AA2012-5

AIRCRAFT ACCIDENT
INVESTIGATION REPORT

ALL NIPPON AIRWAYS

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June 29, 2012

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.

Norihiro Goto
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

OPERATING AGENCY : ALL NIPPON AIRWAYS
AIRCRAFT TYPE : BOEING 767-300
AIRCRAFT REGISTRATION : JA8569
ACCIDENT CATEGORY : CABIN ATTENDANT INJURY BY TURBULENCE
OCCURRENCE TIME : AROUND 16:53 JST, APRIL 27, 2011
OCCURRENCE POINT : AT AN ALTITUDE OF APPROX. 25,000 FT ,
27NM EAST-SOUTHEAST OF KUSHIMOTO

June 8, 2012
Adopted by the Japan Transport Safety Board

Chairman	Norihiro Goto
Member	Shinsuke Endoh
Member	Toshiyuki Ishikawa
Member	Sadao Tamura
Member	Yuki Shuto
Member	Toshiaki Shinagawa

SYNOPSIS

〈Summary of the Accident〉

On April 27, 2011, at 16:16 Japan Standard Time (JST: unless otherwise stated all times are indicated in JST, UTC+9h), a Boeing 767-300, registered JA8569, operated by All Nippon Airways, took off from Miyazaki Airport for Tokyo International Airport as a scheduled flight 610. While flying at 25,000 ft, 27 nm east-southeast of Kushimoto, around 16:53, the aircraft encountered turbulence and one cabin attendant was seriously injured in front of the left aft lavatory. Four other people consisting of passengers and cabin attendants were slightly injured.

〈Probable Causes〉

It is highly probable that the accident occurred as follows:

The aircraft encountered atmospheric disturbance all of a sudden during flight, and was shaken so severely that one of the cabin attendants in the aft section of the aircraft was seriously injured after she was thrown up in the air and fell on the floor.

It is possible that the atmospheric disturbance the aircraft encountered were CAT which was created locally and temporarily by a wind shear in the vicinity of frontal zone beneath a jet stream.

List of Abbreviations

ACARS	Aircraft Communications Addressing and Reporting System
AIREP	Air Report
AOA	Angle of Attack
CAT	Clear Air Turbulence
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
FL	Flight Level
G	Gravity
MAC	Mean Aerodynamic Chord
MAGICS	MAPS and Graphic Information Creative System
MCP	Mode Control Panel
OMC	Operation Management Center
PF	Pilot Flying
PIC	Pilot in Command
PIREP	Pilot Report
PNF	Pilot Not Flying
POBS	Pilot Oriented Briefing System
SAT	Static Air Temperature
TCAS	Traffic Alert and Collision Avoidance System

Unit Conversion Table

1 ft	： ０．３０４８ m
1 kt	： １．８５２ km/h（０．５１４４ m/s)
1 lb	： ０．４５３６ kg
1 in	： ２５．４ mm
1 nm	： １.８５２ km

1. PROCESS AND PROGRESS OF THE AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident

On April 27, 2011, at 16:16 Japan Standard Time (JST: unless otherwise stated all times are indicated in JST, UTC+9h), a Boeing 767-300, registered JA8569, operated by All Nippon Airways, took off from Miyazaki Airport for Tokyo International Airport as a scheduled flight 610. While flying at 25,000 ft, 27 nm east-southeast of Kushimoto, around 16:53, the aircraft encountered turbulence and one cabin attendant was seriously injured in front of the left aft lavatory. Four other people consisting of passengers and cabin attendants were slightly injured.

There were 119 people on board: a PIC, seven crew members and 111 passengers.

The aircraft was not damaged.

1.2 Outline of the Accident Investigation

1.2.1 Investigation Organization

On May 2, 2011, the Japan Transport Safety Board designated an investigator-in-charge and two other investigators to investigate this accident.

1.2.2 Representatives from Relevant States

Although this accident was notified to the United States of America, as the State of Design and Manufacture of the aircraft involved in this accident, the United States did not designate its accredited representative.

1.2.3 Implementation of the Investigation

May 2 and 3, 2011: aircraft examination and interviews

May 6, 9, 10, 12 and 15, 2011: interviews

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 States

Comments were invited from the relevant State.

2. FACTUAL INFORMAION

2.1 History of the Flight

On April 27, 2011 at 16:16, a Boeing 767-300, registered JA8569, operated by All Nippon Airways (hereinafter referred to as "the Company"), took off from Miyazaki Airport for Tokyo International Airport as a scheduled flight 610.

The outline of the flight plan was as follows:

Flight rules:	Instrument Flight Rules (IFR)
Departure aerodrome:	Miyazaki Airport
Estimated off-block time:	16:10
Cruising speed:	444 kt
Cruising altitude:	FL[1] 270
Route:	JACKY(position reporting point) - MADOG (position reporting point) -BILLY(waypoint)- CHALK (waypoint) - ADDUM (position reporting point)
Destination aerodrome:	Tokyo International Airport
Total estimated elapsed time:	1 hr16 min
Fuel load expressed in endurance:	3 hr29 min
Alternate aerodrome:	Narita International Airport

A total of 119 persons consisting of the PIC, seven other crew members and 111 passengers (including two infants) were on board the aircraft. In the cockpit of the aircraft, the PIC sat in the left seat as a PF (pilot flying: pilot mainly in charge of flying), and the First Officer (FO) sat in the right seat as a PNF (pilot not flying: pilot mainly in charge of duties other than flying). The history of the flight up to the time of the accident is summarized as below, based on the records of the Digital Flight Data Recorder (DFDR) and the Cockpit Voice Recorder (CVR), the air traffic control (ATC) communications records, as well as the statements of the flight crew members.

2.1.1 History of Flight based on DFDR, CVR and ATC Communications Records

The aircraft took off from Miyazaki Airport at 16:16, and maintained the cruising altitude of FL270 from around 16:26 detouring the echo area detected by the weather radar over Shimizu to the south. The following is the summary of the events until its landing at Tokyo International Airport after its climb to FL290 and descent to FL250 followed by an encounter of strong turbulence at 27nm east-southeast of Kushimoto.

16:27:27 A chime sounded indicating that the seat belt sign (hereinafter referred to as "belt sign") had been turned off. Cabin attendants requested passengers over the Passenger Address (PA) system to keep their seat belts fastened although the seat belt sign had been turned off.

16:32:58 By contacting Zen nikku Kinki over the company radio[2], the FO reported the flight conditions, and confirmed the en route weather conditions.

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[1] FL stands for flight level. It is a pressure altitude expressed in hundreds of feet. This altitude is calculated from the international standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure. This expression applies to the altitude higher than 14,000 ft in Japan.

[2] Company radio means air carrier's communication system over the radio used for the communication between their flight crew and dispatchers. The Company has ground radio stations at Osaka International Airport and Tokyo International Airport, with a call sign "Zen nikku Kinki" for the former, and "Zen nikku Kanto" for the latter.

16:34:45 The PIC made a PA informing passengers of the latest flight conditions and requested that they fasten their seat belts all the time.

Around 16:39:00 The aircraft started a climb to FL 290.

Around 16:40:00 The aircraft reached FL 290.

16:41:41 A cabin attendant made a PA requesting passengers who leave their seats to be cautious although the belt sign had been turned off.

Around 16:42:00 The aircraft started descent to FL 250.

