in FL390, the Captain held approach briefing and decided to request Runway 16R for landing, set the target approach speed to reference landing velocity (V_{REF}[*1]: 138 kt for the weight at that time) plus 7 kt, and make the auto braking setting of 3.

About 13:04 When descending to an altitude of 11,000 ft, the aircraft established communication with Tokyo Approach Control Center (Tokyo Approach). Although Runway 16L was designated, it requested Runway 16R. Then Tokyo Approach allowed it to land at Runway 16R and commenced a radar vectoring.

[*1] V_{REF} is a reference velocity of landing.

About 13:08	Upon a request from another aircraft, Tokyo Approach gave a wind shear[*2] report for landing at Runway 16L: 10 kt decrease at an altitude of 700-500 ft, reported 4 minutes before by Boeing 767. In addition, Tokyo Approach reported that there was no wind shear report for landing at Runway 16R.
About 13:12	The aircraft established communication with Tokyo Approach Control Center (Tokyo Radar).
About 13:17	Tokyo Radar cleared the aircraft to make ILS approach to Runway 16R.
13:18:31	The aircraft established communication with Narita Airport Control Facility (hereinafter referred to as “the Tower”). The Tower issued clearance the aircraft to land on Runway 16R and informed that the wind direction was 230° and the wind velocity was 8 kt. The aircraft read back it.
13:18:53	The Tower requested the aircraft to report the wind shear information after landing. The aircraft acknowledged it.
13:19:00	The Captain talked with the First Officer about the increase of wind velocity indicated by the instrument (wind velocity at an altitude of that time) to 44 kt.
13:19:24	At an altitude of 2,800 ft, the Captain made a call “Glideslope Capture” and the First Officer made the same call.
13:19:38	The aircraft passed the final approach fix (8 nm from the threshold of Runway 16R, hereinafter referred to as FAF).
13:19:43	The Captain ordered gear down and then flap 20 to the First Officer.
13:20:09	The Captain and the First Officer began performing a landing check list using and suspended the check, leaving the check item “Flap”.
13:20:14	Since the instrument indicated the wind velocity of 50 kt, the Captain said that “Wind shear warning” would be issued and confirmed together with the First Officer a procedure to take in the event of the warning.
13:20:33	The First Officer called the runway insight and the Captain also called it.
13:20:55	The Captain ordered flap 25 to the First Officer, confirmed the flap 25 together with the First Officer, and finished on the landing check list using.
About 13:21	The change of the wind direction and speed began. Roll angle and pitch angle began the change. Since then, there were continued changes of ±5° or larger in the roll angle (+: right roll) and about ±3° in the pitch angle (+: nose up).
13:21:19	The Captain changed the target approach speed to VREF + 10 kt (148 kt).
13:21:28	The First Officer called altitude 1,000 ft and the Captain responded “No Flag” (meaning that the instrument was working properly).
13:21:41	The First Officer said that the wind velocity indicated on the instrument was about 35 kt.
13:22:10	The First Officer called altitude 500 ft and the Captain responded “Stabilized” and continued the approach.
13:22:16	The First Officer called “Airspeed” (meaning that the airspeed was out of

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[*2] Wind Shear is a considerable change of the wind direction or wind velocity in the horizontal or vertical direction.

	the designated range) and the Captain responded “Checked”. At that time, the FDR recorded the airspeed of 140 kt (8 kt slower than the target approach speed.)
13:22:19	The auto-throttle (hereinafter referred to as “the AT”) was disconnected, and then the auto-pilot (hereinafter referred to as “the AP”) was disengaged.
13:22:31	The FDR recorded the airspeed of 164 kt (16 kt faster than the target approach speed.).
13:22:33	The First Officer called “Minimum” (meaning the decision altitude) and the Captain responded “Landing”. At that time, the FDR recorded the airspeed of 150 kt (2 kt faster than the target approach speed.).
13:22:36	The FDR recorded the airspeed of 137 kt (11 kt slower than the target approach speed.).
13:22:40	The First Officer called “Airspeed” again to pay attention to the air speed and the Captain responded “Checked”. At that time, the FDR recorded the airspeed of 159 kt (11 kt faster than the target approach speed.).
13:22:41	There was a call out in automatic voice[*3] (hereinafter referred to as “the Automatic Call”), “One hundred” (radio altitude of 100 ft). Then the Automatic Calls continued, “Fifty” (radio altitude of 50 ft), “Thirty” (radio altitude of 30 ft), “Twenty” (radio altitude of 20 ft), and “Ten” (radio altitude of 10 ft.)
13:22:47	The FDR recorded the pitch angle of -1.6°.
13:22:49	Only the right main landing gear touched down (vertical acceleration: 1.58 G) with the pitch angle of about +5°, roll angle of about +4°, and airspeed of 143 kt, and about 1 second after that, the aircraft rebounded into the air.
13:22:51	Immediately after the nose landing gear touched down, the right main landing gear touched down again, and then the left main landing gear touched down (vertical acceleration: 1.72 G).
13:22:52	The nose gear rebounded into the air. The speedbrakes deployed and the thrust reversers began to deploy.
13:22:53	The nose landing gear touched down again and the FDR recorded the maximum vertical acceleration of 1.82 G.
13:23:14	The First Officer called “Autobrakes” (meaning the release of the autobrake.)
13:23:18	The First Officer called “Sixty” (meaning the airspeed of 60 kt.)

During the approach, there was no record of the issuing of a wind shear warning. The motion of the elevator was consistent with the CCP (control column position) inputs and the motion of the aileron was consistent with the CWP (control wheel position) inputs. After the landing, there was no call about speedbrake from the First Officer.
(See Fig. 2 Estimated Flight Route, Figs. 3-1 through 3-3 FDR Records, and Fig. 4 Events in the

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[*3] “Call out in automatic voice” is verbal expression of a ground altitude (ft) measured by radio waves in English and helps pilots know the timing of starting the flare and the descending rate.

during Flare (descending Rates and Automatic Calls))

2.1.2 Statements of the Flight Crew members

Sections 2.1.2(1) and 2.1.2(2) below represent the accounts of the event made by the Captain and First Officer based on interviews performed following the event.

(1) The Captain

Prior to the take-off, the Captain had a pre-flight briefing in the aircraft and expected air traffic control congestion at Beijing Capital International Airport and congestion due to the influence of the weather when landing at Narita Airport. Additional loading of reserve fuel for 20-minute flight was presented in the flight plan and approved by the Captain. The Captain assigned himself of PF and the First Officer of PM for the flight.

In a briefing with the cabin attendants, the Captain told them that there could be air turbulence and go-around when approaching Narita Airport due to strong crosswind with gust expected to occur at around estimated time of arrival at Narita Airport.

The aircraft cruised almost steadily after the take-off. The Captain acquired weather information of Narita Airport before descending for the landing and recognized that Narita Airport had strong southwest wind with gust and that Runway of the aircraft would be 16L. The Captain and the First Officer held a briefing based on the information. In the briefing, he said that the flap 25*4 was selected for the landing and the target approach speed was set to V_{REF}+7*5 (145 kt), and that he would request landing on Runway 16R, the longer runway, to the Air Traffic Control, and requested the First Officer to make safety advices proactively.

The Captain illuminated the seat-belt sign about ten minutes prior to the scheduled landing, and sent to the cabin attendants a final check signal for the landing. The aircraft received clearance from Tokyo Radar to approach Runway 16R, and then to land on it. He began to prepare for final approach using AP and AT and completed the pre-landing check list using.

From an altitude of about 2,800 ft at which the glide slope captured, the crosswind to the right side of the nose of the aircraft became stronger with considerable gust. To respond to a rapid decrease of the velocity, the Captain changed the target approach speed to V_{REF}+10 (148 kt).

At an altitude of about 1,000 ft, the instrument in the cockpit showed that the crosswind component of the wind had a velocity of about 30 kt and the velocity of the wind reported from the tower*6 was 8 kt; therefore, the Captain expected that there would be a wind shear some time during the approach. At an altitude of about 500 ft, the crosswind component became weaker a little, and AT and AP were went on to manual control.

The Captain remembered that the First Officer made several velocity deviation calls*7 at an altitude of about 1,000 ft or lower. He responded to the calls properly and the path (approach angle) was maintained properly at all times. During the approach, a wind shear warning was not issued.

The Captain confirmed that the aircraft had the aiming thrust*8 at the runway threshold and began flare operation also using automatic calls as reference. Although a small wind correction angle toward the wind was necessary, he was maneuvering the aircraft so that the longitudinal axis almost

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*4 The flap of the Aircraft for the landing can be chosen from 25 and 30.

*5 "+7" means that the wind additive (velocity to add) to V_{REF} is 7 kt. Pilots determine this wind additive when necessary according to the wind situation.

*6 "Wind reported from the tower" is 2-minute average wind measured in the area around the runway.

*7 "Deviation call," specified as ordinary operation by an aircraft operating manual, is a call made by PM to PF when the velocity, descending rate, or others deviates from a designated range.

*8 "Aiming thrust" is the thrust that pilots use as a guide to keep the aircraft velocity in a stable way.

aligned with the runway centerline. Hearing the automatic calls of 50 (fifty), 30 (thirty), 20 (twenty), and 10 (ten), he noticed that the interval between the automatic calls of 20 (twenty) and 10 (ten) was shorter than usual, and also felt sudden descending of the aircraft. He then maneuvered controlled the aircraft to take a nose up position with the elevator. The aircraft, in a nose up position, landed on the runway with relatively strong impact. There was no call about speedbrake from the First Officer.

Considering that the right main landing gear touched down and the aircraft began a landing roll and that early touch down of the nose landing gear to keep its heading would be safer for the landing roll in the strong crosswind, the Captain controlled the aircraft to take a nose-down position by pushing the control column forward. He considered that the main landing gear was still on the runway, but the nose landing gear touched down in the nose-down position. At that moment, he recognized that the aircraft bounced and the main landing gear floated.

Then the main landing gear touched down severely and the nose landing gear floated. At that moment, the Captain prioritized maintaining the heading and did not begin a reverse control. He momentarily thought about go-around; however he remembered the tail strike accident of affiliated company (described in 2.11.4). Accordingly, he got to avoid its accident in mind and did not executed a go-around. He decided to recover the attitude of the aircraft and make the nose landing gear touch down again.

During the taxiing from the taxiway to the apron, the Captain asked the cabin attendants about the situation of the cabin, and they answered that there was no abnormality.

The aircraft could run properly to the apron.

On the apron, the Captain told mechanic that the landing had been slightly hard and the mechanics inspected the exterior of the aircraft, and then reported to him that there was damage on the aircraft.

(2) The First Officer

In the pre-flight briefing, the First Officer confirmed the weather forecast that there would be strong crosswind in Narita Airport at around the arrival time of the aircraft. Concerned about the wind conditions in Narita Airport during the flight, he successively acquired weather information of Narita Airport. In the briefing before the commence descent, the Captain told him that landing at Runway 16R would be requested because it had a lower wind velocity and longer runway in comparison with Runway 16L. After that, he requested landing on Runway 16R to Tokyo Approach and it was approved.

The Captain first set the target approach velocity to V_{REF}+7, but changed it to V_{REF}+10 when the aircraft entered on the final approach.

The First Officer made the speed deviation calls several times at an altitude above ground of 1,000 ft or lower. The last deviation call was probably for the speed exceedance from the target approach velocity by 10 kt at around the decision altitude. Since the speed of the aircraft gradually decreased but the thrust was about 60%, which was the aiming thrust, he considered that the thrust was enough to maintain the speed. There was no problem of its path. The flare began at around 30 ft and he felt no abnormality in the pitch until the start of the flare. He then recognized that the interval between the automatic calls of “20” and “10” was shorter than usual and the rate of descent was large. At that moment, the right main landing gear of the aircraft touched down but he did not consider that it was hard landing. Also he did not feel that the aircraft was floating. Therefore, according to ordinary procedure after landing, he tried to look at the speedbrake lever on the right side of the left seat in order to confirm that the speedbrake was activated. At that moment, he found that the pitch went down rapidly and lifted his eyes to the front. Accordingly, he could not make a call about the speedbrake. The impact of the touch-down of the nose landing gear was large.

After that, the main landing gears of the aircraft touched down and the nose landing gear jumped up. Since it would had been dangerous if the nose landing gear had touched down again and jumped up, the First Officer considered making a call of go-around. However he considered that the aircraft could stop because the nose landing gear did not float again.

The auto-brake was set to 3 and the Captain made usual reverse control.

In the apron, the mechanic said that there was damage on the airframe.

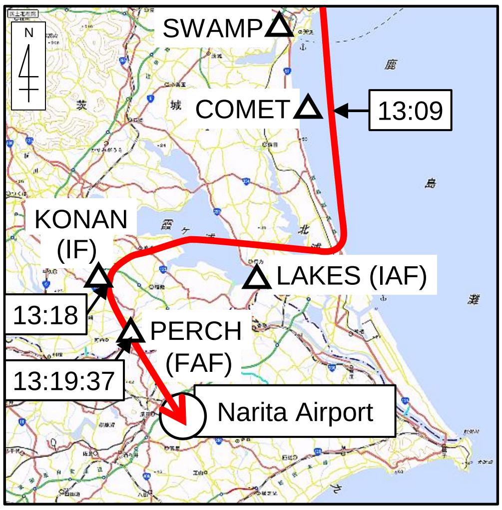

Fig. 2.1 Estimated flight route

The accident occurred on Runway 16R of Narita Airport (35° 50’ 30” N, 140° 3’ 50” E) at around 13:23, on June 20, 2012.

2.2 Injuries to Persons

There were a total of 193 persons on board, consisting of the Captain, nine crew members and 183 passengers, and four cabin attendants suffered minor injuries.

2.3 Damages to the Aircraft

2.3.1 Extent of Damage

Substantial damage

2.3.2 Damages to the Aircraft Components

Outer panel (fuselage): Fractured and deformed

Structural component (fuselage): Fractured and deformed

Nose landing gear: Deformed

2.3.3 Details of Damage

(1) Outer panel (fuselage)

Fracture, deformation, and distortion (STA[*9]654+22-654+66) in the forward fuselage upper crown and minor distortion near the nose landing gear retraction door (STA276-303) were found.

(2) Structural component (fuselage)

Cracks and deformation on a frame (STA654+44) and 36 stringers (STA654-654+110) of the fuselage were found.

(3) Nose landing gear

The nose landing gear had two wheels.

Upward deformation from the wheels axis, wheels deformation, and scratches on the shock strut and inner cylinder liner were found. In the investigation by the tire manufacturer, a sign of

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[*9] “STA” indicates fuselage station, designating location along the length of the aircraft, and is expressed by the distance from a virtual plane at the nose in unit of inch.

contact between inner surfaces of the tires and a wrinkle were found inside the tires. (This will be described in 2.8.4.)

(See Photo 1: Aircraft Involved in the Accident; Photo 2: Fracture and Deformation of Outer Panel and Structural Component)

2.4 Personnel Information

(1) The Captain Male, Age 44

Airline transport pilot certificate (Airplane)	February 7, 2005
Type rating for Boeing 767	July 17, 1997
Class 1 aviation medical certificate	
Validity	June 19, 2013
Total flight time	9,249 hr 25min
Flight time in the last 30 days	69 hr 50 min
Total flight time on the type of aircraft	6,408 hr 53 min
Flight time in the last 30 days	69 hr 50 min

(2) The First Officer Male, Age 30

Commercial pilot certificate (Airplane)	February 23, 2007
Type rating for Boeing 767	August 18, 2008
Instrument flight certificate	November 16, 2007
Class 1 aviation medical certificate	
Validity	February 2, 2013
Total flight time	1,847 hr 21min
Flight time in the last 30 days	60 hr 38 min
Total flight time on the type of aircraft	1,592 hr 51 min
Flight time in the last 30 days	60 hr 38 min

2.5 Aircraft Information

2.5.1 Aircraft

Type	Boeing 767-300
Serial number	32979
Date of manufacture	November 22, 2002
Certificate of airworthiness	No. 2003-009
Validity	Period starting from April 16, 2003 during which the maintenance rules (All Nippon Airways Co., Ltd.) are applied.
Category of airworthiness	the Aircraft Transport T
Total flight time	28,043 hr 04 min
Flight time since last periodical check (C05C inspection: January 31, 2011)	4,992 hr 06 min

(See Figure. 1: Three View Drawing of Boeing 767-300)

2.5.2 Weight and Balance

When the accident occurred, the weight of the aircraft was estimated to have been 274,400 lb and the position of the center of gravity (CG) was estimated to have been 25.5% mean aerodynamic chord (MAC)[*10]. Both of them were estimated to have been within the allowable range (the maximum landing weight of 345,000 lb, and CG of 11.8 to 32.9% MAC corresponding to the weight at the time of the accident).

2.5.3 Records of Maintenance and Repair

According to the maintenance records, there was no malfunction at the time of the accident, no repair record of the structural components, or no major repair of the upper fuselage.