16:44:14 The FO reported to Zen nikku Kinki over the company radio of the flight conditions including wind shear at altitudes between FLs 250 and 290, adding that there were no cloud echoes detected en route ahead.

Around 16:45:00 The aircraft reached FL 250.

16:47:02 Cabin attendant reported to the PIC that the in-flight service had been completed.

16:52:22 The speed selector was set at 300 kt.

16:52:25 The wind velocity increased by 10 kt in 7 sec to reach 60 kt, and decreased by 4 kt in the next 4 sec, and then increased by 7 kt in the next 4 sec. During this period, the wind direction changed only about 5°.

16:52:31 The static air temperature (SAT) started to fluctuate with the gauge moving down, up and down again in about 12 sec, and resulted in an increase of 0.7°C compared with the temperature prior to fluctuation.

16:52:37 The thrust lever was retarded.

16:52:38 A bump sound was heard in the cockpit, and a vertical acceleration of −0.34 G was recorded.

16:52:39 The pitch angle of the aircraft started to increase.

16:52:41 The altitude of the aircraft decreased by 80 ft in 1 second. A chime sounded indicating that the belt sign had been turned on.

16:52:52 The wind velocity settled at 50 kt.

16:52:58 The FO reported to the Tokyo Area Control Center that the aircraft had encountered MODERATE turbulence.

16:53:02 Cabin attendant informed passengers over the PA system the belt sign had just been turned on, requesting them to remain seated until the belt sign was turned off.

16:53:41 The aircraft requested a descent to FL 230.

16:54:33 With the ATC clearance, the aircraft started to descend to FL 230.

16:55:12 Cabin attendant reported to the PIC the situation observed in the cabin.

16:56:20 A chime sounded indicating that the belt sign had been turned off.

16:56:27 The FO reported to Zen nikku Kinki that the aircraft had encountered a MODERATE turbulence, and that several persons were injured.

16:57:43 The aircraft started to descend to FL 210.

17:05:43 The aircraft started to descend to FL 170.

17:07:43 The FO informed Zen nikku Kanto that arrangements for an ambulance would not be necessary for the time being although several persons were injured as a result of turbulence encounter.

Around 17:11:00 Cabin attendant informed the PIC of the detailed conditions of the injuries.

17:15:22 The PIC informed Zen nikku Kanto of the conditions of the detailed injuries, requesting arrangements of a wheel chair upon arrival.

17:22:18 The PIC informed passengers over the PA system that the aircraft had encountered turbulence and it would not affect the scheduled flight.

About 17:43:00 The aircraft landed at Tokyo International Airport.

(See Figure 1: Estimated Flight Route, Figure 2: DFDR Records and Figure 3: Turbulence Intensity Reporting Criteria)

2.1.2 Statements of Flight Crew Members

(1) PIC

The PIC checked the weather map, radar echoes and others on the pilot briefing system (POBS) at the Station Control of Miyazaki Airport. The surface weather map showed that south-west end of a frontline was over Miyazaki, which extended from the low over the Sea of Japan. He shared the understanding with the FO that the flight would be somewhat bumpy. While the radar map showed radar echoes scattered over Miyazaki, he concluded that the aircraft would be able to stay away from them by either the use of airborne weather radar or visual observation. He obtained similar information from the flight crew of the arriving and departing flights. A dispatcher on duty at the operation management center (OMC) recommended FL 390. However, an analysis of the upper-level cross section chart showed that strong wind shear would be expected at altitudes between FLs 300 and 400, and similar information had been observed in the pilot report (PIREP[3]). An operations assistant at Miyazaki Station Control suggested cruising altitudes of FL 270 or FL 290, either of which was later accepted as an appropriate altitude by both the PIC and the FO. The PIC consulted with the dispatcher over the phone and decided to choose FL 270 as the cruising altitude.

After that, during the pre-flight briefing to the cabin attendants in the cabin, the PIC explained that turbulence encounter was possible all along the route, and the belt sign would not be turned off until they reached a cruising altitude of FL 270 because they would stay away from clouds of strong radar echoes during the climb. He also instructed them to pay full attention while carrying out in-flight services during cruising since slight shaking should be expected even after the belt sign was turned off.

After takeoff, the PIC found radar echoes scattered as had been expected, and the situation remained the same even after reaching FL 270. He then detoured the clouds of strong radar echoes to the south, and continued the flight. Judging from the information over the company radio that FLs 270 and 260 were almost smooth, and the fact that the shaking the aircraft had experienced was more or less LIGHT MINUS he turned off the belt sign requesting passengers to keep their seat belts fastened all the time to prepare for the expected shaking at several points en route. The PIC thought the LIGHT shaking experienced was due to FL 270 which was situated nearly the top of the stratus-type clouds formed in several layers, and he climbed to see the conditions at FL 290. When he encountered shaking of similar intensity while climbing – a wind shear of 10 kt per 1,000 ft, and he started to descend to FL 250 as he believed it inappropriate to stay in higher altitude.

When he reached FL 250, it was out of clouds and the flight was smooth without wind shear. When he was about to prepare for the approach to Haneda, he felt a “floating” sensation as if he had been riding on a big wave. Although the shaking was a light one, the PIC retarded

[3] PIREP denotes a report from a pilot to the ATC organization in case of an encounter of adverse weather conditions which affect the aircraft operations. In this report, PIREP includes C-PIREP (common PIREP) which contains weak turbulence information, which is shared among air carriers.

the thrust lever to reduce speed as a precaution. Immediately following that, the aircraft was thrust upward all of a sudden, and then was violently thrust downward. The shaking lasted only an instant, and the suddenness and the intensity of the shaking was far greater than any other shaking he had experienced before. The PIC could not understand what had happened at that moment, and he soon turned on the belt sign. The strong shaking lasted less than one to two seconds, and did not happen again. He then found the aircraft had lost its altitude by 100 ft during the turbulence encounter.

The airborne weather radar was in WX mode and the PIC monitored its display with the detection range of 160 nm and the tilt setting between －1° and －2°. When the flight was passing over Shimizu, the radar display did not show any sort of echo, not even weak ones. The autopilot remained engaged, when the aircraft encountered the turbulence. At this point, the PIC reduced speed by using mode control panel (MCP[4]). The shaking itself was the sort that was commonly experienced during wake turbulence; however, the traffic alert and collision avoidance system (TCAS) display showed no traffic.

(2) FO

The aircraft took off from runway 27. The cloud top was not as high as had been detected by the airborne weather radar, and the aircraft did not encounter strong shaking. The intensity of the shaking continued to range from LIGHT MINUS to LIGHT. Then, as the intensity of the shaking started to become a little stronger, the aircraft climbed to FL 290 and, soon after that, it descended to FL 250. After that, the FO, while flying between layers of clouds and just before the shaking occurred, felt a "floating" sensation as if he had been riding on a wave. The aircraft was thrown upward by 100 ft, and instant later thrown abruptly downward. The speed at that time was approx. 300 kt, and the PIC soon retarded the thrust lever to reduce the speed. Immediately before the shaking, the wind velocity increased from 40- something kt to 50-something kt. The FO was unsure how the direction of the wind had changed after the shaking, but he was sure that the direction of the wind immediately before the shaking had been between 250° and 260°. The temperature had also changed, but he did not remember by what degrees.

He and the PIC looked at each other with an expression of "what was that." Immediately after that, the PIC turned on the belt sign. No more shaking occurred. Then, the aircraft descended from FL 250 to FL 230. He checked the cabin conditions and learned that a passenger with an infant and three cabin attendants were injured, one of whom could hardly stand, according to a report from the cabin.

He judged that it would be possible to continue the flight to Haneda, and the FO reported over the company radio that four people were injured, requesting arrangements for a wheel chair upon arrival. He also informed the ATC that they had encountered a MODERATE turbulence.

Before departure, he recognized that radar echoes of clouds were scattered mainly over Shikoku and Kyushu areas, and over the Kii Peninsula. The airborne weather radar, however, did not display any cloud echos in the east of Kushimoto on the display. Normally, in case of increasing intensity of shaking, he changes altitudes or reduces airspeeds to see its effectiveness; however, he was unable to take any preventive measures against the shaking,

[4] MCP is an instrument panel that controls such functions as autopilot, automated flight-director system and auto-throttle.

because it happened suddenly without the slightest indication after the previous shaking had subsided.

2.1.3 Statements of Cabin Attendants

(1) Chief Purser (in charge of L1)

The PIC explained in the pre-flight cabin briefing that weather conditions en route would be bad not only during takeoff and landing, but also during cruising, and the flight would continue to be bumpy. So the chief purser determined to carry out cabin services without using service carts. After takeoff, bumpy conditions continued. The turbulence occurred when she was working in the forward cabin after completing the in-flight service. Immediately before the turbulence, she felt a rattling shake which she thought would endanger safety, although unsure whether it was a movement of pitching or yawing. At that precise moment, she felt like she was lifted up very softly. Although the chief purser instantaneously grabbed a curtain in front of her, she was lifted up by 20 cm only to be dropped to the floor with the hem of the curtain over her arm. Soon after that, the belt sign was turned on, and she made a fasten-seat-belt announcement, and then instructed each of the cabin attendants over the interphone to report the current situation. After the belt sign was turned off, she checked whether there was anybody injured or any damage observed in the cabin. She learned that one passenger and three cabin attendants were injured and reported it to the PIC. The PIC asked whether an ambulance would be required for the injured. She asked only a wheel chair for the injured cabin attendant who could barely walk at that time, who was later found to have suffered a bone fracture. There was no report of damage observed in the cabin, though most of the in-flight magazines and headphone sets in the seat pockets were found scattered over the floor in the aft cabin.

After landing, another passenger claimed both legs injury. The injured, consisting of two passengers and three cabin attendants, deplaned on a high-lift loader and were transported to a hospital.

(2) Cabin Attendant A (in charge of L2)

The flight was mostly bumpy. When the cabin attendant A was about to turn her body toward the cabin after checking conditions of a lavatory in the left aft cabin, she was suddenly thrown up in the air. Next time she realized that she had hit her head against and landed on the buttocks. She felt as if she were caught in a vertical tremor, and could not afford to grab a seat near her because the shaking occurred suddenly without the slightest prior indication. She moved to the galley at the midsection of the cabin talking to each passenger to see if they were all right. It was after she reported to the chief purser that no passenger was injured that she felt too severe a pain in the waist to move. The duties she had been assigned were taken over by a cabin attendant responsible for the other side of the compartment.

After deplaning she was diagnosed with suspected avulsion fractures at a hospital. On May 2 she was finally diagnosed as having bone fractures.

(3) Cabin Attendant B (in charge of RC)

After takeoff, intermittent shaking continued and they subsided 5 to 10 minutes before the strong shaking occurred. When the strong shaking occurred the cabin attendant B was pulling out a service cart to get the service items back in position in the galley located at the midsection of the cabin. She felt like she was thrown up high in the air, and so was the service

cart she was working on, almost reaching the ceiling of the galley. But as she was working in a half-sitting posture, she could avoid bumping her head against the ceiling. When she landed, she hit her forehead against the cart while trying to hold it down. The cart landed upright.

After that she took her seat as the belt sign was turned on. The aisles were filled with in-flight magazines which had escaped from seat pockets. Cabin attendants are instructed to grab a safety handrail or an armrest from underneath in order to keep from floating in case of turbulence; however, she could not do so since she didn't have time suddenly found herself afloat in the air. The intensity of the bumpiness was by far larger than that she had experienced before.

(4) Cabin Attendant C (in charge of R2)

The PIC instructed the cabin attendants to remain seated while the belt sign was on, saying that weather conditions en route of that day would be generally bad, and that strong shaking would be expected, particularly during climb and descent. The chief purser's pre-flight instruction was to carry out cabin services without using service carts.

When the aircraft encountered the turbulence, the cabin attendant C was in the aft galley where there were handrails installed to hold on to when necessary. She grabbed one of them from above. However, the shaking upward was so violent that she could not hold on to it. Next time she felt pain in her knees and found that they had abrasion. Upon turning on the belt sign, she got back to her seat and heard a child crying in a lavatory. When she opened its door she found a passenger sitting on the floor holding her child in her arms with the retractable diaper table extended. The cabin attendant C learned that she had hit her head against the lavatory ceiling, took care of the child and gave her first-aid treatment in one of the rearmost seat. The cabin attendant C then realized that she herself had hit her head against the ceiling and she gradually began to feel pain.

2.1.4 Statements of Passengers

(1) Passenger A (with a child)

The moment the passenger A had finished putting shoes on her child held in her arms in a standing position after she changed the diapers in the aft lavatory, she encountered the turbulence. Before the strong shaking she felt rolling and she anticipated another shaking, but her anticipation was betrayed by the pitching by which she was thrown upward to have her head hit against the ceiling, and was dropped on the floor. The child was unhurt, because, the moment the shaking occurred, she held her child tightly in her arms in a situation where there was nothing to hold on to or nothing else she could do. She said the bumpiness as "bang" rather than "floating", and felt like being thrown up all of a sudden.

(2) Passenger B (a Company's flight crew member on personal business)

Shaky conditions continued during climbing and cruising. He was using a laptop in his seat when he looked out of the window to find that the aircraft was flying through clouds. He thought that the aircraft was descending as he saw speed brakes extended. Later, the aircraft was flying below the clouds and the shaky conditions subsided. After that, a smooth flight continued for 10 to 15 min.

Immediately before the strong turbulence, he felt a strong uplift for 3 to 5 sec as if he had been surfing. At that precise moment, he was hit by the drop. Then he saw in-flight magazines escape from the seat pocket in front of him and scatter over the aisle. An empty paper cup jumped up by 30 cm and rolled away. Similar situations were observed in the area

up to about the 15th row from the cabin end. His whole body was thrown up even though his seat belt was fastened. It seemed the whole cabin was seized by such a surprise that passengers were left speechless. The shaking with a big banging sound made him think of some explosion. He was unable to understand why that shaking had occurred in a situation where no cloud was observed on either side of the aircraft.

This accident occurred around 16:53 on April 27, 2011, in an airspace approximately 27 nm east-southeast of Kushimoto (33°20′35″N, 136°19′20″E), at an altitude of about 25,000 ft.
(See Figure 1: Estimated Flight Route and Figure 2: DFDR Records)

2.2 Damage to the Aircraft

After landing, the aircraft underwent a special inspection which is required after encountering big turbulence; however, no damage or anomalies were found.