2.6 Meteorological Information

2.6.1 General Information from Surface Analysis Chart

According to Asia Pacific surface analysis chart of 15:00 on June 20, 2012, there was a low pressure with central pressure of 998 hPa moving northeast on the east sea of the Tohoku region, Japan, which changed from Typhoon No. 4. A cold front extending from the low pressure was extended in the southern part of Kyushu the Kanto coastal sea. In addition, there was a low pressure with central pressure of 996 hPa moving east over the Sea of Japan.

Besides, a high pressure with the central pressure of 1016 hPa became stationary over the south side of Japan and the pressure gradient between the high pressure and the above two low pressures was growing.

The weather in Chiba Prefecture was forecasted to be fine with strong wind.

Moreover, the 850 hPa upper air weather chart of 09:00 on June 20, 2012 indicated that there was southwest wind at an altitude of about 1,500 m over the area covering Hokuriku, Kanto, and the Ogasawara Islands under the influence of the low pressure over the Sea of Japan, and that the wind velocity was 20 kt as of 09:00.

The wind direction and velocity data from Automated Meteorological Data Acquisition System called AMeDAS of 13:20 around the time of the accident indicated that the area covering Tokyo Bay and Narita Airport was in a strong wind area with prevailing southwest wind.

(See Fig. 2.6.1.)

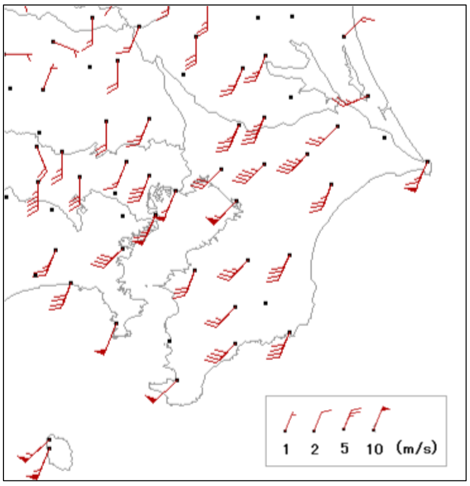

Fig. 2.6.1 AMeDAS data
(wind direction and velocity)

The radar observatory data at that time indicated that Kanto Plain including Narita Airport was not in a precipitation area (radar echo).

(See Fig. 5-1: Asia Pacific Surface Analysis Chart (magnified) and Attached Fig. 5-2: 850 hPa upper air chart (magnified).)

2.6.2 Aviation Weather Observation

The aerodrome routine weather report of Narita Airport around the time of the accident was as follows:

13:00 Wind direction 220°; Wind direction fluctuation 170° to 250°;
Wind velocity 14 kt; Maximum instantaneous wind velocity 27 kt,

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[*10] "MAC" abbreviates mean aerodynamic chord, which is a chord representing aerodynamic characteristics of a wing and given by a mean value if the chord is not constant as in the case of a sweptback wing. 25.5% MAC indicates a position located at 25.5% distance from the leading edge of the mean aerodynamic chord.

Prevailing visibility: 10 km or longer,
Cloud: Amount 1/8, Type Cumulus, Cloud base 2,500 ft
Amount 5/8, Type Altocumulus, Cloud base 18,000 ft
Temperature 28° C; Dew point 22° C,
Altimeter setting (QNH) 29.47 inHg,
Wind shear[11] Runway 16R

13:30 Wind direction 230°;
Wind velocity 16 kt; Maximum instantaneous wind velocity 29 kt,
Prevailing visibility: 10 km or longer,
Cloud: Amount 1/8, Type Cumulus, Cloud base 2,500 ft
Temperature 28° C; Dew point 21° C,
Altimeter setting (QNH) 29.48 inHg,
Wind shear Runway 16R

2.6.3 Doppler LIDAR observation data

A Doppler Light Detection and Ranging (LIDAR) is a system which observes the wind velocity, wind velocity variation and other parameters by monitoring floating aerosol (dust particles in the atmosphere and others.). It rotates its head scanning LASER beams at predetermined elevation angle and bearing (Elevation angles of 1°, 2°, 3° and 45° in all directions, and elevation angles from 0° to 90° to the bearing of 336° comprise one set of pattern, and this pattern is repeated in every two minutes and 30 seconds).

The Doppler velocity is a wind component associated with the location of the Doppler LIDAR site as the central point. The cold colors represent the wind components toward the LIDER site, while the warm colors represent away from the site. An area where the wind direction and the laser beam cross almost perpendicular is indicated in white due to the absence of wind components to and away from the observation point.

A shear line represents a boundary at which the wind velocity difference between both sides of the shear line equals to or exceeds 5 m/s.

In addition, airspaces where particular attention about a wind shear is necessary are established to cover a runway and neighboring area as detection area; 3 nm from the runway threshold and 2 nm from the take-off runway end, laterally 1 nm on either end of the runway, at a height of less than 1,600 ft. In case of a headwind component velocity variation of 20 kt or more is detected, a low level wind shear information is issued from air traffic control organizations as a wind shear alert.

The wind velocity variation indicates the degree of wind disturbance in a given space by observing the direction and the speed of aerosol. The variation becomes zero when the movement of the whole aerosol in the space is uniform, but when a strong wind (a gust) blows instantaneously, the variation grows larger. Therefore, the areas where the variation exceeds 4.5 m/s is detected are shown as TURB (turbulence).

Besides, observation data with elevation angle of 2° are used for the detection of shear lines and turbulence at Narita Airport.

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[11] When information of wind shear which could affect the aircraft flight during the touch-down and take-off at a height of 1,600 ft or lower from the runway is obtained within 30 minutes before actual observation time, the corresponding runway number is displayed following “WS.”

The Doppler velocity and Doppler velocity spectrum width at Narita Airport at the time of the Accident were as follows:

(1) Doppler velocity (elevation angle 2°)

According to the Doppler velocity observation data of 13:21:43, cold colors of the velocity component approaching the LIDAR site clearly distributed on the southwest side of the Doppler LIDAR (at the azimuth angle of about 140° to 320°) and warm colors of the velocity component leaving the LIDAR site clearly distributed on the northeast side of the Doppler LIDAR (at the azimuth angle of 320° to 140°); accordingly, the southwest wind was blowing. There was a streaky strong wind area extending parallel to the wind direction, covering the threshold and touch-down zone of Runway 16R.

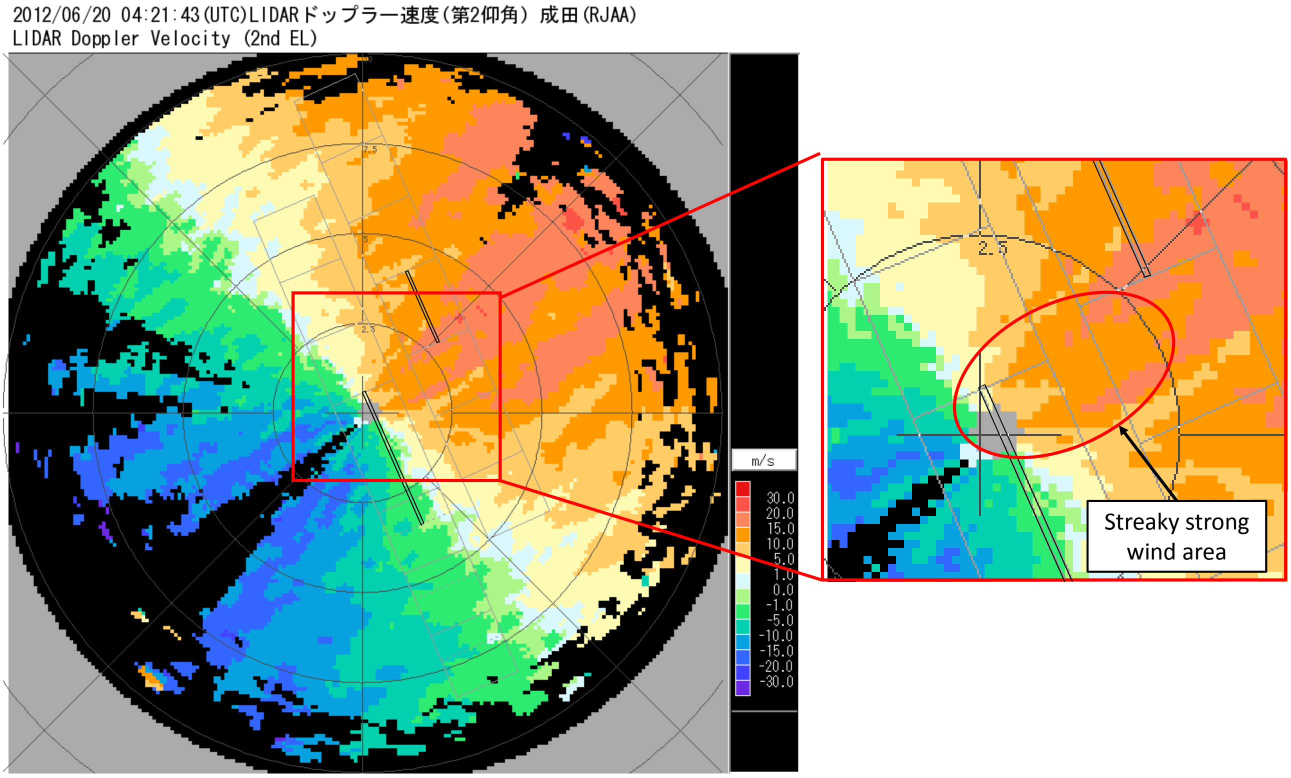


Fig. 2.6.3 (1) Doppler velocity observation data (elevation angle 2°)

(2) Doppler velocity spectrum width (elevation angle 1°)

According to the Doppler velocity spectrum width observation data of 13:22:20, a velocity variation of 7.0 m/s or larger, presented by red color, was observed around the threshold and touch-down zone of Runway 16R, indicating the presence of strong turbulence.

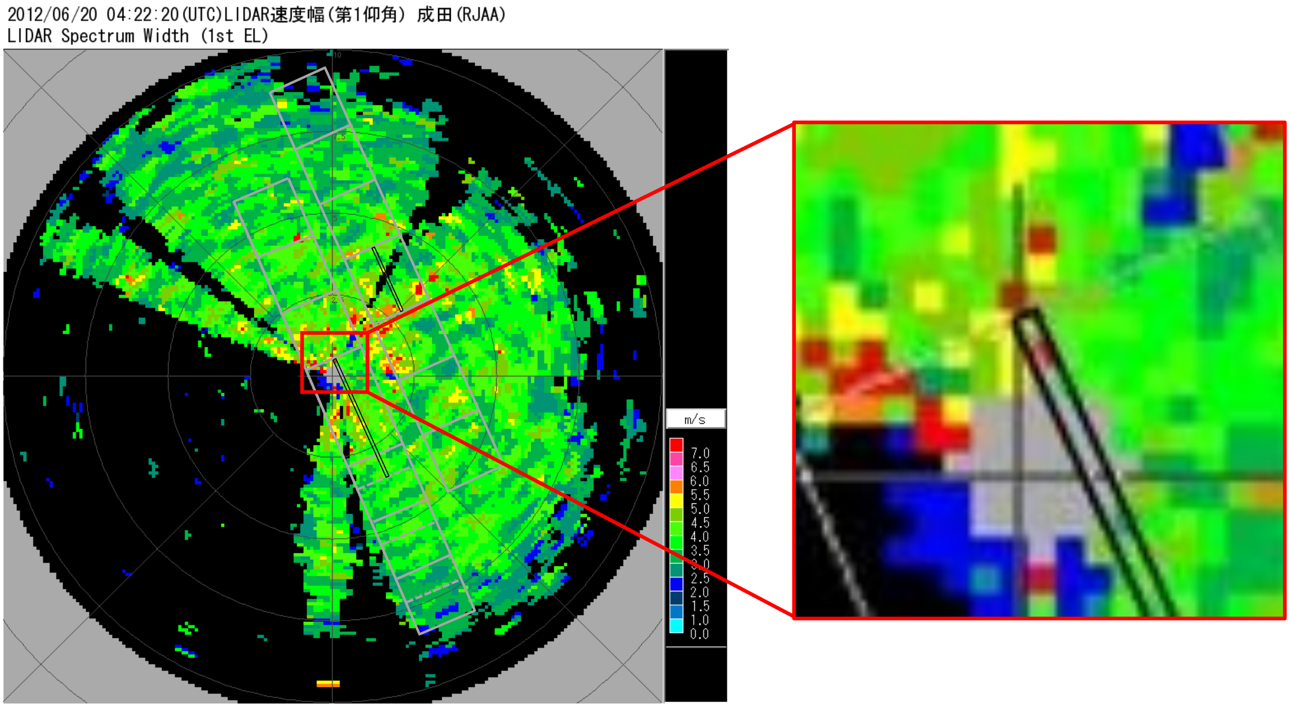


Fig. 2.6.3 (2) Velocity spectrum width observation data (elevation angle 1°)

2.6.4 Observation values of wind direction and velocity

The observation values of instantaneous wind direction and velocity around the touch-down point of Runway 16R at Narita Airport at around the time of the accident are shown in Fig. 2.6.4-1.

According to this, from 13:10:00 to 13:40:00, the wind direction was variable between 160° and 280° and the wind velocity fluctuated in the range from about 2 kt to 24 kt.

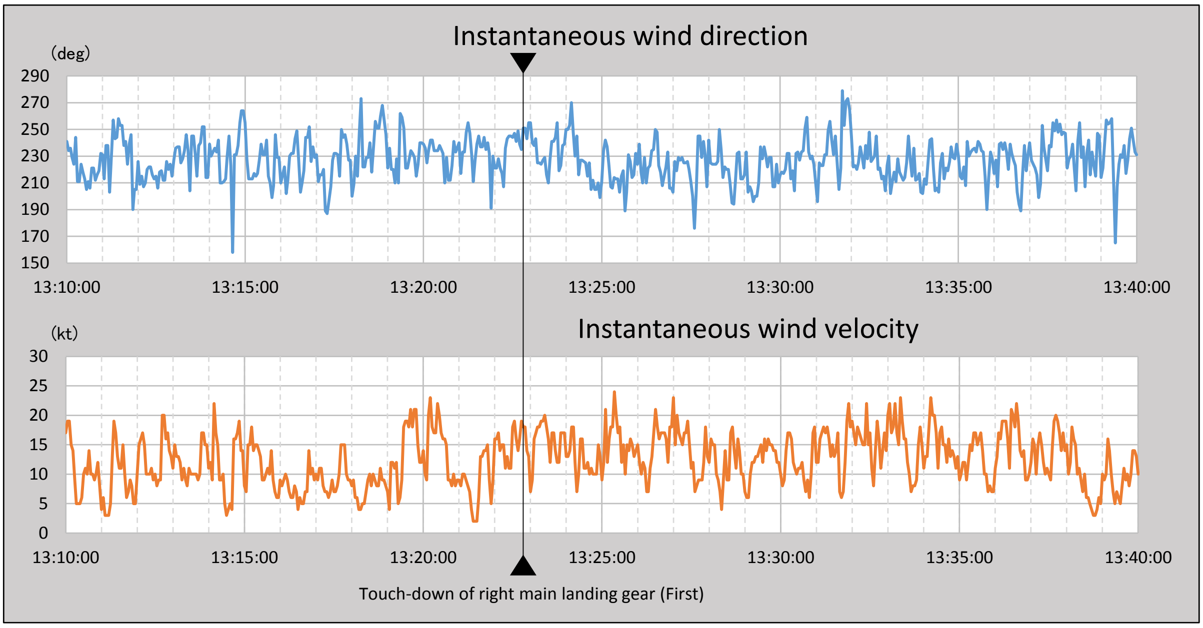


Fig. 2.6.4-1 Instantaneous wind direction and velocity observation data

(The observation data of the instantaneous wind direction and velocity were recorded every three seconds.)

In addition, according to the two-minute average wind direction and velocity data (See Fig. 2.6.4-2), the maximum instantaneous wind velocity at that time varied between about 14 kt and 28 kt, the minimum instantaneous wind velocity varied between 2 kt and 9kt, and the wind direction varied between about 225° and 245°.