2.3 The Dead, Missing, and Injuries to Persons

One cabin attendant was seriously injured, while two passengers and two other cabin attendants were slightly injured.
(See Figure 5: Locations of the Injured when the Accident Occurred, Photo 2: Right aft lavatory and Photo 3: Left aft lavatory)

2.4 Information on the Flight Crew Members

(1) PIC Male, Age 41

Airline Transport Pilot Certificate (Airplane)	January 28, 2005
Type Rating for B767	July 17, 1997
Class 1 Aviation Medical Certificate	
Validity	June 20, 2011
Total flight time	8,410 hr 24 min
Flight time in the last 30 days	69 hr 35 min
Total flight time on the type of aircraft	5,740 hr 08 min
Flight time in the last 30 days	69 hr 35 min

(2) FO Male, Age 55

Airline Transport Pilot Certificate (Airplane)	July 30, 2002
Type Rating for B767	November 25, 2003
Class 1 Aviation Medical Certificate	
Validity	October 6, 2011
Total flight time	7,633 hr 35 min
Flight time in the last 30 days	21 hr 38 min
Total flight time on the type of aircraft	1,388 hr 58 min
Flight time in the last 30 days	21 hr 38 min

2.5 Aircraft Information

2.5.1 Aircraft

Type	Boeing 767-300
Serial number	27050

Date of manufacture	August 26, 1993
Certificate of airworthiness	99-055
Validity	Period during which the Maintenance Manual has been effective since March 12, 1999.
Category of airworthiness	Airplane, Transport T
Total flight time	39,133 hr 06 min
Time in service since the last regular inspection (C inspection on May 21, 2010)	2,250 hr 18 min

(See Figure 4: Three Angle Views of B767-300 and Photo 1: The Aircraft Involved in the Accident)

2.5.2 Weight and Balance

When the accident occurred, the aircraft's weight and the position of the center of the gravity (CG) are estimated to have been 257,500 lb and 20.1% mean aerodynamic chord (MAC), respectively, within the allowable range (maximum takeoff weight of 280,000 lb, and 11.9 to 32.8% MAC corresponding to the weight at the time of the accident).

2.6 Meteorological Information

2.6.1 General Weather Conditions

According to the Asia Surface Analysis Map at 15:00 on the day of the accident, a low was moving northeast at 15 kt over the Sea of Japan. Two fronts extended from this low: one toward west to the East China Sea, the other to the east of Japan striding over Tohoku Region. Southerly moisture-laden warm air was blowing into this low and the fronts, making the atmospheric conditions unsteady.

(See Figure 6 Asia Surface Analysis Map)

2.6.2 Domestic Significant Weather Analysis Chart

The Domestic Significant Weather Analysis Chart valid at 15:00 was summarized as follows:

A radar echo area which developed along the forefront of the cold front extending from the low spread like a belt and was advancing to the east at 15 kt. The area of strong radar echo intensity and high top radar echo altitudes were observed along the area off the coast of Shikoku, Chugoku Region and off the coast of Hokuriku. However, there were very few echoes present with 5 mm/h or less in the airspace where the accident occurred, and their tops were as low as 2 to 4 km high.

The cloud imagery by a meteorological satellite showed that corresponding to the echoes described as above, convective cloud line containing cumulonimbus clouds in the forefront of a cold front were running from Amami-oshima Island through Shikoku and Chugoku Regions. It also showed that, to the east of the convective cloud line, there were upper clouds along a jet stream, running across from Okinawa to the northern end of the Japanese Archipelago via Kii Peninsula. There were also upper clouds scattered in the vicinity of the accident airspace.

Also two strong jet stream wind axes (with the maximum velocity of 140 kt) were analyzed: one running from Amami-oshima Island through Kanto Region; and the other across from the Japan Sea to Hokkaido. It also showed that a clear air turbulence area was present at altitudes of FL 260/340 along the frontal zone under the jet streams, which were advancing toward east-northeast at 20 kt.

(See Figure 7: Domestic Significant Weather Analysis Chart. [For the analysis of the weather conditions, Upper-level Weather Chart, Radar Echo Chart, and Meteorological Satellite Imagery at the corresponding points and the time frame were referred to.])

2.6.3 Hourly Analysis Chart

(1) Horizontal Cross Section Chart

According to the hourly analysis chart showing the conditions at about FL 250 which was close to the time when the accident occurred, there was a vertical wind shear of 6 to 9 kt approx. 30 nm south of where the accident occurred and beyond. And further to the south, another wind shear of by far a larger scale was analyzed; however, the vertical wind shear present in the vicinity of the accident airspace was as weak as 0 to 6 kt.

(2) Vertical Cross Section Chart

According to the vertical cross section charts at 135.0°E and 137.5°E, there was a jet stream present at altitudes between FL 380 and FL 400 in the vicinity of the accident airspace, accompanied by a strong wind area with a velocity of 140 kt. The wind in the vicinity of the accident airspace was accelerated. In addition, the jet stream, core altitude became higher as it flowed northeast, and the area of strong wind (the maximum wind area) also became enlarged. In proportion to these changes, the isotachs around the frontal zone under the jet stream became dense, and the area of large vertical wind shear became enlarged. However, the vertical cross section analysis showed nothing more than a vertical wind shear as weak as 0 to 6 kt at an altitude around FL 250, where the temperature lapse rate showed only a minor change.

An analysis of vertical cross section chart covering the Tokyo-Kagoshima route, part of which runs closest to the accident airspace, provided wind information as: wind direction west-southwest at approx. 50 kt; vertical wind shear, as weak as 0 to 6 kt.

(See Figure 8: Hourly Analysis Chart [vertical cross section], Figure 9: Hourly Analysis Chart [horizontal cross section] and Figure 10: Hourly Analysis Chart for Tokyo-Kagoshima)

2.6.4 Domestic Significant Weather Prognostic Chart

The domestic significant weather prognostic chart at 15:00 which was available to the PIC before the flight predicted that convective clouds accompanied by scattered cumulonimbus would generate a turbulence of MODERATE intensity along the forefront of the cold front crossing the northern part of Kyushu through the San-in Region, with the cloud top reaching FL 320. Although the cloud zone over that region was moving eastward at 15 kt, it had not yet reached the accident airspace at the time of the accident. At the same time, the chart had predicted clear air turbulence of MODERATE intensity in an inclined airspace with the southern and northern tips reaching the altitude of FL 270 and FL 330, respectively, along the frontal zone under the jet stream extending from Amami-oshima Island through the Kanto Region. The accident airspace was situated in the vicinity of the northern tip of this airspace.

(See Figure 8: Hourly Analysis Chart (vertical cross section) and Figure 11: Domestic Significant Weather Prognostic Chart)

2.7 Operations Control by OMC

According to the statements by the dispatcher and other personnel assisting operations control at OMC, the weather conditions on the day of the accident were summarized as follows:

(1) Dispatcher

The dispatcher, upon showing up at the OMC, checked his assignment of that day and was briefed by a staff in charge of weather activities on the general conditions and his forecast for the remaining hours of that day: There was a low present over the Sea of Japan accompanied by fronts, and the state of the atmosphere had been unsteady under the influence of southerly moisture-laden warm air; and this situation was shown as radar echoes mainly over Western Japan, although there might not be any major changes as the low was slowly moving northeast. In addition, he was briefed on how the staff had judged the weather conditions en route from the forecast charts available including significant weather prognostic charts and upper-level vertical cross section charts, as well as on the actual reports observed in PIREPs. When the briefing was over, he took over the job of assigned area.