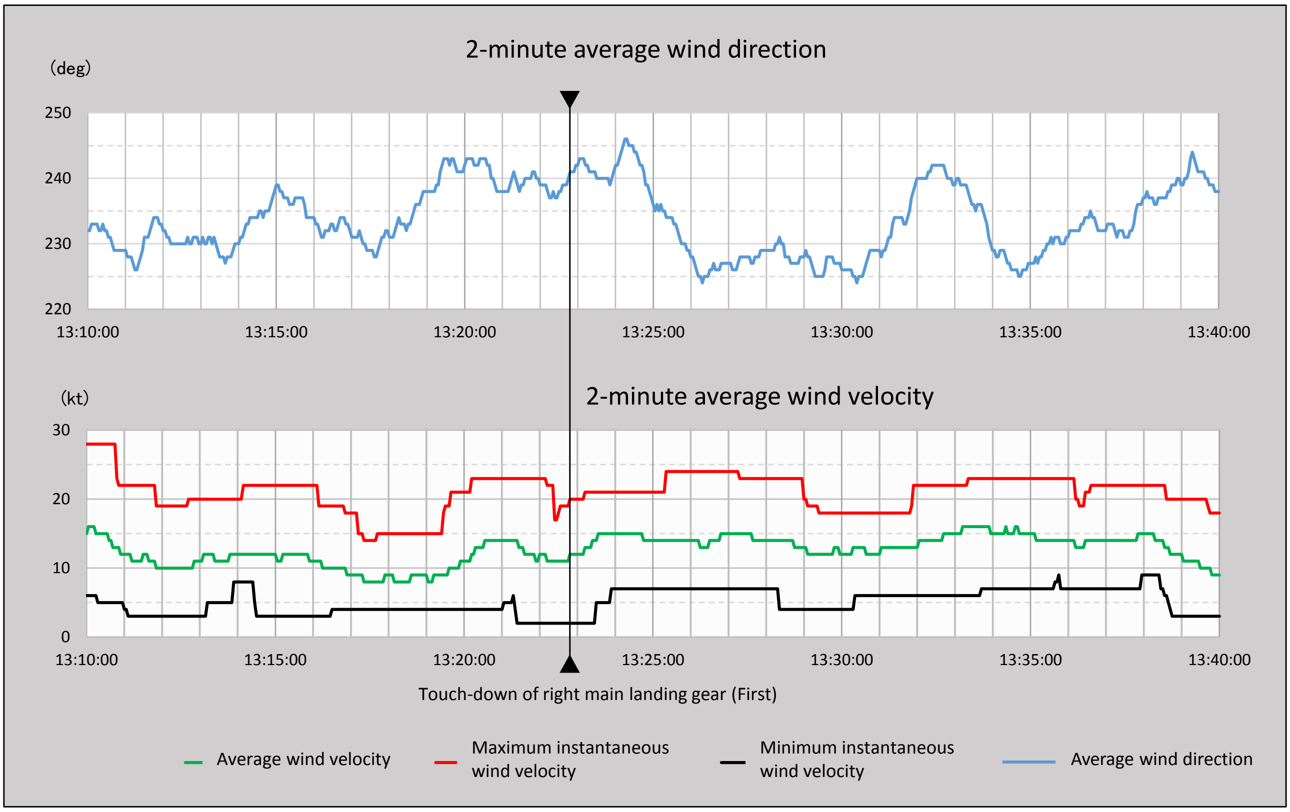


Fig. 2.6.4-2 2-minute average wind direction and velocity observation data

2.6.5 Information about wind shear and aircraft executing go-around

The Tower provides "lower-level wind shear information*[12]" when the observed wind data exceed a certain criterion based on the information from Narita Aviation Weather Service Center, the Meteorological Agency. At around the time of the accident (13:00-14:00), no lower-level wind shear information about Runway 16R was provided.

All the aircraft which executed go-arounds during the period from 10:00 to 15:00 reported that they executed the go-around due to wind shear. (See Fig. 2.6.5.)

Table 2.6.5 Cause for go-around

Landed time (JST)	Runway	Cause
10 : 15	16R	Wind shear
11 : 46	16L	Wind shear
13 : 53	16L	Wind shear
14 : 45	16R	Wind shear
14 : 49	16R	Wind shear

---

*[12] There are two types of "Lower-level wind shear information": WSA (wind shear alert) and MBA (micro burst alert). In the approach (landing) route or take-off route or on the runway (area centered at the runway of the width 1 nm, the length extending from 3 nm before the approach end to 2 nm beyond the take-off end of the runway, and the height 1,600 ft), WSA is issued if an increase or decrease of the headwind component by 20 kt or larger is observed and MBA is issued if an increase or decrease of the headwind component by 30 kt or larger is observed.

2.6.6 Characteristic weather cases in Narita Airport

The document "User's manual of Doppler LIDAR" (March 2009) issued by Narita Aviation Weather Service Center, the Meteorological Agency, says "It is known that a wind shear is often observed under strong southwest wind at Narita Airport" and describes the characteristic weather cases in Narita Airport as follows: (The item number, expression of the runway, and figure number are partly modified.)

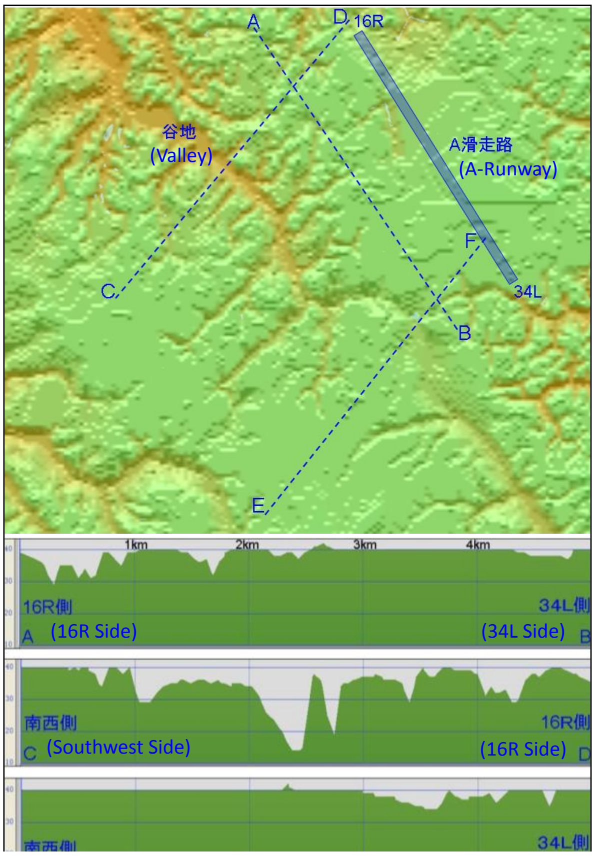


Fig. 2.6.6 (1) Topographic map around Narita Airport
A-B, C-D and E-F correspond topographic profile.

(1) Topography around the airport

Shear lines are detected mostly around RWY 16R probably because of the topography around the airport. Figure 2.6.6 (1) *shows the topography on the southwest side of the airport. Narita Airport is located on elevated ground and the valleys exist in some places linear in near the airport. In particular, on the west side of Runway A (16R), a large valley extends to the northwest in the parallel direction to the runway, and a narrow valley extends from the southwest to the northeast in orthogonal to the runway. The cross section between A and B shows large undulations from the center to A in the northwest. Also, when the cross section C-D and cross section E-F, both extends 5 km from the runway to the southwest, are compared with each other to see the influence on 16R and 34L of the runway, the cross section C-D shows large undulations (height difference: about 25m) while the cross section E-F shows flat land. Therefore, it is confirmed that the undulations are largest around Runway 16R.*

(2) Situation of shear line detection by wind direction

The wind shear pilot reports by wind direction from 2002 through 2006 are graphed the Fig. 2.6.6 (2). The graph shows that the largest number of the reports by wind direction is the direction of about 220° (southwest wind). The description about this in the above mentioned document is as below.

One can see that the reports are mostly made for the three directions, southwest, northwest, and northeast, at Narita Airport. With strong southwest wind, a shear line tends to be formed in orthogonal to the runway, which is probably because the influence of the wind shear is enhanced by crosswind.

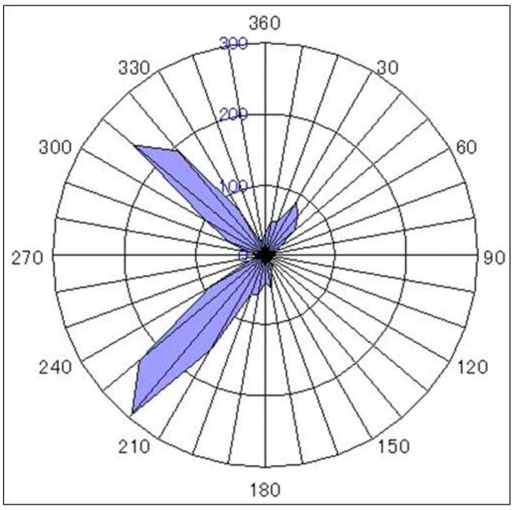


Fig. 2.6.6 (2) Number of pilot reports by wind direction (2002-2006)

(3) Influence of topography

a. Topographic map

Figure 2.6.6 (3)-1 *is a topographic map of the area around the airport. The airport is located on Shimofusa upland in the northern part of Chiba Prefecture and many trough – shaped erosion areas distribute around the airport. In particular, there are many valleys (blue lines) extending from the northwest to the southeast on the west and north sides of the airport and many streaky valleys (red* *lines) extending the southwest to the north east in the orthogonal direction to the blue lines. Among others, the direction of the valleys indicated by the red lines suggests that those are closely related to the shear lines which arise under a strong southwest wind.*

b. Simulation

Since the airport is located on elevated ground as stated above, a wind blowing on the low land is lifted up and blows onto the airport. The wind rising up the slope converges to the airport area and could be accelerated. Besides, the wind flowing into valleys go through narrow flow channels and could be accelerated. This resembles a case where a river flow is accelerated when the river width becomes narrow.

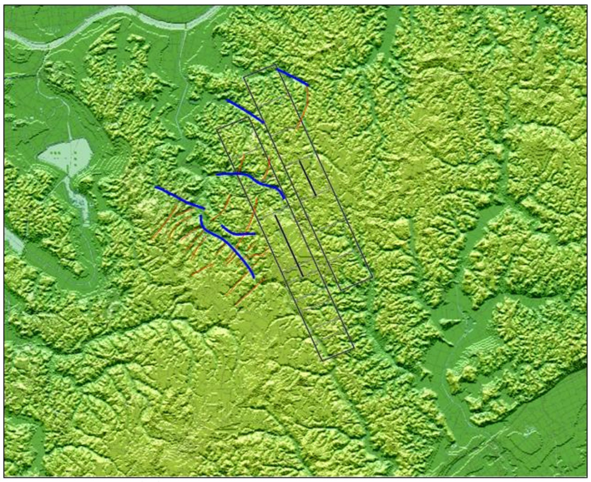


Fig. 2.6.6 (3)-1 Topographic map around the airport (Red and blue lines show valleys.)

Figures 2.6.6 (3)-2 *and* 2.6.6 (3)-3 *show images of wind flows obtained by two-dimensional simulations with simple models of the topography around the airport. Although the flows are potential flows with no vortices and different from actual viscous flow, although both figures show the acceleration of the fluid.*

Figure 2.6.6 (3)-2 *shows that winds blow from the left to right of the figure and accelerates when rising up from the valley to the airport. (The warmer colors indicate faster wind.)*

Figure 2.6.6 (3)-3 *shows a southwest wind with the top of the figure being the north. It can be seen from the figure that the winds accelerate when flowing through the valleys. In particular, it is remarkable around Runway 16R which is used for landing under southwest wind. The accelerating winds cause wind velocity differences from the southwest wind which does not flow through the valleys.*

As stated above, it becomes clear that shear lines are detected mostly at a landing course in southwest wind by simulations of winds considered characteristics of the topography around the airport from the topographic map and also it could prove many reports of wind shears.

Figure 2.6.6 (3)-1 *is an image of Digital Map 50000 issued by the Geospatial Information Authority of Japan drawn with Casimir 3D.*

Figures 2.6.6 (3)-2 *and* 2.6.6 (3)-3 *show the results of simulations by XFEM (JIKO's Software for CAE).*

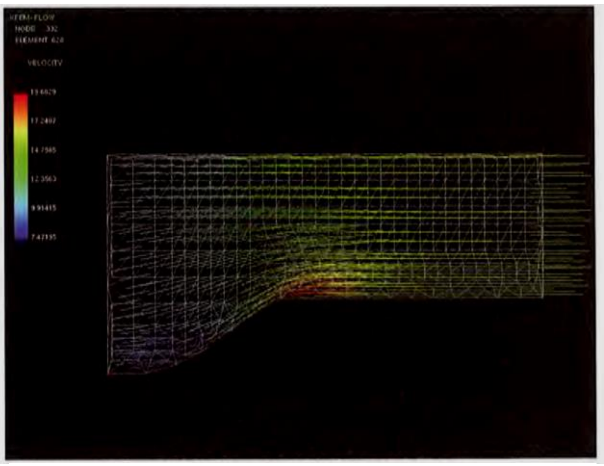


Fig. 2.6.6 (3)-2 Wind rising up to the airport

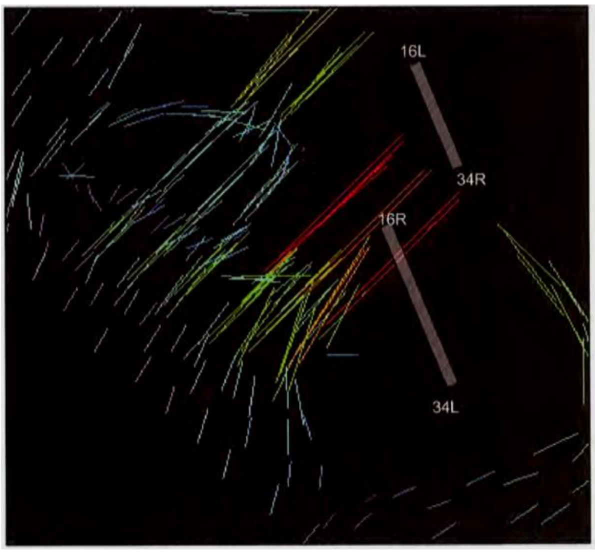


Fig. 2.6.6 (3)-3 Wind flowing through the valleys

2.7 Information on Flight Recorders

The aircraft was equipped with a FDR made by Honeywell of the United States of America, which could record flight data for about 25 hours and a CVR made by L3 Communications of the

United States of America, which could record voice data for about two hours. The data at the time of the Accident remained in these flight recorders.

The time calibration for the FDR and CVR was conducted by comparing the time signals recorded in the air traffic control communication records with the VHF wireless transmission signals recorded in the FDR and the air traffic control communications recorded in the CVR.

2.8 Test and Analysis Information

2.8.1 Analysis of fracture of damaged fuselage

Simple analysis of the fracture of the damaged outer panel on the fuselage upper crown found in the aircraft investigation indicated a possibility of fatigue failure; accordingly, a detailed analysis was entrusted to NIMS. As a result, there was no sign of fatigue failure on the fracture and it was highly probable that the fracture was a ductile fracture caused by overload.

2.8.2 Wind shear alert

The aircraft was equipped with both wind shear alert systems; a reactive-type device, which could detect encountered a wind shear and raise an alarm, and a predictive-type device, which could detect a wind shear in the flight direction by the weather radar installed on the device and raise an alarm.

According to the records of the FDR, a wind shear was not detected by either of the reactive- and predictive-type devices and no wind shear alarm was issued.

2.8.3 Analysis by Aircraft Manufacturer

The records of the FDR and aircraft damages were analyzed by the aircraft manufacturer and the results are as follows:

(1) Wind condition

The crosswind component changed by ±10 kt or more during the time period from when the aircraft reached the runway threshold to when it touched down. Besides, the weak headwind component changed to tail wind at the time of the touch-down. All of these wind changes at and beyond the threshold crossing are further evidence of increased workload for the crew member to maintain the path of the airplane over the runway. (See Fig. 2.8.3 (1).)

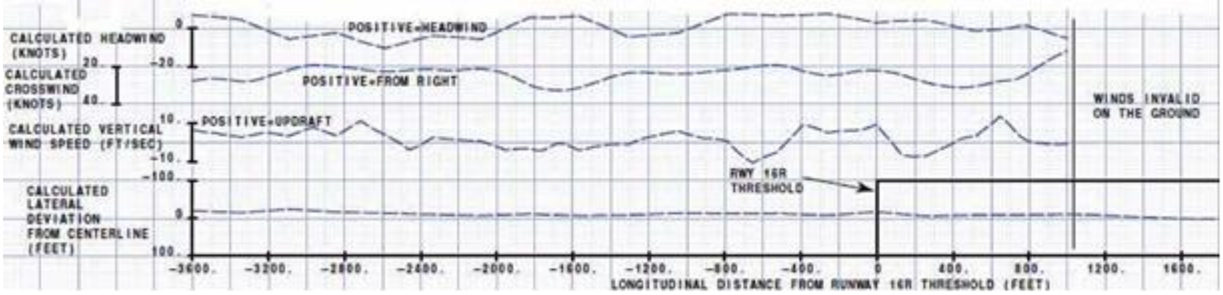


Fig. 2.8.3 (1) Wind analysis by aircraft manufacturer

(2) Standard of stabilized approach

The standard of stabilized approach is specified in 767FCTM. The early phase of the approach of the aircraft complied with the standard of stabilized approach. Besides, 767FCTM specified that, when an aircraft passes a runway threshold, it has to stay on a stable flight route by ordinary operation. While the approach frequently reached the margins of the stabilized approach recommendations, there was not any sustained exceedance of the thresholds of the stabilized approach.

(3) Hard landing of nose landing gear

The pilot did not suppress the nose-down motion of the aircraft caused by the first bounce of the right main landing gear and the first hard landing of the nose landing gear occurred. The pilot controlled the aircraft to take a full nose-down position, which caused extremely large nose-down rate, and then the second hard landing of the nose landing gear occurred.

(4) Loads on nose landing gear and fuselage

The data of the FDR cannot be used for accurate load calculation because the sample rates of the parameters necessary for the calculation is low. Instead, the maximum load on the nose landing gear caused by the accident was calculated based on the damage on the aircraft nose. The result shows that the load on the nose landing gear was 150,000 lb or larger. The estimated load on the nose landing gear indicates that it received a bending moment larger than the design requirement and the structural strength of the fore fuselage. The damage on the fore fuselage could be caused by either or both the first and second hard landings of the nose landing gear. (See Figs. 2.8.3 (4)-1 and 2.8.3 (4)-2.)

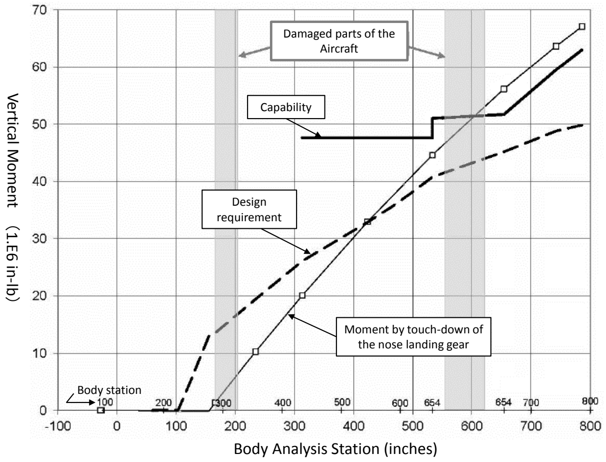


Fig. 2.8.3 (4)-1 Estimation of bending moment (First touch-down of nose landing gear)

2.8.4 Analysis by Tire Manufacturer

The tire manufacturer investigated one of the tires of the main landing gears and one of the tires of the nose landing gear of the aircraft. As a result, since there was no sign of contact among inner surfaces of the tire of the main landing gear and wrinkle inside of, it was highly probable that the inner surfaces did not contact with each other.

Since signs of contacts among inner surfaces of the tire of the nose landing gear and wrinkles were found on the entire inner surface of the tire, it was highly probable that the tire rotated once or more times with its inner surfaces of the nose landing gear contacting with each other. (See Photos 2.8.4-1 and 2.8.4-2. The contact signs are enclosed by red and wrinkles by yellow.)

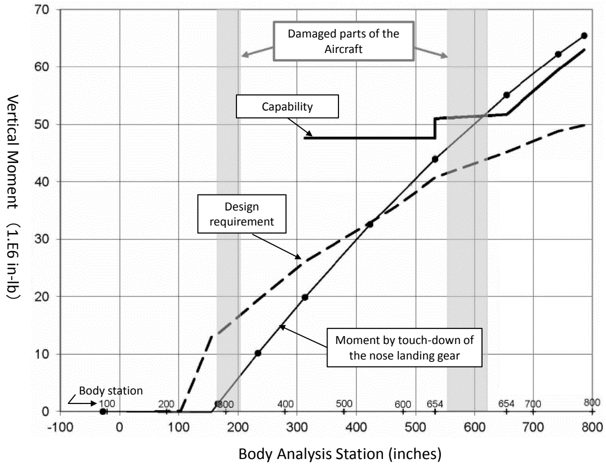


Fig. 2.8.3 (4)-2 Estimation of bending moment (Second touch-down of nose landing gear)

The tire manufacturer estimated that the load which caused the contacts between inner surfaces of the tire was three times (72,300 lb) or more larger than the designated load (24,100 lb) when the tire of the nose landing gear had the designated inner pressure (165 psi).

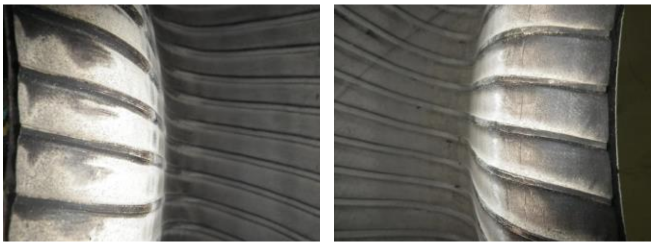


Photo 2.8.4-1 Inside of main landing gear tire

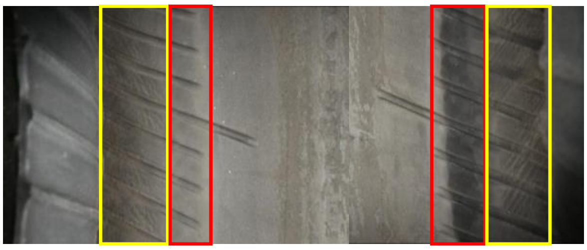


Photo 2.8.4-2 Inside of nose landing gear tire

2.9 Description in Manuals of the Company

2.9.1 Aircraft Operating Manual (AOM)

The description in the AOM of the Company is as below. (excerpt)

Chapter 1 Limitations

1-4 Miscellaneous limits

Maximum crosswind during landing and take-off

The maximum crosswind during landing and take-off shall be the followings depending on the runway condition. Temporary exceeding of crosswind after the take-off or after the decision of making landing is allowed.

Runway condition: DRY[*13] *(including DAMP*[*14]*), Maximum crosswind: 33 (KTS)*

Chapter 3 Normal Procedure

3-1-5 Standard Callouts

Under the following condition, caller shall make designated callouts. Crew members shall observe the callouts even if they are not assigned as their task and make a designated callout if it is not made. PF shall not only make designated callouts but also acknowledge callouts by saying "CHECKED" or repeating them. However PF does not have to acknowledge a callout of autopilot status during autoland.

(Omitted)

Deviation Call

CONDITION	PF	PM
After 1,000 ft AFE, significant deviation from target approach speed, sink rate, localizer and glideslope	----------------	*AIRSPEED or VREF ± ___ (KNOT), SINK RATE or SINK ___ (FEET PER MINUTES), LOCALIZER or ___ DOT LEFT / RIGHT, GLIDESLOPE or ___ DOT ABOVE / BELOW*

Rough estimate of Significant Deviation

Airspeed : Above 10 KIAS or below 5 KIAS (with landing flap)

3-1-8 Use of Autopilot, Autothrottle and FMS

If autoland is not performed, autopilot can be used in the approach only until DA/MDA. After passing DA or when descending to the altitude lower than MDA, Autopilot shall be immediately disengaged.

When autopilot is disengaged in the approach, autothrottle shall also be disconnected.

3-1-16 Stabilized Approach

LANDING CHECK LIST shall be completed and the aircraft shall be stabilized before passing an altitude of 1,000 ft above the runway (an altitude of 500 ft above the runway in case of circling approach). An aircraft is stabilized when the following conditions are met.

-The aircraft is in an appropriate attitude and position.

-The airspeed and descending rate are within the designated range.

-The engine thrust is appropriate.

If the stabilized approach cannot be established by the time when passing the above mentioned altitude, the aircraft has to execute a go-around. It also has to execute a go-around when the non-stabilized state continues at an altitude lower than the above mentioned altitude.

Note: In the approach other than circling approach, if the stabilized approach cannot be established due to ATC or other restrictions before passing an altitude of 1,000 ft above runway, the stabilized approach shall be established as soon as possible.

3-1-18 Go-Around

[*13] "DRY" is the condition in which the runway is dry, not covered with snow, ice, or others.

[*14] "DAMP" is the condition in which the runway is wet but has almost no water layer on the surface. The water layer shall be less than 0.3 mm (0.01 in).

When safety may not be ensured if approach and landing are continued, the aircraft must execute a go-around without hesitation.

When safety in landing may not be ensured, PM, either captain or first officer, shall make a call "Go-around."

Even PM made a call of go-around, the captain (the Captain) has to make the final decision.

The go-around shall follow the Go-Around and Missed Approach Procedure.

2.9.2 AIRPLANE OPERATIONS REFERENCE (AOR)

The AOR of the Company is a reference material for the flight of Boeing 767 and gives addendum and explanation to the AOM. In the AOR, it is described as below. (Excerpt)

Chapter 2 Procedure Reference
2-1-13 Stabilized Approach
1. What is Stabilized Approach

Stabilized approach is an important concept for preventing accidents during approach and landing.

Aircraft changes the altitude, velocity, route, and configuration during flight in order to take final approach. The final approach and landing are critical phases where about half of the accidents occur.

The final approach is an important phase where the aircraft adjusts the configuration and stabilizes the velocity, descending rate, and flight route to prepare for landing.

(Omitted)

Stabilized approach has the following advantages.

-Situational awareness is enhanced by monitoring the attitude, route, path, airspeed, descending rate, and engine thrust.

-By adjusting landing configuration before reaching the minimum stabilization height, the aircraft can prevent a configuration change at a low altitude and have enough time for communication with ATC and responses to weather change and system operations.

-By setting the minimum stabilization height and deviation criteria, appropriate decision on landing or go-around can be made.

-Appropriate velocity and appropriate touch down point make a margin for the landing performance.

2. Conditions of Stabilized Approach

(1) Aircraft in stabilized state

Whether the aircraft is in a stabilized state is determined referring to the value designated in Deviation Call, Chapter 3 Standard Callout, AOM. However, if the parameter values related to the stabilized approach exceed the roughly estimated criteria of the significant deviation due to a sudden change of wind direction or disturbance in air stream and if it is temporary, could be adjusted, and is being adjusted proactively, the values exceeding the criteria are allowed.

(Omitted)

(2) Concept of Go-Around in Stabilized Approach

(i) Before reaching minimum stabilization height

If the stabilization approach cannot be established before reaching the minimum stabilization height, the approach cannot be continued and go-around has to be executed.

(ii) After reaching minimum stabilization height

If the stabilization approach is established before reaching the minimum stabilization height, the approach can be continued. However, if the aircraft is not kept in a stabilized state after reaching the minimum stabilization height and before starting flare, go-around has to be executed.

2.10 Operation Training

2.10.1 Recurrent Training of the Flight Crew

The recurrent training of the flight crew for Boeing 767 of the Company is conducted once a year.

(1) The Captain

The Captain received recurrent trainings according to the provision of the Company. Subject on a wind shear is provided every year and his score was evaluated as appropriate.

(2) The First Officer

The First Officer received recurrent trainings according to the provision of the Company. Subject on a wind shear is provided every year and his score was evaluated as appropriate.

2.10.2 Training Manual of the Company (Excerpt)

(1) Flare and Touchdown

(i) For flare, back pressure begins to be applied at around 30 ft RA and the aircraft is controlled to make a positive change of the pitch at 20 ft RA to enter the landing path (approximately 1/2 to 1/3 of the approach path).

(ii) After the aircraft actually changes the path, the thrust begins to be slowly reduced.

(iii) Without letting the nose down until the touch down, the back pressure is increased to let the aircraft touch down in the touch down zone. The final flare pitch shall be about 5°. To prevent pitch down moment due to the thrust reduction and airspeed decrease, the line of sight should be gradually shifted to the runway end when starting the flare.

Theoretically the aircraft should touch down on the touch down point with these operations. After starting the flare, do not try to control the aircraft to touch down on the touch down point. Just focus on touching down inside the touch down zone.

(iv) After the main landing gear touched down, the control column must not be moved rapidly. During the flare, or after the touch-down, the trim must not be moved. These operations could increase the pitch attitude after the touch-down and increase the possibility to cause a tail strike.

Do not increase the pitch attitude and extend the flare by trying to make complete, smooth landing. Also it is not recommended to keep the nose wheels in the air.

After the main landing gear touched down, the nose wheels begins to be smoothly lowered onto the runway. Aeromagazine recently issued by Boeing describes that, for the prevention of tail strike, let the nose gear touch down immediately after the touch-down of the main gear and not to use the aerodynamic brake by taking the nose up position after the touch-down.

The above operations are standard ones in a calm atmosphere. With a strong wind, turbulence, or gust, situation-dependent responses are necessary in addition to the above standard operations.

During the period from when the aircraft passes around 50 ft RA to the touch-down, the auto callouts from the radio altimeter are effective for decision about the path. Relation with RA calls including STD callouts (threshold) and position of the aircraft should be understood.

(2) After Touchdown and Landing Roll

After the main wheel touches down, attention needs to be paid since tail strike or hard touch-down of the nose wheels could be caused by a change of the pitch moment due to the auto brake, reverse thrust operation, or speed brake extend.

(Omitted)

The landing roll shall be made by rudder steering and the line of sight should be directed to far distance to keep the centerline.

After the deceleration to the speed of turnoff, disarm the auto brake and change from *rudder steering to nose wheels steering.*

In addition, the reverse thrust is smoothly reduced to reverse idle when a call "60 kt" is made. After confirming that the reverse idle is stabilized, it is shifted to forward idle.

2.10.3 Flight Crew Training Manual (FCTM) issued by Aircraft Manufacturer

The flight crew training manual (FCTM) issued by the aircraft manufacturer describes the operation of letting the nose landing gear touch down after landing as below. (Excerpt)

Landing Roll

Avoid touching down with thrust above idle since this may establish an airplane nose up pitch tendency and increases landing roll.

After main gear touchdown, initiate the landing roll procedure. If the speedbrakes do not extend automatically move the speedbrake lever to the UP position without delay. Fly the nose wheels smoothly onto the runway without delay. Control column movement forward of neutral should not be required. Do not attempt to hold the nose wheels off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique and results in high nose gear sink rates upon brake application and reduced braking effectiveness.

To avoid possible airplane structural damage, do not make large nose down control column movements before the nose wheels are lowered to the runway.

To avoid the risk of a tail strike, do not allow the pitch attitude to increase after touchdown. However, applying excessive nose down elevator during landing can result in substantial forward fuselage damage. Do not use full down elevator. Use an appropriate autobrake setting or manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available. Maintain deceleration rate with constant or increasing brake pressure as required until stopped or desired taxispeed is reached.

Bounced Landing Recovery <FCTM 6.21>

If the airplane should bounce, hold or re-establish a normal landing attitude and add thrust as necessary to control the rate of descent. Thrust need not be added for a shallow bounce or skip. When a high, hard bounce occurs, initiate a go-around.

Apply go-around thrust and use normal go-around procedures. Do not retract the landing gear until a positive rate of climb is established because a second touchdown may occur during the go-around.

If higher than idle thrust is maintained through initial touchdown, the automatic speedbrake deployment may be disabled even when the speedbrakes are armed.

This can result in a bounced landing.

If the speedbrakes started to extend on the initial touchdown, they will retract once the airplane becomes airborne again on a bounce, even if thrust is not increased.

The speedbrakes must then be manually extended after the airplane returns to the runway.

Go-Around after Touchdown <FCTM 5.74>

If a go-around is initiated before touchdown and touchdown occurs, continue with normal go-around procedures. The F/D go-around mode will continue to provide go-around guidance commands throughout the maneuver.

If a go-around is initiated after touchdown but before thrust reverser selection, auto speedbrakes retract and autobrakes disarm as thrust levers are advanced. The F/D go-around *mode will not be available until go-around is selected after becoming airborne.*

Once reverse thrust is initiated following touchdown, a full stop landing must be made. If an engine stays in reverse, safe flight is not possible.

(i) Over-Rotation during Go-Around

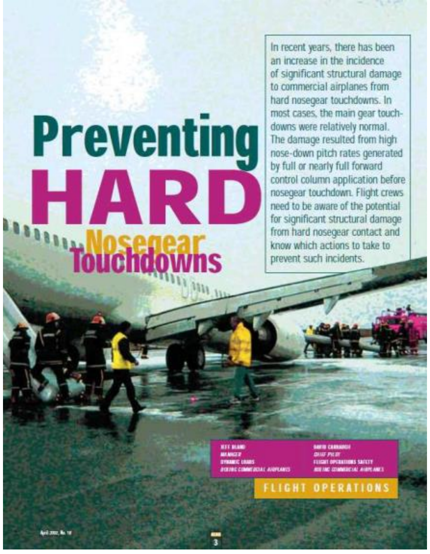
Go-arounds initiated very late in the approach, such as during the landing flare or after touching down, are a common cause of tail strikes. When the go-around mode is initiated, the flight director immediately commands a go-around pitch attitude. If the pilot flying abruptly rotates up to the pitch command bar, a tail strike can occur before the airplane responds and begins climbing. During a go-around, an increase in thrust as well as a positive pitch attitude is needed. If the thrust increase is not adequate for the increased pitch attitude, the resulting speed decay will likely result in a tail strike. Another contributing factor in tail strikes may be a strong desire by the flight crew to avoid landing gear contact after initiating a late go-around when the airplane is still over the runway. In general, this concern is not warranted because a brief landing gear touchdown during a late go-around is acceptable. This had been demonstrated during autoland and go-around certification programs.

2.11 Additional Information

2.11.1 Accident Review Material by Aircraft Manufacturer

In the section FLIGHT OPERATIONS in a periodical magazine issued by the aircraft manufacturer of the United States of America "AERO: April 2002 No.18," there is an article "Preventing Hard Nosegear Touchdowns."

This article was provided as part of new information material provision method which the aircraft manufacturer considered effective for those who are involved in flight to review similar past accidents which will be described in 2.11.3. The aircraft manufacturer also produced video materials corresponding to this article.
(The followings were extracted from AERO.)