He opted to apply a standard altitude for the flight plans passing over the area he was in charge. However, as the wind around Haneda was strong, he instructed operations assistants to see that aircraft should be loaded with a little more fuel than required. Although FL 410 was a standard altitude applicable to the flight of the accident, he instructed that the flight plan should be made with an altitude of FL 390 which would enable fuel consumption to be minimal.

The dispatcher checked mainly the significant weather charts available to learn about weather conditions. According to those weather charts, occasional LIGHT turbulence were expected at altitudes between FLs 280 and 340 across the area from the western part of Kanto to Kii Peninsula, and at altitudes between FLs 230 and 340 across the area from Kii Peninsula to above the ocean beyond. He recommended FL 390, because actual flight reports contained no strong turbulence at altitudes higher than FL 350. After that, he was told over the phone by the PIC at Miyazaki Airport that he wanted to change the altitude to FL 270. Upon analyzing again the weather conditions on relevant forecast charts available, he predicted that there would be shaking at high altitudes over the area covering Kanto through the east of Kinki, while, at low altitudes, there would be only occasional LIGHT turbulence. He thought that the flight might encounter occasional turbulence over Kii Peninsula under the influence of the front. However, he concluded that changing the altitude to FL 270 would not disrupt the flight in any way, taking into account the fact that no major turbulence had been reported by actual flights. He then changed the flight plan accordingly.

After the aircraft took off, he started flight monitoring. Company's Itami Station in Osaka received the initial report from the aircraft that it had encountered a MODERATE to SEVERE turbulence. Until that moment, OMC had not received any weather inquiry nor any report of major turbulence from the aircraft, and it did not give information to the aircraft. In case of a report of MODERATE or stronger turbulence within the range of 30 nm on either side of a flight route, the aircraft communications addressing and reporting system (ACARS) automatically uplinks that information. Although he had predicted LIGHT MINUS to MODERATE turbulence, the real intensity of the turbulence was beyond his expectation. All the weather related data and information are accessible at each station including en route information which is reflected selectively when something important is reported during debriefings by flight crews arriving at each station.

(2) Operations Assistant (at the Company's Miyazaki Station Control)

The flight crew members involved in the accident showed up around 15:00, looked through the weather charts, and asked the operations assistant about the availability of any reports from previous flights. He provided them with a copy of a report from the scheduled

flight ANA608: The echo top at an altitude of FL 400 with the cloud base at FL 300; LIGHT to LIGHT PLUS turbulence encountered in the clouds during climbing; turbulence intensity equal to LIGHT MINUS across MADOG to Shimizu after reaching a cruising altitude of FL 410. He suggested an altitude of FL 300 or lower, and provided en route weather conditions obtained from MAPS and graphic information creative system (MAGICS), which predicted SMOOTH to LIGHT MINUS turbulence at altitudes between FLs 250 and 300, while LIGHT to LIGHT MINUS at FL 300 and above.

The PIC asked the scheduled flight ANA609's PIC, who had arrived from Haneda at 15:04, about the en route weather conditions, although the operations assistant was unsure which weather charts the PIC had checked prompted him to do so. According to the scheduled flight ANA609's PIC, the weather conditions en route had been almost the same as what had been available at Miyazaki Station Control, with occasional LIGHT MINUS turbulence at FL 400. He also reported that his aircraft had been unable to clear out of the clouds even after reaching FL 410, and he had experienced LIGHT MINUS to LIGHT turbulence between FLs 300 and 360, with occasional LIGHT PLUS turbulence. For that reason, the PIC called a dispatcher at OMC and obtained permission to change the cruising altitude to FL 270. Change of cruising altitudes is often done in the case of bad weather conditions.

The operations assistants' job is to provide information for the operation of a flight; it is expected that pilots themselves should collect such information from POBS, and a pre-flight meeting with the flight crew may end up with confirmation of general matters. On fine days his briefing sometimes ends replaced by general confirmations.

2.8 Medical Information

The extent of the injuries suffered by passengers and cabin attendants were as follows:

(1)	Cabin Attendant A (in charge of L2)	Right pubis, fractured	Seriously injured
(2)	Passenger A (in a R2 lavatory)	Head, bruised	Slightly injured
(3)	Passenger C (seat 33A)	Both shanks, bruised	Slightly injured
(4)	Cabin Attendant B (in charge of RC)	Head, bruised	Slightly injured
(5)	Cabin Attendant C (in charge of R2)	Both knees and head, bruised	Slightly injured

(See Figure 5: Locations of the Injured when the Accident Occurred)

2.9 Information on DFDR and Cockpit Voice Recorder

The aircraft was equipped with a DFDR made by LAS of the United States of America (part number :10077A500-803) and a CVR made by L3 Communications of the United States of America (part number: 2100-1020-00).

All records at the time of the accident were retained on the DFDR and the CVR. The time was determined by correlating the recorded VHF transmission keying signals in the DFDR with the speaking clock signal in the ATC communications records.

2.10 Operating Conditions before the Accident Occurred

The radar tracking records of Tokyo Area Control Center registered no aircraft operating other than the aircraft near the accident airspace during the 10-min period before the occurrence of the accident, within 2,000 ft above or below FL 250 which was assigned to the aircraft.

2.11 Additional Information

2.11.1 Company's Regulations on Seat Belt

The Company's Operations Manual includes the seat belt usage as follows: (excerpt)

2－1－2 General

⑦ Seat Belt and Shoulder Harness

The following procedures apply to the fastening of seat belts.

(3) The PIC must turn on the seat belt sign and instruct the passengers and cabin attendants to fasten their seat belts, in such cases as,

1) during taxiing

2) during takeoff and landing

3) when the flight is expected to encounter Turbulence, or when it has encountered the turbulence that is considered dangerous to the safety of the passengers and cabin attendants, and

4) whenever the PIC considers it necessary

(4) Cabin attendants should take the following measures when the seat belt sign is turned on:

1) upon completing essential safety measures, return to their seats or take the nearest seat available, and fasten the seat belts.

2) ensure that all the passengers have had their seat belts fastened through Passenger Address system. In the case of security duties before takeoff or permitted by the PIC, return to their seats and fasten the seat belts upon completion of the duties.

2.11.2 Posture to be taken by Cabin Attendants upon Encountering Turbulence

The Company's Cabin Attendants' Manual contains the following description: (excerpt)

In case of the unexpected turbulence, cabin attendants squat to lower their center of gravity to prevent falling and try to take the nearest unoccupied seat. Try to grab an armrest from underneath when unable to find an unoccupied seat. In the galley, hold on to the handrail therein.

2.11.3 Information on Clear Air Turbulence

The working guidelines for aviation weather forecasting services established by Japan Meteorological Agency provides the following descriptions for predicting clear air turbulence (CAT):

CAT is likely to be observed in the vicinity of a deep low trough or along a jet stream and a frontal zone (stable layer). Additionally, examinations show that the vertical and horizontal scales of CAT are quite small compared to that of a synoptic phenomenon (large-scale phenomenon) with the life span of somewhere from several tens of minutes to several hours, making the resolution currently available on the synoptic scale useless to predict precise time and airspace of CAT. With these factors considered, the agency forecasts based on a statistical method while using PIREP and AIREP the areas, altitudes, and timing of high potential (probability of occurrence), and intensity .

3. ANALYSIS

3.1 Qualifications of Flight Crew

Both the PIC and the FO held valid airman competence certificates and valid aviation medical certificates.

3.2 Airworthiness Certificate

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

3.3 Relation to Meteorological Conditions

It is highly probable that the meteorological conditions around the accident airspace and their influence on the flight were as follows:

(1) Convective Clouds

As described in 2.6.2, it is probable that there were no convective clouds near the accident airspace at the time of the occurrence, while to the west of the airspace a convective cloud zone existed accompanied by tall cumulonimbi associated with a cold front. Although some layers of thin clouds existed along the jet stream, it is highly probable that the aircraft was not shaken by the influence of convective clouds judging from the statements in 2.1.2 that neither the PIC nor the FO found echoes on the airborne weather radar screen, observing no clouds at their altitudes while flying between the thin cloud layers.

(2) Winds

As described in 2.1.1, a tail wind was becoming stronger on and after 16:52:25, immediately before the aircraft's strong turbulence encounter. The wind values fluctuated up and down corresponding to the change of altitudes (approx. 100 ft) before the occurrence, although the data acquisition interval and the values obtained during the turbulence are not fully valid, the following facts are confirmed.

a. Fluctuation range was wide for the corresponding duration.

b. SAT changed suddenly by 3℃ immediately before the strong turbulence.

c. The mean value of SAT showed a slight increase before and after the occurrence, even though it was as small as 0.7℃.

Judging from these findings, it is highly probable that the existence of layers in the accident airspace, whose temperature and atmospheric pressure values were different, accompanied by wind velocity difference (wind shear), generated the unsteady air conditions where turbulence was likely to occur near the layer boundary. While the aircraft was flying in the vicinity of the boundary, it is possible that the unsteady airspace generated the turbulence and shook the aircraft with a downdraft, judging from the fact that at the moment of the turbulence, the wind velocity increased by approximately 8 kt while the angle of attack (AOA) decreased sharply by more than 3°.

(3) Wake Turbulence

It is highly probable that the aircraft was not affected by wake turbulence, judging from the fact that the PIC states in 2.1.2 that TCAS showed nothing as well as the fact that there was no radar record of other aircraft operating within 2,000 ft above or below the aircraft as described in 2.10

3.4 Flight before and after the Turbulence

As the PIC stated in 2.1.2, he felt a "floating" sensation as if he had been riding on a big wave adding that the shaking was a light one and this corresponds to the DFDR records indicating, as described in 2.1.1(Figure 2), that the aircraft started to experience vertical shakes on and after around 16:51:40, with the gradual increase of the amplitude resulting in a change of altitude by approximately 100 ft at the most. Responding to the turbulence the PIC set the speed selector at 300 kt around 16:52:22 in an effort to reduce the speed to minimize the influence of the turbulence. He then retarded the thrust lever to reduce the speed, quickly followed by a strong shaking around 16:52:38, registering a negative vertical acceleration. This sharp change in acceleration lasted only for 2 sec, and stopped around 16:52:40 without recurring. The highest value of vertical acceleration recorded during this period of time was + 1.40 G, while the lowest was −0.34 G. Judging from the fact that the ground speed of the aircraft was 500 kt, it is probable that the strong shaking occurred in a range of about 800 m. It is highly probable that the shaking thrust the entire aircraft downward, diminishing its altitude by 80 ft within a second.

It is highly probable that the PIC operated the thrust lever to reduce speed judging that it would take time before the setting of the speed selector at 300 kt to control speed took effect, or setting auto throttle in position would not effectively function in time. It is highly probable that autopilot remained engaged and the aircraft was able to recover the attitude.

3.5 The Shaking

The turbulence took a toll of five injured persons including one seriously injured person as described in 2.8. According to the statements in 2.1.3 and 2.1.4 made by the cabin attendants and the passengers, cabin attendants and passengers in the aft cabin were thrown up high enough to hit their heads against the ceiling, and a cabin attendant working in the midsection of the cabin working with the service cart was thrown up high almost reaching the ceiling of the galley, by contrast, those in the forward cabin only by 20 cm. Likewise, in-flight magazines escaped from most of the seat pockets in the aft cabin, by contrast in the forward cabin, this happened only to three or four rows of seats close to the midsection of the cabin. On the other hand, according to the statements described in 2.1.3 (3), the cart was thrown up straight with no sideways movement, and DFDR records in 2.1.1(Figure 2) showed a very small value of lateral acceleration. Judging from these findings, it is highly probable that the aft section of the aircraft received larger amplitude and strength of vertical shaking than that of the forward section. In addition, judging from the fact that the value of −0.34 G recorded in DFDR was the value detected by the accelerometer installed near the aircraft CG, it is possible that a far larger negative vertical acceleration was inflicted on the aft section of the aircraft. It is highly probable that the aircraft motion around the CG, which was created by additional pitch up of 1.4° at the time of the strong shaking, integrated with the sharp descent of the aircraft by 80 ft as described in 3.4, gave the aft section of the aircraft a sudden lowering, causing the cabin attendant near aft left lavatory to be thrown up in the air, inflicting a serious injury on her upon falling on the floor. As described in 2.11.2, it is probable that the Cabin Attendants' Manual contains the counter turbulence posture and they knew how to respond; however, the suddenness and strong intensity of the turbulence probably prohibited them from taking the defensive posture.

3.6 The Turbulence

As described in 2.6.3 Hourly Analysis Chart, it is highly probable that, the aircraft gradually approached the frontal zone under the jet stream as it moved to the east becoming susceptible to wind shear. It is highly probable that the aircraft encountered a local and temporary, strong CAT induced by wind shear judging from the findings: nothing more than a weak vertical shear with 0 to 6 kt was analyzed at the occurrence point; the strong shaking lasted only for a very short period and ended without recurring as described in 3.4; and the flight crew stated as in 2.1.2 that the flight encountered it while flying through cloudless airspace.

As described above, possible turbulence of small scale occurs even at location where vertical shear is relatively weak. Pilots should, therefore, be cautious to possible turbulence even if they are not flying through unstable airspace.

3.7 Selection of Flight Altitude

According to the statements in 2.7 (1), the proposed flight altitude by the dispatcher was FL 390. It is highly probable that the dispatcher most probably made the proposal out of comprehensive judgment considering that: the altitude would enable the least fuel consumption for the aircraft; the significant weather prognostic chart in 2.6.4 did not predict strong turbulence on the route except climbing through clouds; and the PIREP also reported LIGHT to SMOOTH turbulence. On the other hand the FL 270 which the PIC and the dispatcher agreed to change to was an altitude which would require more fuel consumption and flight time, while the wind shear presented a velocity far smaller than 10 kt, which falls into a MODERATE turbulence with a very mild temperature change and the PIREP contained intensities of LIGHT MINUS to SMOOTH. It is highly probable that the PIC most probably chose FL 270 based on the judgment that during climbing to and descending from an cruising altitude, flying at lower altitudes away from the frontal zones would give him milder shaking than flying through the vicinity of frontal zones below the jet stream axis, where substantial wind velocity change would exist.

3.8 Acquisition of Meteorological Information during Flight

If the other aircraft had encountered turbulence of MODERATE intensity or more around the planned flight route of the aircraft after its takeoff from Miyazaki Airport, such information would have been sent automatically to all the aircraft flying in the vicinity via ACARS as in the dispatcher's statement described in 2.7 (1). However, as there was no reporting of strong turbulence on the route, it is highly probable that such information was not provided to the aircraft. As described in 2.1.2, it is highly probable that the flight crew tried to maintain communication with OMC over the company radio by reporting post-takeoff conditions and obtaining the latest en route weather information in order to avoid turbulence by changing altitude to FL290, reporting before and after the change.