Preventing HARD Nosegear Touchdowns

In recent years, there has been an increase in the incidence of significant structural damage to commercial airplanes from hard nosegear touchdowns. In most cases, the main gear touchdowns were relatively normal. The damage resulted from high nose-down pitch rates generated by full or nearly full forward control column application before nosegear touchdown. Flight crews need to be aware of the potential for significant structural damage from hard nosegear contact and know which actions to take to prevent such incidents.

JEFF BLAND
MANAGER
DYNAMIC LOADS
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FLIGHT OPERATIONS

Preventing Hard Nosegear Touchdowns

In recent years, there has been an increase in the incident of significant structural damage to commercial airplanes from hard nosegear touchdowns. In most cases, the main gear touchdowns were relatively normal.

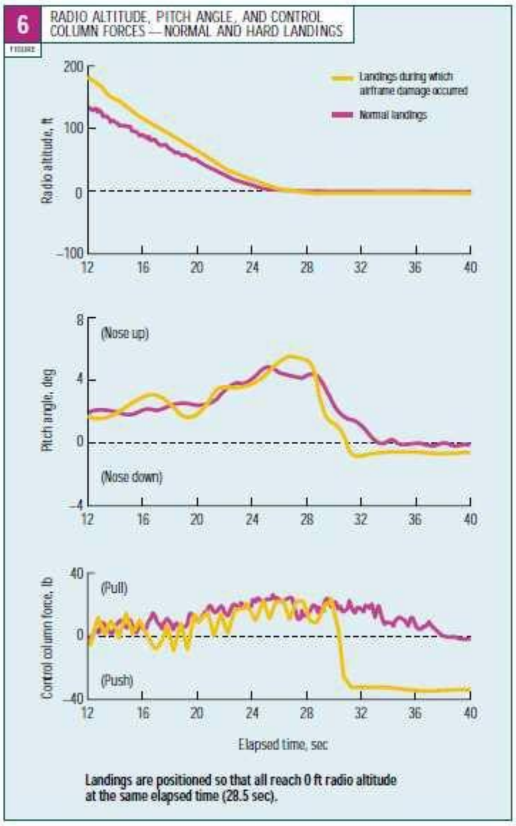
The damage resulted from high nose-down pitch rates generated by full or nearly full forward control column application before nosegear touchdown. Flight crews need to be aware of the potential for significant structural damage from hard nosegear contact and know which actions to take to prevent such incidents.

(Omitted)

Hard nosegear landings can produce heavy loads on the nosegear and its support structure. The resulting high stresses in the forward fuselage upper crown and between the flight deck and wing front spar can cause the fuselage structure to buckle. Appropriate actions by the flight crew can help prevent such incidents.

(Omitted)

With the nose down, spoilers up, and thrust reversers deployed, the airplane is in the correct stopping configuration. This should be established as soon as is practical during landing. Forward column movement should not be applied to lower the nose rapidly in an effort to improve landing performance or directional control. The rudder provides the required directional control until the airplane is at a relatively low speed, then rudder pedal nosewheel steering is used to complete the landing rollout. Large forward column displacement does not improve the effectiveness of nosewheel steering and may reduce the effectiveness of main-wheel braking because it reduces the amount of weight on the main gear.



6 FIGURE RADIO ALTITUDE, PITCH ANGLE, AND CONTROL COLUMN FORCES — NORMAL AND HARD LANDINGS

Landings are positioned so that all reach 0 ft radio altitude at the same elapsed time (28.5 sec).

SUMMARY

Flight crews can reduce the chances of airplane damage from hard nosegear contact by avoiding high derotation rates and excessive forward column inputs. In the event of a hard landing, the flight crew should report the event to the engineering and maintenance departments so that the airplane can be inspected for potential structural damage.

2.11.2 Information Magazine issued by the Company Group

The following is an article in the magazine "The Flight ANA Group" issued by the Company group three months prior to the accident (March 12, 2012). It introduced the accident case study material AERO (See 2.11.1) of the aircraft manufacturer and described about "Avoidance of hard landing of nose landing gear." (Excerpt)

4. For Avoidance of Hard Landing of Nose Landing Gear

Next, let us see from a view point of avoiding hard landing.

It was reported in a foreign country that too much attention on forward pressure to the control column after the touch-down of the nose landing gear caused unintentional application of forward pressure to the control column even before the touch-down of the nose landing gear, resulting in an accident of hard landing of the nose landing gear.

This kind of operation needs to be prevented to avoid hard landing of nose landing gear.

2.11.3 Past Accidents that Provide Reference

2.11.3.1 Similar Accident in the Same Type of Aircrafts

According to the accident investigation agencies in the United States of America and the United Kingdom, the past accidents which caused damage similar to the damage in the accident are as below.

(1) Accidents before the design change of the fuselage upper crown

The following three accidents occurred before the design change of the fuselage upper crown.

(i) January 16, 1992 at Jeju International Airport, Republic of Korea

(ii) October 27, 1992 at Sao Paulo/Guarulhos Governor Andre Franco Montoro International Airport, Brazil

(iii) December 31, 1993 at Warsaw Chopin Airport, the Republic of Poland

The above three accidents had a similar characteristic, hard landing by large nose down control column movement. Responding to the three accidents, the aircraft manufacturer took the following countermeasures.

-Strengthening of the structure of the forward fuselage upper crown

-Change of metering pin to reduce the maximum impact on nose landing gear

-Creation of training materials (video) for pilots of Boeing 767 and distribution of information magazines to notify relevant parties of a possibility that strong nose landing gear touch-down could cause damage on the fuselage

(2) April 20, 2009 at John F. Kennedy International Airport, the United States of America

The cause of the accident identified in the investigation report by the National Transportation Safety Board (NTSB), the United States of America is as follows.

Conclusion

The National Transportation Safety Board determines the probable cause(s) of this accident as follows.

The first officer's input of full nose down elevator at touchdown. Contributing to the accident was the gusty wind conditions.

(3) October 3, 2010 at Bristol International Airport, the United Kingdom

The cause of the accident identified in the investigation report by the Air Accidents Investigation Branch (AAIB), the United Kingdom is as follows.

Conclusion

Damage to the fuselage occurred as a result of rapid de-rotation of the aircraft following a hard landing on the main landing gear. The runway profile, nuisance GPWS alerts and the meteorological conditions may have influenced the landing.

2.11.3.2 Past Hard Landing Accidents at Narita Airport

At around 14:12 on March 24, 1990, fuel leakage from a damaged fuselage occurred in a hard landing accident at Narita Airport. The followings are extracted from the aircraft accident investigation report.

(1) Outline of the Aircraft Accident

VR-HOC, Lockheed L1011-385-1, of Cathay Pacific Airways which departed Hong Kong International Airport as its scheduled flight 508 on March 24, 1990, made a hard landing on Runway 16 (currently Runway 16R) of New Tokyo International Airport (currently Narita Airport) about 14:12, in which the rear spar of the wing root and its vicinity of the left wing were damaged and the fuel flowed out from the No.1 fuel tank. Fire did not occur.

On board the aircraft were a crew of 18 and 283 passengers, a total of 301 persons, and in the emergency evacuation effected, two passengers were seriously injured.

(2) Probable causes

It is estimated that immediately after the aircraft, which was approaching in a crosswind varying extensively in direction and speed, initiated a decrab operation, it encountered such a change of the wind that the strong wind which had been blowing crosswise at a right angle until immediately; therebefore, suddenly decreased and temporarily turned to a tailwind, wherein the captain could not conduct a relevant landing operation with a result of giving rise to a hard landing.

(3) Meteorological situation at the time of the approach and landing

It is recognized that Narita Airport was, at the time the accident occurred, in a warm area in front of a cold front extending from a low pressure off the Sanriku Coast, and was in a strong wind belt from SW originating at Izu Peninsula and reaching around Narita Airport through Tokyo Bay.

According to records of the 2-minute wind sensor, the accident occurred in this time zone where the variation in wind direction on the Runway 16 side was remarkable and the maximum in wind speed was large.

From the results of test and research, it is estimated that the wind direction and speed while the aircraft was approaching to land varied considerably with the position of the aircraft. The variations in wind direction and speed would be attributable mainly to effects of the topography below the flight course as well as on the windward side of the course.

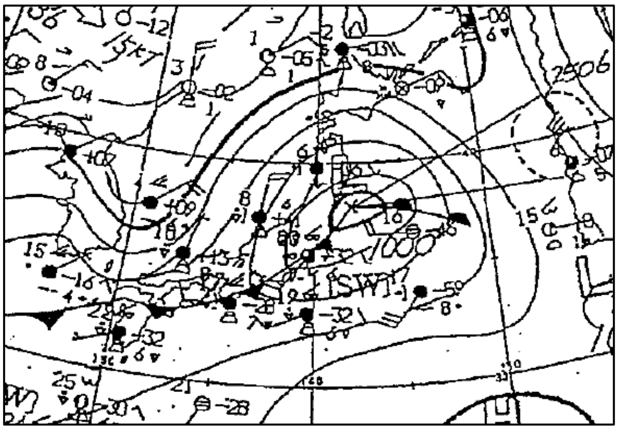


Fig. 2.11.3.2 (3) Surface weather chart (only around Japan)

2.11.4 Tail Strike Accident of an Affiliated Company of the Company

After the accident of the aircraft A320 owned by an affiliated company of the Company occurred at Sendai Airport on February 5, 2012, a document was issued to notify all flight crew members of the companies of the occurrence situation and cautions.

3. ANALYSIS

3.1 Qualification of Crews

The Captain and the First Officer held both valid airman competence certificates and valid aviation medical certificates.

3.2 Airworthiness Certificate of the Aircraft

The aircraft had a valid airworthiness certificate and had been maintained and inspected as designated.

3.3 Effect of Meteorological Conditions

3.3.1 Synoptic Situation at the Time of the Accident

As described in 2.6.1, the synoptic situation at the time of the accident was that a cold front extending from the low pressure on the east sea of the Tohoku region was extended in the southern part of Kyushu through the Kanto coastal sea. According to the AMeDAS data (wind direction and velocity), it was highly probable that Narita Airport was in a strong southwest wind zone.

From the aerodrome routine weather reports of Narita Airport of 13:00 and 13:30 described in 2.6.2, it is highly probable that the weather situation at Narita Airport at the time of the accident was the prevailing visibility was good, namely 10 km or longer, and the wind was southwest wind with gust.

3.3.2 Weather Analysis

3.3.2.1 Influence of Topography around Narita Airport on Strong Southwest Wind

The information in 2.6.6 indicates that Narita Airport is located on elevated ground and valleys exist in some places linear on the southwest side of Narita Airport. The valleys around Narita Airport extend toward the approach course to Runway 16R and the threshold of Runway 16R. A southwest wind rising up the slope from the low land converges and accelerates on the uphill. The valleys make the wind paths narrower and accelerates the wind flowing through the valleys. The accelerated wind causes a wind velocity difference from a wind not going through the valleys.

Besides, according to the number of pilot reports by the wind direction, the wind shear was reported most often under a strong southwest wind.

In light of above mentioned facts, it is highly probable that severe wind disturbance could occur on the approach course of Runway 16R and on Runway 16R near the threshold under the influence of the topography around Narita Airport with a strong southwest wind.

3.3.2.2 Wind Velocity Change around Runway 16R

Figure 3.3.2.2 shows the headwind component and crosswind component of the wind at around the time of the accident (13:21 to 13:24) obtained from the observation data of instantaneous wind direction and velocity near the touch-down point on Runway 16R, Narita Airport, described in 2.6.4.

The crosswind component fluctuation between 1 kt and 19 kt, which was within the maximum crosswind value allowed for touchdown and take-off specified in AOM in 2.9.1.

The severe wind component showed a sudden decrease by about 7 kt between before and after the touch-down.

It is probable that the tendency of the wind indicates that the wind velocity changed largely with a gust.

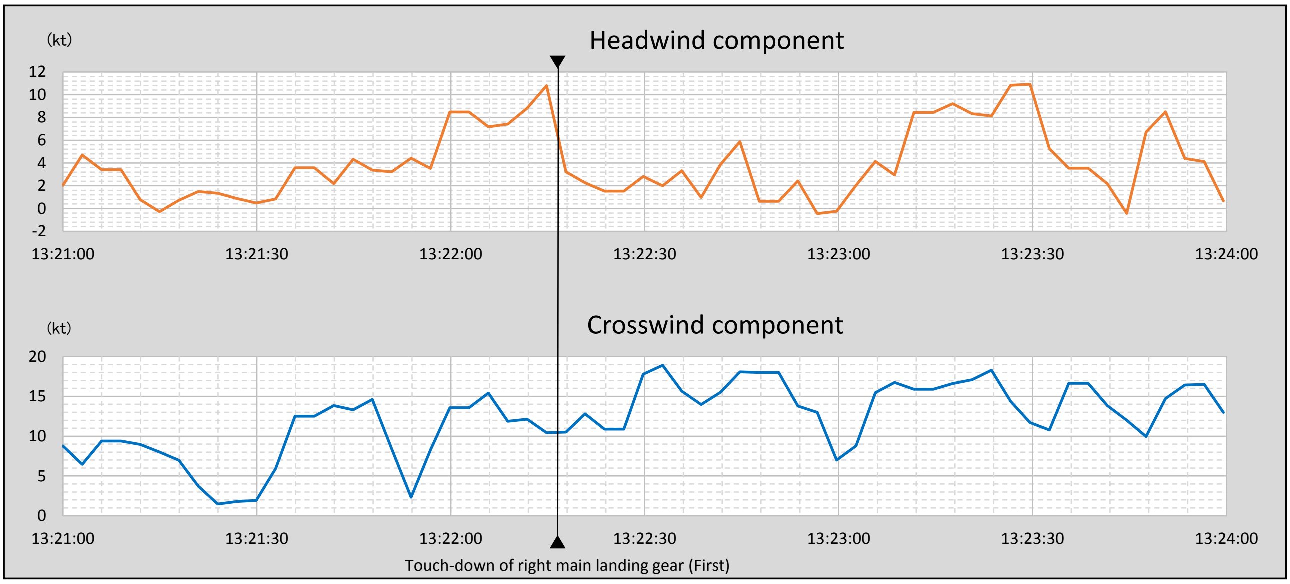


Fig. 3.3.2.2 Headwind and crosswind components before and after the accident

3.3.2.3 Wind Shear

As described in 2.6.5, no lower-level wind shear information about Runway 16R at around the time of the accident was provided, and no wind shear was detected from the ground observation. There were five go-arounds due to wind shears on Runway 16R and Runway 16L during the period from 10:00 to 15:00 on the day of the accident, but no aircraft, including the aircraft, executed go-around due to wind shear on Runway 16R at around the time of the accident. In addition, according to the flight history in 2.1.1 and the statement of the flight crew members in 2.1.2, no wind shear alert was issued on board.

In light of above mentioned facts, it is probable that no wind shear, large enough for issuing a wind shear alert, occurred during the approach of the aircraft.

3.3.2.4 Wind Situation at around the Time of the Accident

As described in 3.3.1, Narita Airport was in a strong southwest wind zone at around the time of the accident; therefore, it is highly probable that there was strong wind disturbance on the approach course of Runway 16R and on Runway 16R near the threshold, caused by the influence of the topography around Narita Airport with strong southwest wind.

The Doppler velocity observation data with Doppler LIDAR described in 2.6.3 (1) (See Fig. 2.6.3. (1).) showed the presence of a streaky strong wind area over the approach end and touch-down zone of Runway 16R. The results of the simulation (See Fig. 2.6.6 (3)-3.) with a southwest wind around Narita Airport described 2.6.6 and the strong wind area distribution look similar to each other. In addition, as described in 2.6.3 (2), the velocity spectrum width data obtained by Doppler LIDAR at 13:22:20 showed the presence of wind disturbance of the wind velocity of 7 m/s (13.6 kt) or larger, even higher than 4.5 m/s, the threshold of turbulence, at around the touch-down point of Runway 16R.

The analysis by the aircraft manufacturer described in 2.8.3 showed that the calculated headwind component, crosswind component, and vertical wind component were changing during the approach of the aircraft and immediately before the touch down. In particular, after the aircraft passed the threshold of Runway 16R, the headwind component decreased immediately before the touch down and the crosswind coming from the right side temporarily increased, and then decreased by about 20 kt. The vertical wind component changed from updraft to downdraft immediately after the aircraft passed the threshold end of Runway 16R and changed again to updraft before returning to near zero magnitude immediately before the touch-down.

Based on the above, it is highly probable that, when the aircraft touched down, the wind direction was not stable and the wind velocity was significantly changing on the approach course of runway 16R and at around the Runway 16R threshold and near the touch down zone.

3.3.3 Influence of Wind on Flight Control at the time of the Accident

From the wind situation at around the time of the accident described in 3.3.2.4 and the analysis by the aircraft manufacturer described in 2.8.3 (1), it is probable that the control of the aircraft during approach and landing was extremely difficult under the influence of the wind at around the time of the accident.