3.9 Notification to Passengers and Measures Taken

As described in 2.1.3, as the cabin attendants decided to carry out in-flight services without using service carts when briefed by the PIC, it is highly probable that before takeoff, they predicted turbulence of such intensity as to prevent them from carrying out regular in-flight services, and therefore the PIC and the cabin attendants requested passengers over the PA system to keep their seat belts fastened all the time, as frequently as necessary for the request to be thoroughly observed. However, it is highly probable that, as there existed no clear radar echoes ahead after the aircraft had detoured the echoes around Shimizu as described in 2.1.1, and PIC had not received turbulence

information on the route from the Company as the dispatcher stated in 2.7 (1), he judged that there would be lesser chance of turbulence encounter ahead and turned off the belt sign, although the aircraft was still in the clouds then.

After that, the cabin attendants started the in-flight services under the shaking of LIGHT intensity. Approximately 5min. after the services were over, as the aircraft encountered the strong turbulence. It is highly probable that the PIC turned on the belt sign and the cabin attendants requested passengers to fasten their seat belts over the PA. It is highly probable that these actions taken by the crew were in accordance with the Company's regulations as described in 2.11.1. It was 30 min. after the aircraft encountered the big turbulence when PIC made in-flight announcement to inform passengers of the conditions of the flight. The information should have been provided to the passengers as soon as possible to the extent that doing so would not hinder the flight operation.

3.10 Communications with Ground Staff after the Accident

As described in 2.1.2, immediately after the encounter of the strong turbulence, the flight crew reported it to ATC , and as soon as they were advised by cabin attendants of the cabin situation, they informed it over the radio to Zen nikku Kinki that they had several injured persons. It is highly probable that, considering that the conditions of the injured not to be serious, they decided to request a wheel chair, not an ambulance, upon arrival, and to continue the flight to the destination without changing the flight plan. As described in 2.1.3, it is highly probable that the cabin attendants checked cabin situation to report to the PIC, and carried out first aid treatment to the injured.

3.11 Preventive Measures to be Taken

3.11.1 Installation of Handrails

As the cabin attendants and passengers stated in 2.1.3 (2) and 2.1.4 (1), it is probable that the turbulence involved occurred so suddenly and with such intensity that the cabin attendants as well as the passengers were instantly thrown up in the air, getting injured by hitting their heads against the ceiling and cart. In the case of less intense turbulence, it can be assumed that, installation of equipment such as handrails near lavatories and others, where passengers pass by may help them deal with shaking to some extent. Although the Company has taken safety measures including installation of handrails to the extent possible on some aircraft types with unsafe elements taken into account in view of the turbulence related accidents, it is requested that the Company would not only continue examining the effectiveness of such measures, but also consider taking further safety measures to prevent accidents resulting from turbulence.

3.11.2 Notification to Passengers of Preventive Measures to be Taken against Unexpected Occurrence of Aircraft Shaking

As described in 2.11.2, it is highly probable that the cabin attendants at the Company have been trained to fully counter turbulence encounter, while passengers, who are advised over the PA system to be cautious against shaking when they leave their seats, are not advised of concrete preventive postures. However, mere awareness of such handrails being installed as described in 3.11.1 is probably effective as defensive measures to some extent, when an aircraft is shaken by an unexpected turbulence while a passenger is walking. Therefore, it is desired that the Company's adoption of such a procedure should be considered as advising passengers in advance of preventive measures in case of a shaking, carefully selecting the wording to attain the purpose so as not to urge them to take unsafe behaviors, contrary to the intention.

3.11.3 Prediction of Clear Air Turbulence

As mentioned in 2.11.3, the working guidelines for aviation weather forecasting services point out that CAT occurrence is impossible to predict in detail either in terms of timing or airspace with the technology currently available; instead prediction is concentrated only on detection of the areas, altitudes and timing with high potential of occurrence, and the intensity. Currently, in order to make detection of CAT possible, studies on and development of an airborne Doppler light detection and ranging (LIDAR) is in progress at domestic research institutions, and further progress is expected. At the same time, for the purpose of improved accuracy of prediction (reducing an overlooking ratio), one possible method is to improve prediction models as necessary with advanced elucidation into the mechanism of its occurrence, not only by improving calculative resolution for CAT prediction but by adopting such methods as analyzing specific data acquired before and after the shaking of the aircraft involved in CAT. For these reasons, it is expected that, in addition to actual upper weather data currently available from PIREP and ACARS, providing meteorological organizations with access to and analyze more detailed information including accelerated velocity suffered by the aircraft involved in a turbulence of MODERATE intensity or more, will contribute to the improvement of more accurate CAT prediction.

4. PROBABLE CAUSE

It is highly probable that the accident occurred as follows:

The aircraft encountered atmospheric disturbance all of a sudden during flight, and was shaken so severely that one of the cabin attendants in the aft section of the aircraft was seriously injured when she was thrown up in the air and fell on the floor.

It is possible that the atmospheric disturbance the aircraft encountered were CAT which was created locally and temporarily by a wind shear in the vicinity of frontal zone beneath a jet stream.