3.3.4 Comparison with Past Accidents

It is highly probable that the hard landing accident at Narita Airport described in 2.11.3.2 and the present accident had similar weather situations where a cold front extended over Kanto area from the low pressure off Sanriku Coast and Narita Airport was in a strong southwest wind zone.

3.4 Flight Situation of the Aircraft

3.4.1 From When the Aircraft Passed FAF to When AP was Disengaged (at an Altitude of About 450 ft)

From the description in 2.1.1 and Fig. 3-1, the aircraft descended and passed FAF with the AP and AT using. After passing the FAF, the aircraft was descending to the altitude of about 1,600 ft with small and smooth change in the pitch angle, roll angle, and velocity; therefore, it is highly probable that it was not difficult to maintain its attitude in this situation.

After passing the altitude of 1,600 ft, the aircraft attitude became to fluctuate, larger than before, due to a change in the wind direction and velocity began at around 13:31.

At that time, the Captain changed the speed setting of the AP to increase the target approach speed to 148 kt (V_{REF}+10 kt). It is probable that the Captain increased the target approach speed because the wind direction and velocity changed largely and that the decision of the Captain was reasonable in the wind situation of that time.

During the period from when the aircraft passed the altitude of 1,600 ft to when the AP was disengaged, the increase and decrease of the wind velocity repeated and the pitch angle, roll angle, and speed largely fluctuated in a short period; accordingly, it is highly probable that keeping the aircraft attitude and speed was becoming difficult in that situation.

According to the description in 2.1.1 and Fig. 3-2, the First Officer make a call of the altitude 500 ft at 13:22:10 and the Captain responded saying “Stabilized”. At that time, the aircraft attitude was changing significantly but the aircraft was flying on an appropriate approach course and the speed change was not outside the range that required issuing deviation call. Therefore, it is probable that the aircraft was in the stabilized state specified in 2.9.1 and 2.9.2.

After that, at 13:22:16, since the velocity of the aircraft became 140 kt, lower by 5 kt or less than the target approach speed, the First Officer made a deviation call, and then the thrust was increased and the speed was recovered.

3.4.2 From When AP was Disengaged to When the Aircraft Passed Runway Threshold

According to the description in 2.1.1 and Fig. 3-2, after disconnecting the AT, the aircraft disengaged the AP at an altitude of about 450 ft (altitude above ground level of 340 ft). Since it did not reach the decision altitude (altitude above ground level of 200 ft), it is highly probable that the AP was disengaged to follow the provision of 2.9.1.

During the period from when the AP was disengaged to when the aircraft reached the decision altitude, the control column position (CCP), control wheel position (CWP), and aircraft attitude changed within the same range as those changed during the period of one minute until the AP was disengaged. After that, during the period until it reached the runway threshold, the frequency of the change in its roll angle became shorter and the large adjustment operation against the roll angle change was made frequently.

The change of the pitch angle at that time became more frequent within the range from -1.8° to +2.6° and the adjustment operation against the pitch angle change was made in a similar manner to the adjustment operation against the roll angle change.

In addition, the speed at that time was changing within the range from 137 kt to 164 kt and the change was frequent exceeding the upper and lower limits of a deviation call.

Therefore, it is probable that it was difficult to keep stabilized approach since the aircraft was in a nose-down attitude during the period from the decision altitude to the runway threshold and since the speed was intermittently changed exceeding the limits to issue a deviation call.

3.4.3 From when the Aircraft Passed the Runway Threshold to First Touch Down of Right Main Landing Gear

According to the description in 2.1.1 and Fig. 3-3, the pitch angle changed from about +1.9° to -1.6° after the aircraft passed the runway threshold. The nose-down operation was made at an altitude above ground of 40-30 ft and the nose began to descend at an altitude above ground of about 30 ft at which the flare operation was commenced. At an altitude above ground level of about 30-20 ft, the vertical acceleration decreased to 0.6 G and the aircraft was in a nose-down attitude. According to the description in 3.3.2.4, the wind situation changed from updraft to downdraft, and then to updraft before returning to near zero magnitude, moreover, the headwind component decreased and the crosswind component first increased, and then decreased. From the above, it is probable that the change of the pitch angle was caused by mainly the nose-down operation and also additionally the influence of the wind disturbance.

According to Fig. 3-3, the thrust lever was operated slightly forward when the pitch angle decreased and the aircraft descended, but it is highly probable that the increase of the thrust of the engines were not enough to sufficiently reduce the descending rate.

The statements in 2.1.2 (1) indicate that the Captain felt the descent of the aircraft at an altitude above ground of 20-10 ft and the descent rate data shown in Fig. 4 indicates that it was about 400-600 ft/min during the period from when it passed the altitude above ground level of 37 ft at 13:22:45 after passing the runway threshold to when it touched down. Accordingly, it is highly probable that the descent rate could not be sufficiently reduced due to the failure of making appropriate flare operations.

After that, the nose rose up abruptly; consequently, in order to reduce the nose up, a momentary nose down operation was made, which reduced the increasing rate of the pitch angle. Then a nose up operation was made again and the gradual nose up operation was continued.

Since Runway 16R, a longer runway of Narita Airport, was chosen for the landing of the aircraft, it is probable that it could touch down by effectively taking advantage of the long length of the runway and not decreasing the pitch after it passed the runway threshold. It is probable that, when the pitch significantly decreased after it passed the runway threshold, it should be recognized that appropriate landing operation would not be possible and the landing should not be continued.

The right main landing gear touched down at 13:22:49 with the pitch angle of +4.9°, the roll angle of +4°, and the speed of 143 kt.

3.4.4 After the First Touch Down of Right Main Landing Gear

According to the description in 2.1.1 and Fig. 3-3, the aircraft was rolled to the right at an angle of about 4° and took the nose-up attitude at an angle of about 5° when the main landing gear touched down for the first time. The vertical acceleration recorded in the FDR was 1.58 G at that time. After the touch down of the right main landing gear, the aircraft was rolling to the left and the pitch angle was descending.

About a second after the first touch down of the right main landing gear, the aircraft rebounded into the air. Incidentally, the speedbrakes did not extend due to touching down on the right main landing gear only. Then its pitch angle became negative (nose down) and the nose landing gear touched down. After the touch down of the nose landing gear, the right landing main gear touched down again, and then the left main landing gear touched down. The vertical acceleration recorded in the FDR was 1.72 G at that time.

About a second after the touch down of the nose landing gear, only it rebounded into the air. Almost simultaneously, the speedbrakes extended and the thrust reverser began to deploy.

According to the statements of the Captain and the First Officer in 2.1.2 (1) and (2), it is highly probable that they both could not recognize the bounce of the aircraft when the right main landing gear touched down for the first time. It is probable that even if the central part of the fuselage where the main landing gears were located bounced and floated, the pilots in the cockpit might not feel the airframe floating if the nose was lowered at the same time, because the cockpit was located on the forward fuselage.

The First Officer did not make a call of speedbrake deployment; however, since the time from when the right main landing gear bounced to when the nose landing gear touched down was about one second, it is probable that the Captain, PF, could not have made operations responding to the bouncing even if the First Officer had made the call.

According to Fig. 3-3, the nose-down operation began immediately before the first touch-down of the right main landing gear. It is probable that the nose down operations were made to control of the increase of the pitch angle since the nose was rising fast. It is probable that the nose down operations resulted in the high nose down speed when the nose landing gear touched down in addition to the effect of the right main landing gear bounced, causing the hard touch down of the nose landing gear.

According to the statement described in 2.1.2 (1), it is highly probable that, when the right main landing gear floated and the nose had negative pitch, the Captain noticed that the aircraft had bounced and floated.

After the touch down of the nose landing gear, the Captain controlled the aircraft to take a full nose down operation. As described in 2.1.2 (1), it is highly probable that this control was made since he considered that early touch-down of the nose landing gear would be safer to keep the rolling direction after the touch-down under a strong crosswind. (Nose down operation after the touch down will be further described in 3.6.)

It is probable that this nose-down operation was continued and caused the second hard touch-down of the nose landing gear.

3.5 Damage on Fuselage Upper Crown

As described in 3.4.4, the touch-down situations of the landing gears was as below. After the right main landing gear bounced, the nose landing gear touched down (for the first time). At this moment, only the nose landing gear touched the runway. After that, the right main landing gear and then the left main landing gear touched down and the nose landing gear bounced and touched down again (for the second time). Since the touch down of the main landing gears produced an upward load on and around the center of gravity of the aircraft, it is not probable that the touch down of the main landing gears caused the damage and buckling on the fuselage upper crown. Therefore, it is highly probable that the damage on the forward fuselage upper crown was caused when a large load was applied on the nose landing gear.

According to the analysis by the tire manufacturer described in 2.8.4, the contact among the inner surfaces of one of the nose gear tires was confirmed in the investigation after the accident. The contact among the inner surfaces indicates that the load on each tire was about three times (72,300lb) or more larger than the designated load (24,100 lb). It is highly probable that, since the roll angle of the aircraft was sufficiently small at the first and second touch downs of the nose landing gear, either or both of the first and second touch downs of it produced a load of about 145,000 lb or larger on the nose landing gear, which caused the contact of the inner surfaces of the two nose wheel tires.

According to the flight data analysis by the aircraft manufacturer, it is probable that the change rate of the pitch angle speed at the first touch-down of the nose landing gear was about 45 deg/s^2. Since the elevator angle was small before and after the first touch down of the nose landing gear, the load which contributed to the change of the pitch angle of the aircraft was only the load on the nose landing gear if the aerodynamic pitch moment load of the whole fuselage is assumed to be small and ignored. Based on this assumption, the load on the nose landing gear necessary to cause the pitch angle change rate of 45 deg/s^2 was calculated to be about 150,000 lb.

It was difficult to accurately estimate the load on the nose landing gear at the second touch-down for the following reason; the main landing gears were on weight on wheels; the elevator angle was large making a large aerodynamic effect; the variation of the upward or downward acceleration and pitch angle change rate before and after the touch-down was also large.

The load on the tire analyzed by the tire manufacturer and the load on the nose landing gear at the first touch-down estimated from the change rate of the pitch angle speed in the flight data were almost equivalent.

Based on the above, it is probable that, the load on the nose landing gear when it touched down in the accident was found to be about 150,000 lb, which was consistent with the result of the analysis by the aircraft manufacturer.

Under the assumption that the load of about 150,000 lb was applied to the nose landing gear, Figs. 2.8.3 (4)-1 and 2.8.3 (4)-2 show that the damaged part received a bending moment larger than the design requirement and the structure strength of the forward fuselage. Therefore, it is probable that the damage on the forward fuselage upper crown was caused by either or both of the first and second hard touch-downs of the nose gear.

3.6 Nose-Down Operation at Touch-Down

As described in 2.11.3.1 (1), the hard touch-down of the nose landing gear by abrupt nose-down operations contributed to the occurrence of the three similar accidents of the same type of aircraft in 1992 and 1993. After the accidents, the aircraft manufacturer changed the aircraft design, created an accident review material (See 2.11.1.) to prevent hard touch-down of nose landing gear, and distributed the material to operators of the same type of aircraft.

It is mentioned in the material that appropriate control by pilots could prevent an accident of large structural damage caused by abrupt nose-down operations, and that nose-down operations to make the nose landing gear touch down rapidly to improve the breaking performance or maintain the aircraft heading should not be made.

In the training manual prepared by the aircraft manufacturer described in 2.10.3, it is also mentioned that excessive nose-down operation for landing must not be made since such abrupt nose-down operation could cause hard touch down of the nose landing gear and result in substantial forward fuselage damage.

In the Information Magazine issued by the Company group in 2.11.2, it is described that some flight crew members consider it appropriate to make the nose landing gear touch down promptly after main landing gears are touched down that such operation is not appropriate for landing of jet airliner with reference to the above accident study material made by the aircraft manufacturer. The Magazine was issued with an aim to instruct the flight crew members of the Company group not to make abrupt nose down operations for nose landing gear touch down, although it could not prevent the accident.

In the statements of the Captain described in 2.1.2 (1), he considered that early touch down of the nose landing gear to keep the heading of the aircraft would be safer for the landing roll in the strong crosswind, and then made the nose down operation. As stated above, this was incorrect understanding. It is necessary for flight crew members to fully recognize that excessive nose-down operations for landing should not be made, in order to prevent reoccurrence of similar type accidents.

4. CONCLUSIONS

4.1 Summary of the Analysis

(1) Effect of Meteorological Conditions

It is highly probable that severe wind disturbance could occur on the approach course of Runway 16R and on Runway 16R near the threshold under the influence of the topography around Narita Airport with strong southwest wind. (3.3.2.1)*[15]

It is highly probable that the wind situation was that the wind direction was not stable and the wind velocity was significantly changing on the approach course of Runway 16R and at around the Runway 16R threshold and near touch-down zone. (3.3.2.4)

It is probable that the aircraft control during approach and landing was extremely difficult under the influence of the wind at around the time of the accident. (3.3.3)

(2) Flight Situation of the Aircraft

The wind velocity repeatedly increased and decreased every several seconds until the AP was turned off. The pitch angle, roll angle, and speed of the Aircraft fluctuated largely at a short period. Therefore it is highly probable that it was becoming difficult to keep the aircraft attitude and speed stabilized. (3.4.1)

It is probable that it was difficult to keep stabilized approach since the aircraft was in a nose down attitude during the period from the decision altitude to the runway threshold and since the speed was intermittently changed exceeding the limit to issue a deviation call. (3.4.2)

At an altitude above ground level of about 30-20 ft, the aircraft was in a nose down attitude. Therefore, it is probable that the change of the pitch angle was changed by not only the nose down operation but also the influence of the wind disturbance. The descent rate was about 400-600 ft/min during the period from when the aircraft passed the altitude above ground level of 37 ft after passing the runway threshold to when it touched down. Accordingly, it is highly probable that the descent rate could not be sufficiently reduced due to the failure of making appropriate flare operations. It is probable that, when the pitch significantly decreased after the aircraft passed the runway threshold, it should be recognized that appropriate landing operation would not be possible and the landing should not be continued. (3.4.3)

The nose down operation began immediately before the first touch down of the right main landing gear. It is probable that the nose down operations resulted in the high nose down speed when the nose landing gear touched down in addition to the effect of the right main landing gear bounced, causing the hard touch down of the nose gear. After the touch down of the nose landing gear, the Captain controlled the aircraft to take a full nose down operation. It is probable that this nose down operation was caused the second hard touch down of the nose landing gear. (3.4.4)

(3) Damage on Fuselage Upper Crown

It is probable that the damage of forward fuselage upper crown was caused either or both of the first and second hard touch-downs of the nose landing gear. (3.5)

(4) Nose Down Operation at Touch Down

Excessive nose-down operation for landing must not be made since such abrupt nose down operation could cause hard touch down of the nose landing gear and result in substantial forward fuselage damage. It is necessary for flight crewmembers to fully recognize that excessive nose-down operations for landing should not be made, in order to prevent reoccurrence of similar type accidents. (3.6)

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*[15] The number at the end of each paragraph indicates the section in “3. ANALYSIS” related to the content of the paragraph.

4.2 Probable Causes

It is highly probable that this accident occurred by the damage to the aircraft is a result of the hard landing of the nose landing gear after its bounce when attempting to land at Runway 16R of Narita International Airport.

It is probable that the hard landing of the nose landing gear was caused because the Captain could not notice the bounce of the aircraft and controlled it to take a nose down position in order to make early touch-down of the nose landing gear.

It is probable that the continued landing with the aircraft being in an unstable posture caused by a crosswind with gust which occurs when there is a strong southwest wind around the airport contributed to the occurrence of the accident.

5. SAFETY ACTIONS

5.1 Safety Actions Taken

5.1.1 Safety Actions Taken by the Company

(i) Measures to avoid hard touch-down of nose landing gear

The followings were provided as information in “Notes for nose landing gear touch-down” and that was made well-known in the flight crew members.

-Carefully perform nose down operations after the touch-down of main landing gear.

-Keep the aircraft attitude appropriately and avoid large nose-down operation or nose-up operation, until it is confirmed whether the main landing gear is on the runway or in the air.

(ii) Measures for recurrent training

-Add the elements of bouncing and floating to the training courses.

-With reference to not only the experience of the company but also worldwide incident information from the world and measures and training based on the information, necessary training is examined and a system of making reflection to the recurrent training and others is developed as required.

(iii) Measures of providing information

-The flight crew members were notified of the details of the accident through the Company information magazine, “The Flight.”

-A learning opportunity for the flight crew members using video materials prepared by the aircraft manufacturer or video materials created based on those materials is examined.

-The flight crew members were notified of the new concept “horizontal roll convection” model and application of the model to corresponding phenomena through “The Flight ANA Group” and the dispatchers and flight support staff were trained. This was published as case example analysis in “Weather Handbook.”

-The activation condition of the wind shear alert was confirmed and that was made well-known in the flight crew members through “The Flight ANA Group.”

(iv) Measures by documentation of FCTM

-An environment enabling the flight crew members to confirm the Boeing FCTM at any time is provided.

-The training material of the company and various provisions are revised continuously to be include a necessary part of the Boeing FCTM for safety.

Figure 1 Three Angle View of Boeing 767-300

Unit: m

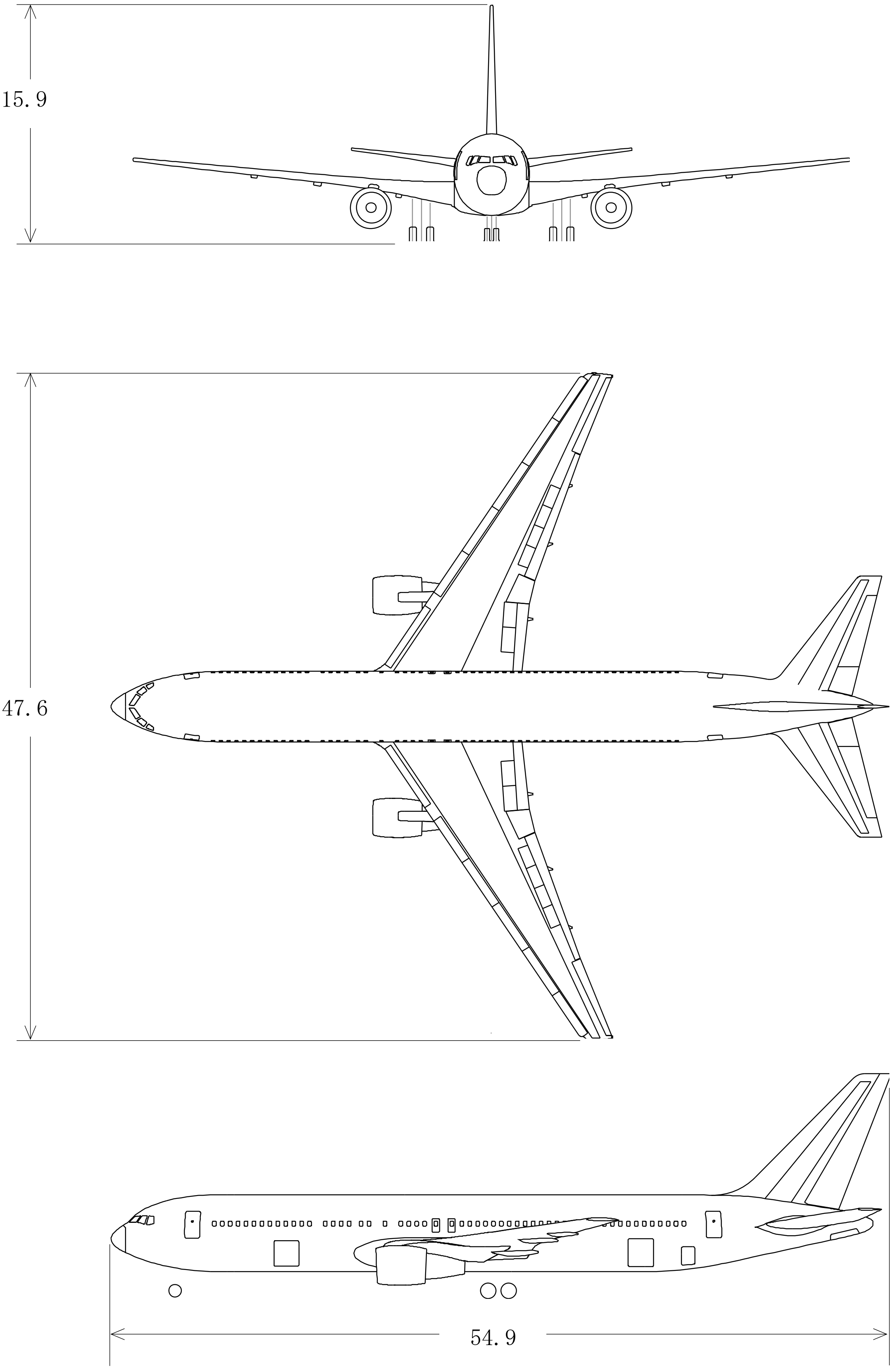
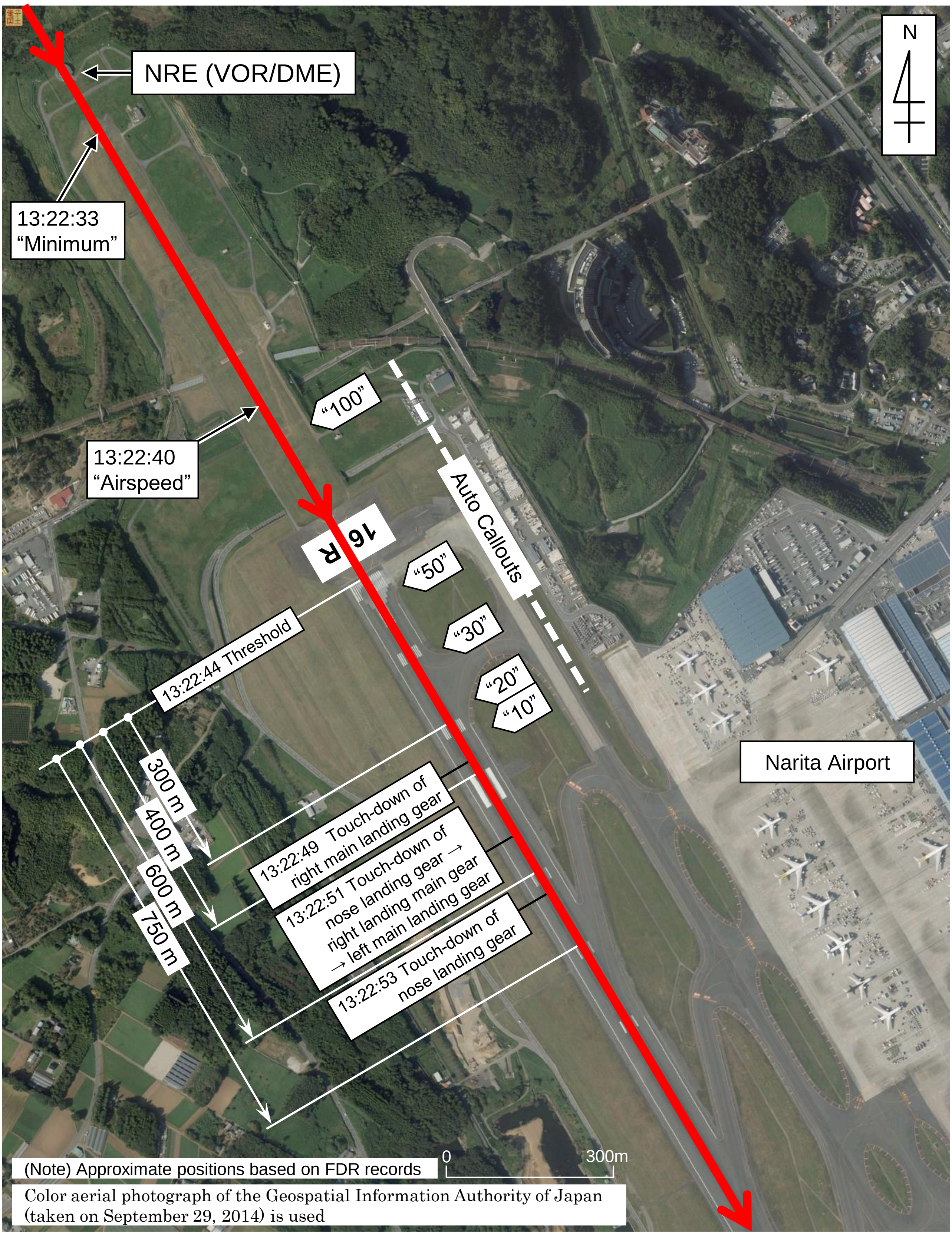


Figure 2 Estimated Flight Route (around Touch-Down)



(Note) Approximate positions based on FDR records

Color aerial photograph of the Geospatial Information Authority of Japan (taken on September 29, 2014) is used

Figure 3-1 FDR Records (2,800-0 ft)

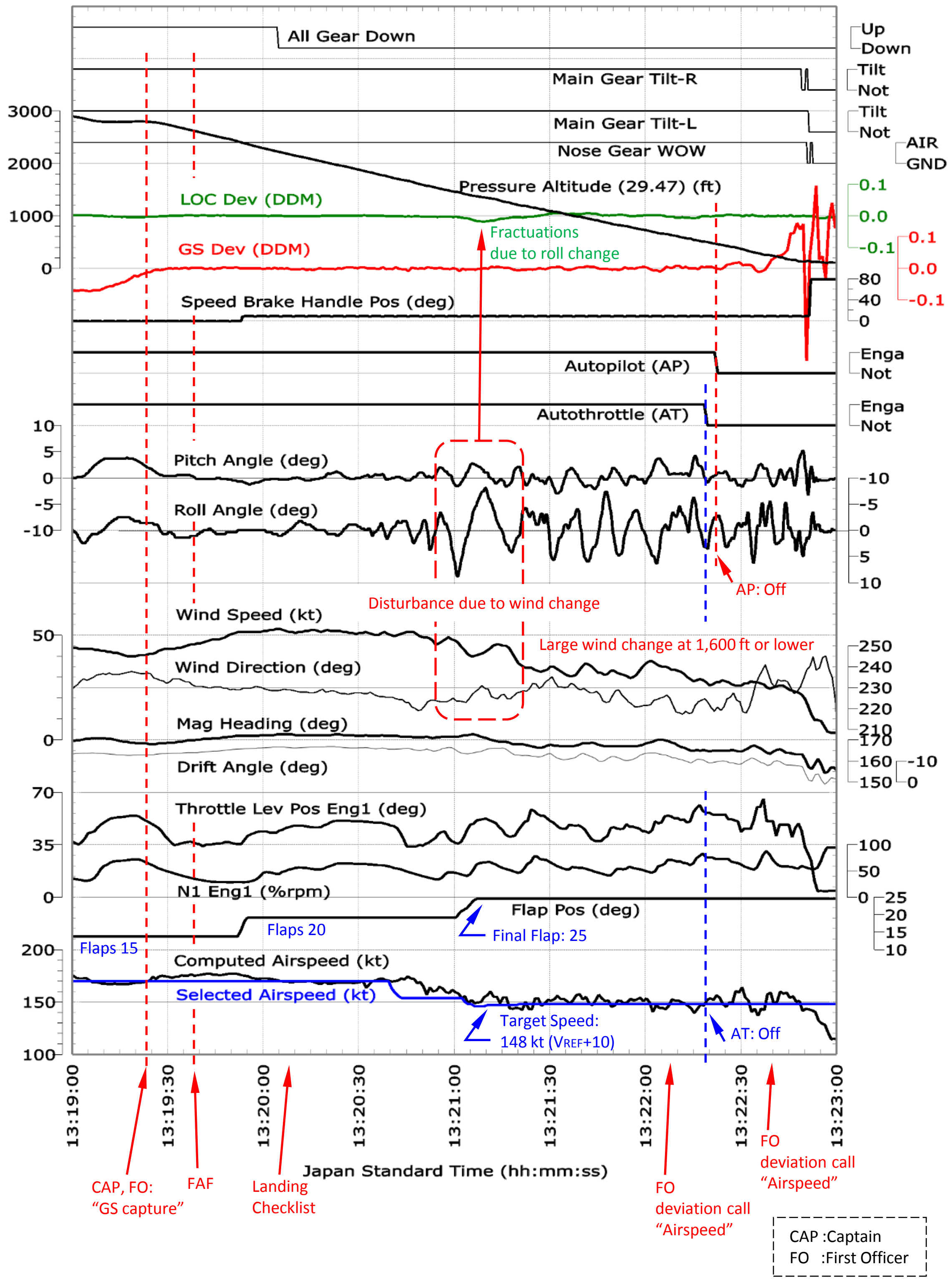


Figure 3-2 FDR Records (600-0 ft)

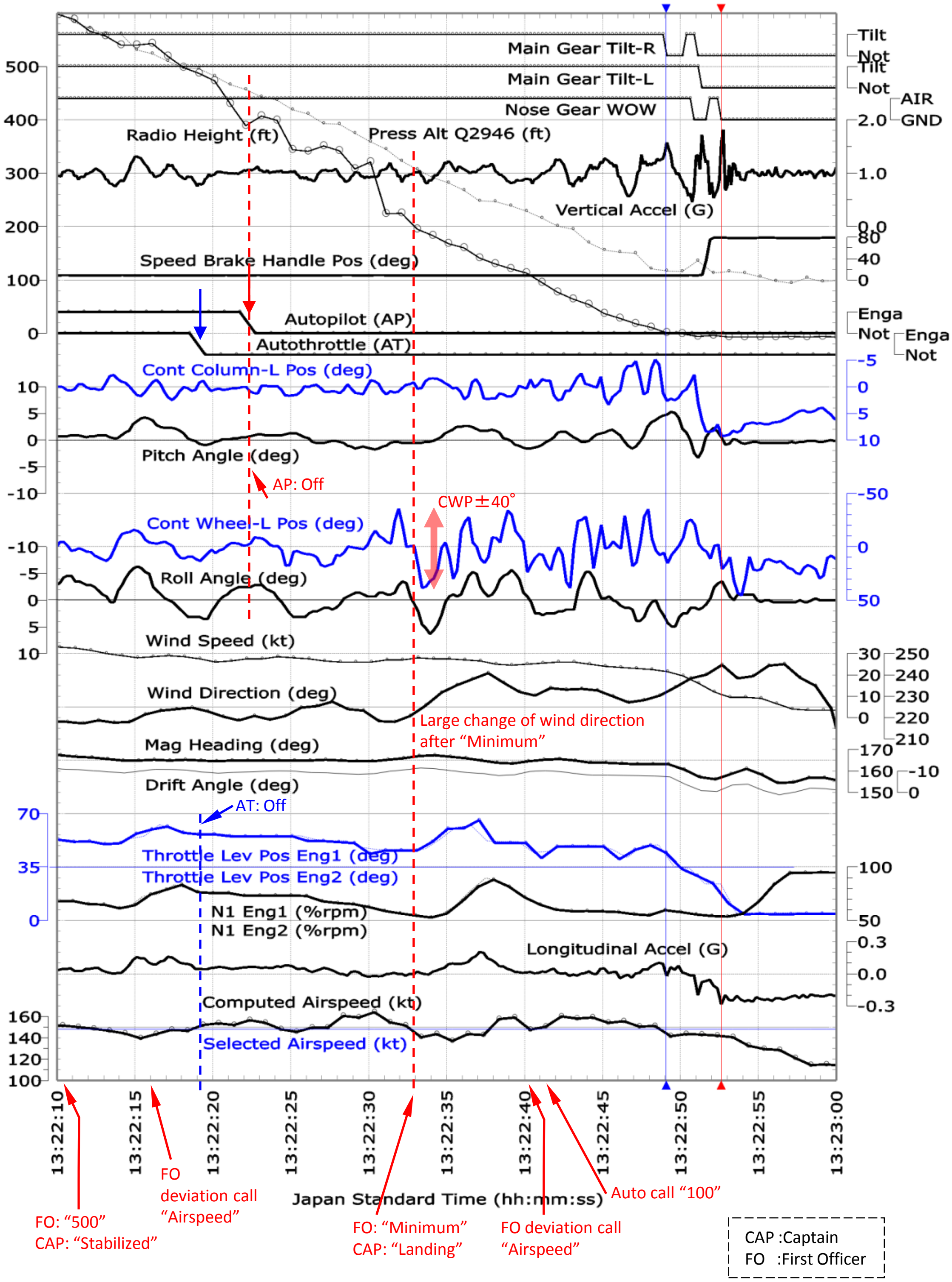


Figure 3-3 FDR Records (100-0 ft)

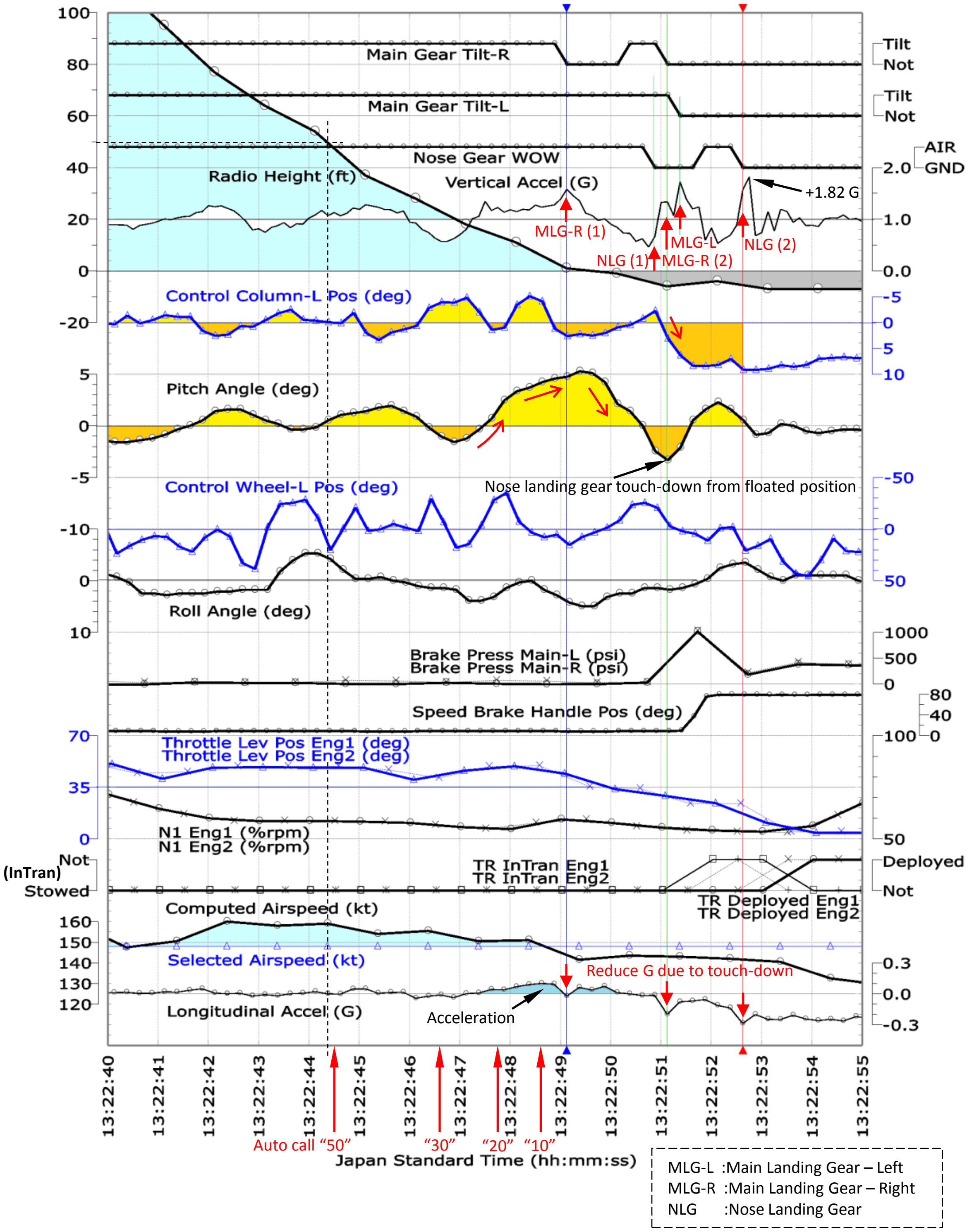


Figure 4 Events in the during Flare

(Descending Rates and Automatic Calls)

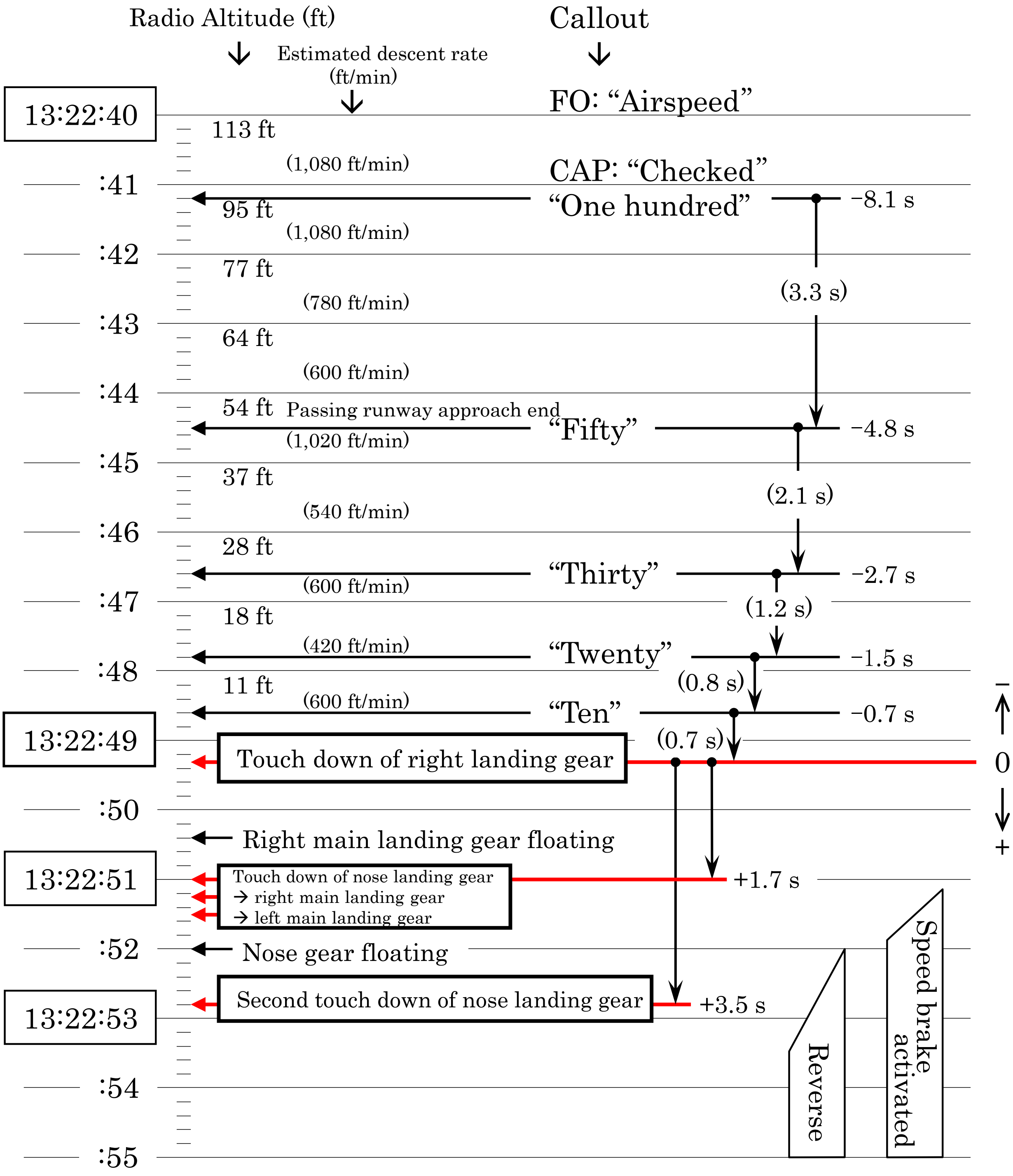


Figure 5-1 Asia Pacific Surface Analysis Chart (magnified)

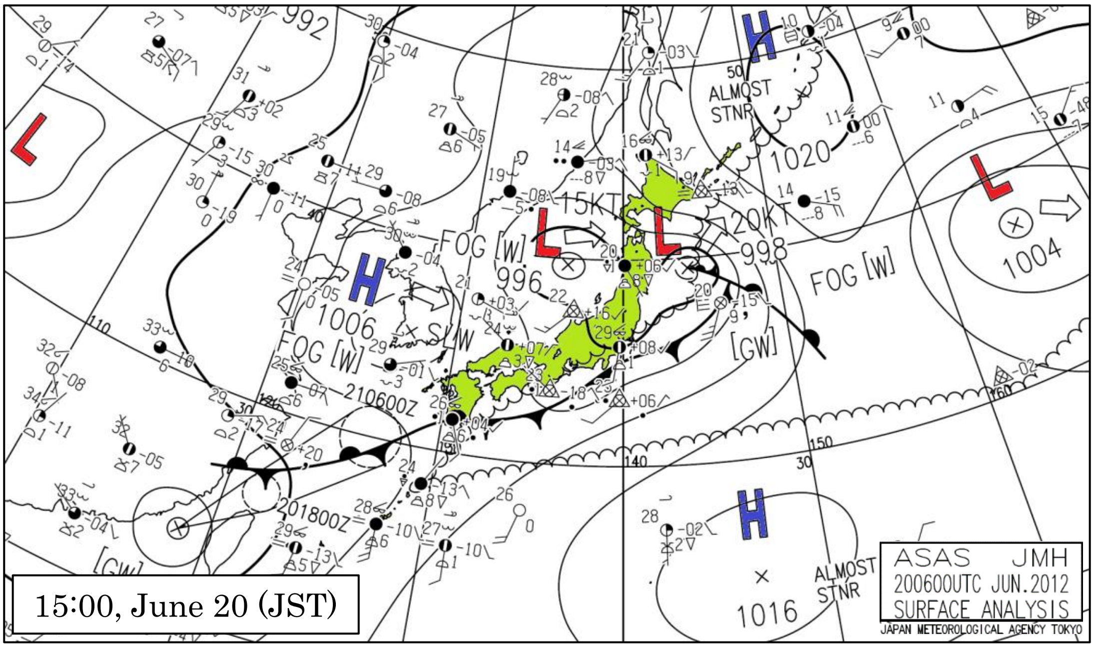
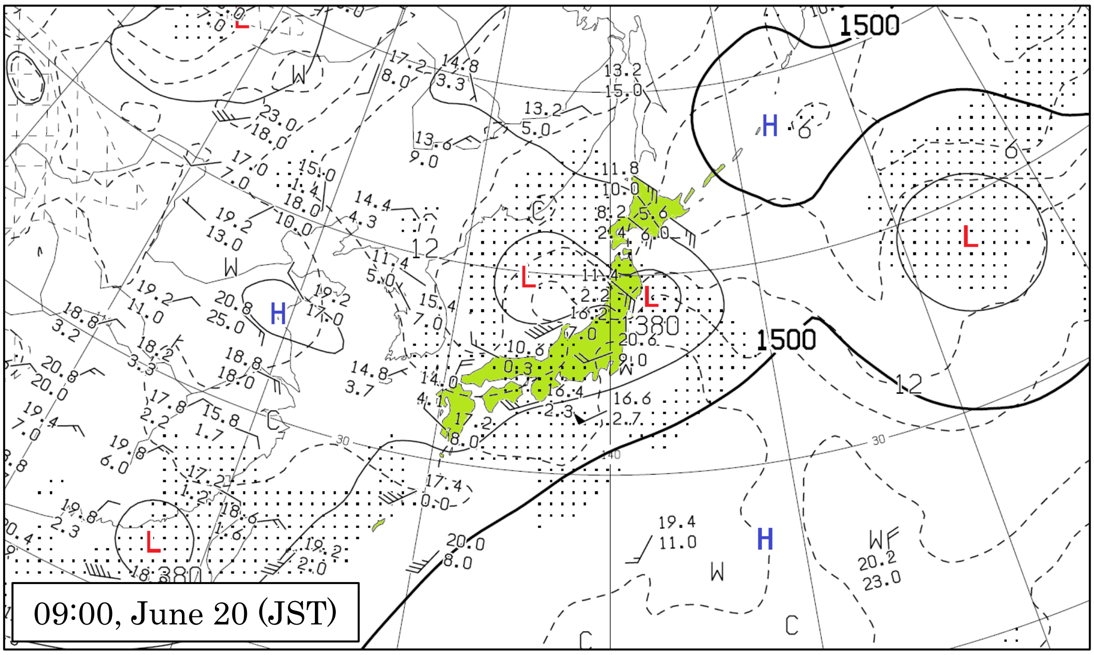


Figure 5-2 850 hPa Upper Air Chart (magnified)



ANALYSIS 850hPa: HEIGHT(M), TEMP(°C), WET AREA::(T-TD<3°C)

AUPQ78 200000UTC JUN 2012

Photo 1 Aircraft Involved in the Accident

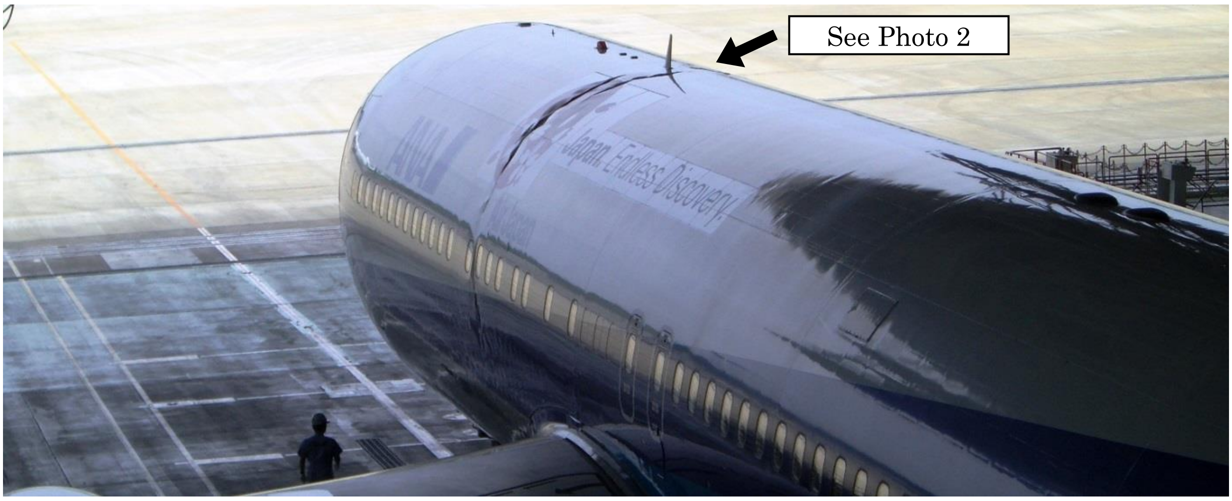


Photo 2 Fracture and Deformation of Outer Panel and Structural Component

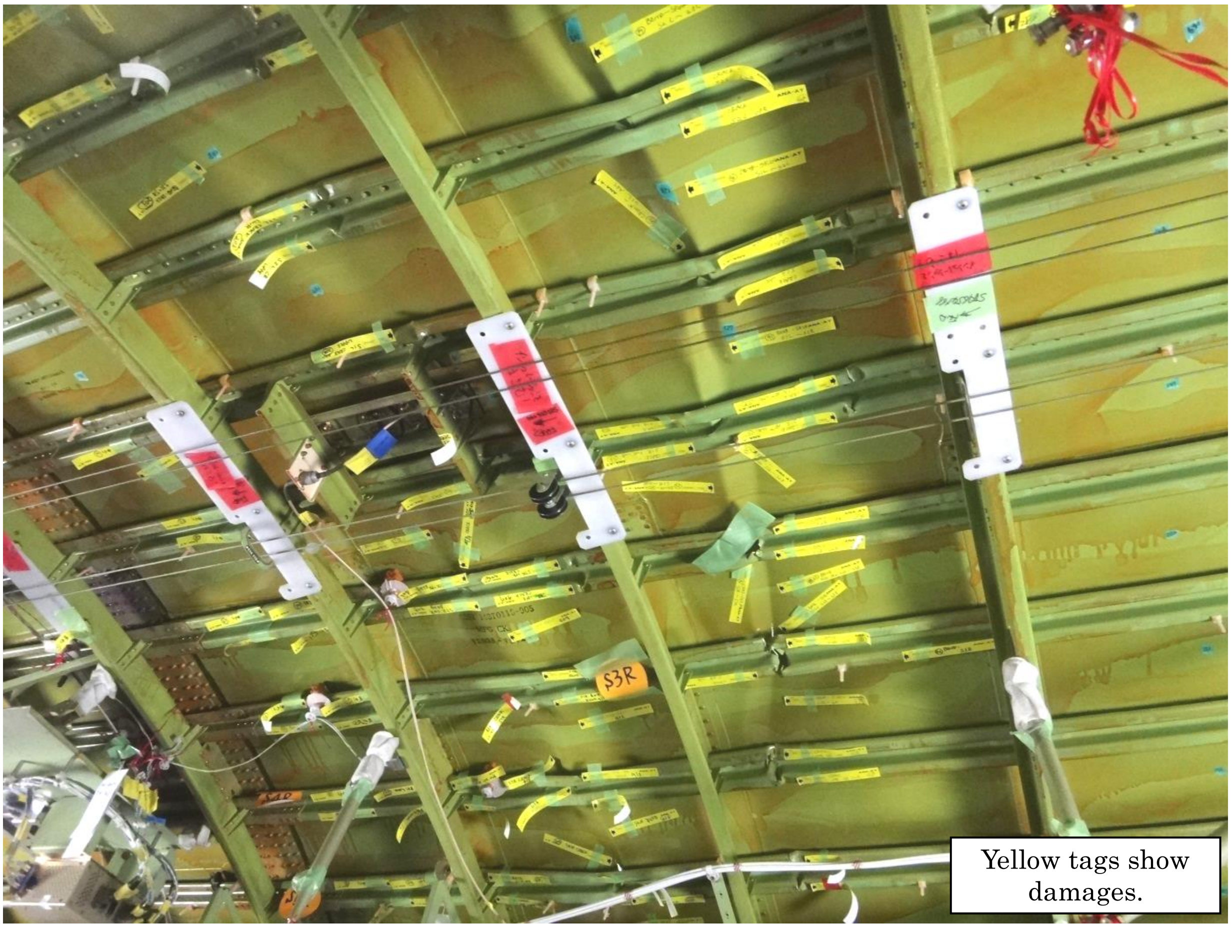


*Photo 2 was taken for the part indicated by the arrow in Photo 1 from inside of the aircraft.