Figure 1　Estimated Flight Route

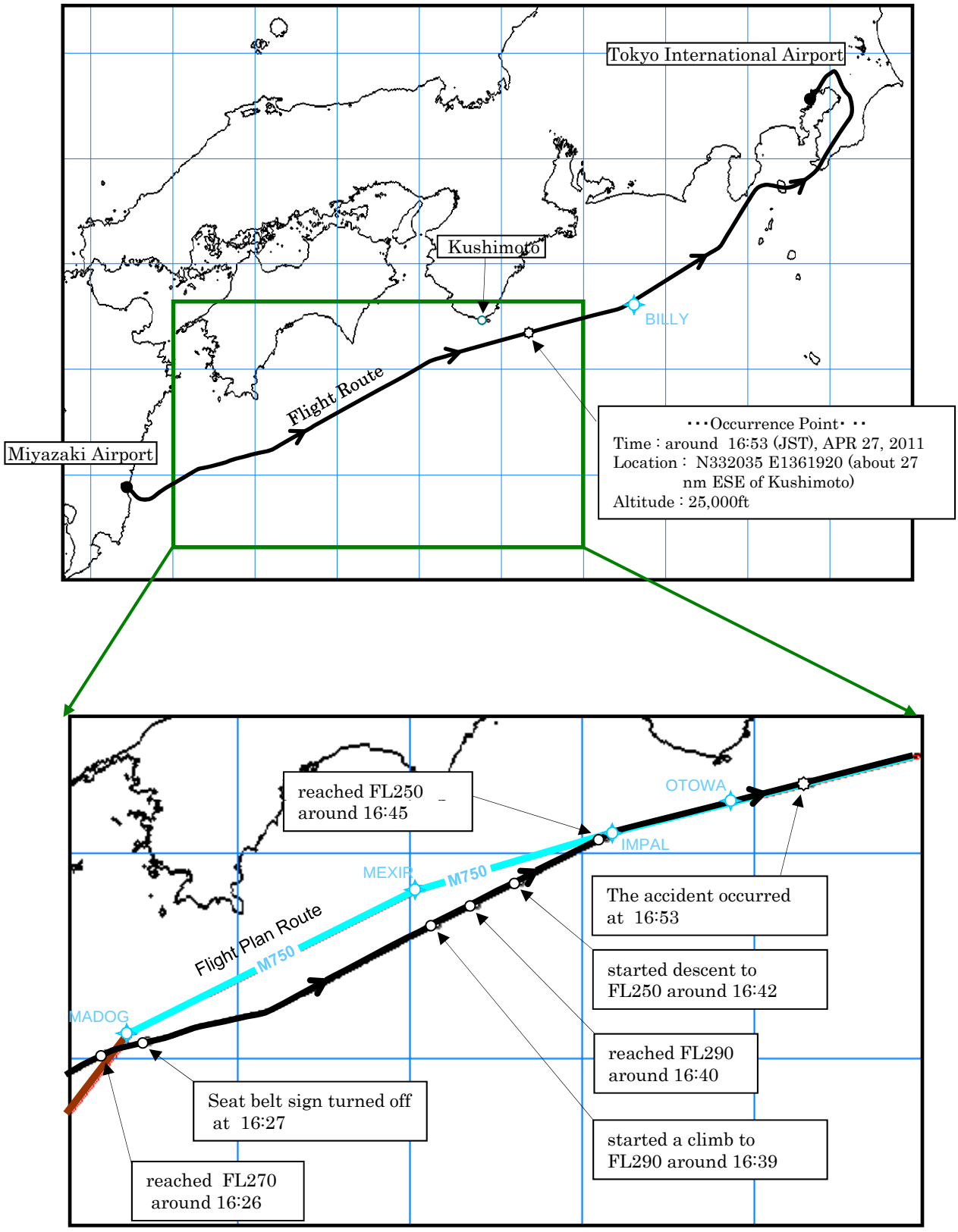

Figure 2　DFDR Records

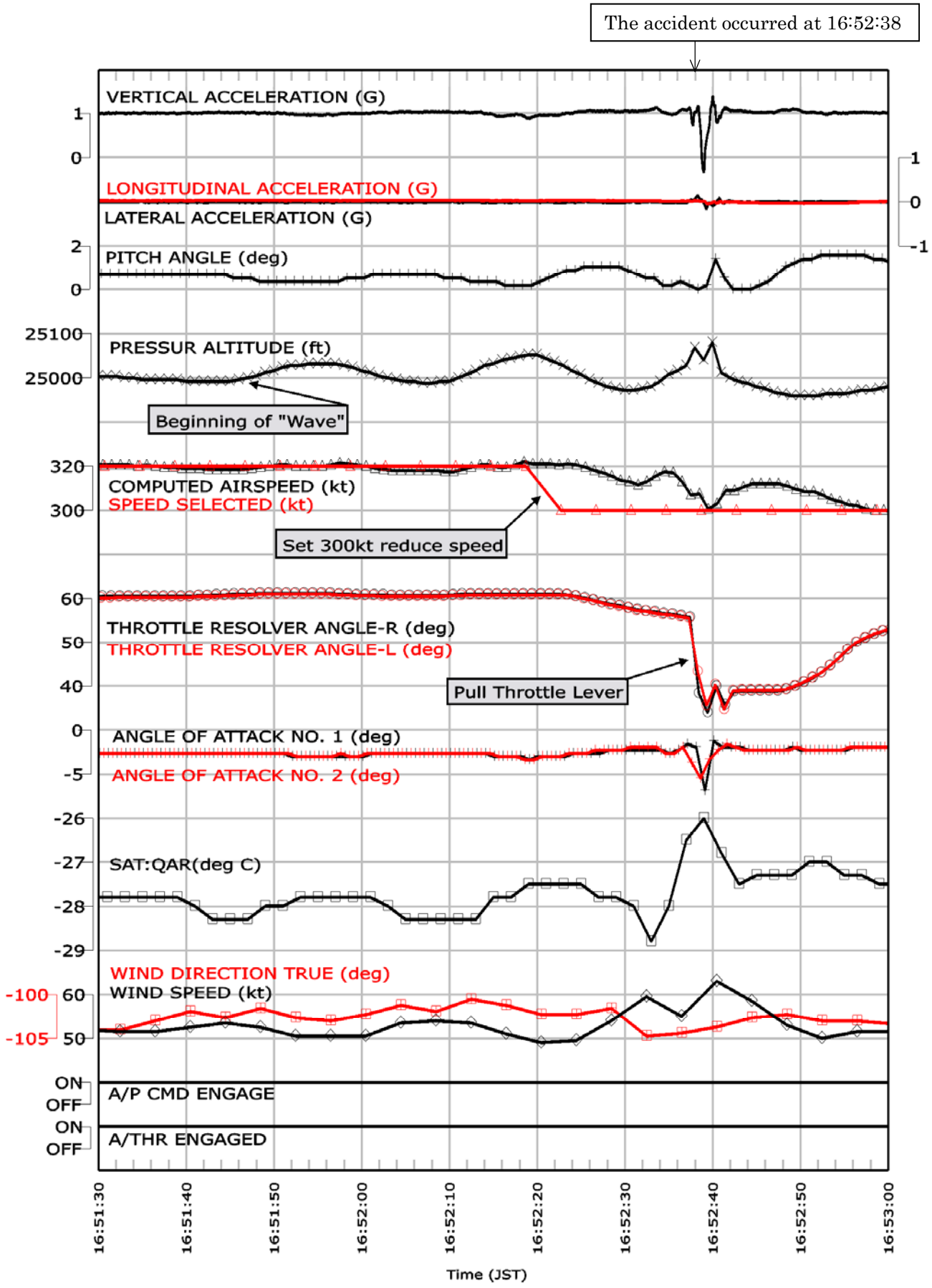

Figure 3　Turbulence Intensity Reporting Criteria

Definition of Intensity		*Applicable Indications*		*Reference*	
Applicable Terms	*Code*	*Aircraft Reaction*	*Reaction inside Aircraft*	*Cabin Service*	*ICAO Standards*
SMOOTH	*SMTH*	*No reaction or very minor reaction if any.*	*Conditions will remain almost the same as on the ground.*	*No difficulty*	—
LIGHT MINUS	*LGTM*	*Affix of "Minus" is added to relatively weaker intensity.*			*LIGHT*
LIGHT	*LGT*	*It momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). However, the aircraft remains in positive control without large variations in IAS (indicated airspeed).*	*Occupants may feel a slight strain against a seat belt or shoulder harness. Unsecured objects may be displaced slightly. No difficulty in walking, but caution is required.*	*May be conducted. Offering hot beverages requires caution.*	
LIGHT PLUS	*LGTP*	*Affix of "Plus" is added to relatively greater intensity.*		*Temporal alteration in service contents, procedure or suspension may be needed.*	
MODERATE	*MOD*	*It causes moderate changes in altitude and/or attitude; however, the aircraft remains in positive control at all times. It causes variations in IAS.*	*Occupants may feel definite strains against a seat belt or shoulder harness. Unsecured objects move around. Walking is difficult.*	*Difficult*	*MODERATE*
SEVERE	*SEV*	*It causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in IAS. The aircraft may be momentarily out of control. It also may affect its airworthiness.*	*Occupants may feel definite strains against a seat belt or shoulder harness, or may be forced into nearly a weightless state. Unsecured objects are tossed around. Walking is impossible.*	*Impossible*	*SEVERE*

✧ The above chart is an extract from the Company's Operations Manual. These criteria are common standards among the air carriers using the system that enables exchange of weather information with the Civil Aviation Bureau and the Meteorological Agency.

Figure 4　Three Angle Views of Boeing 767-300

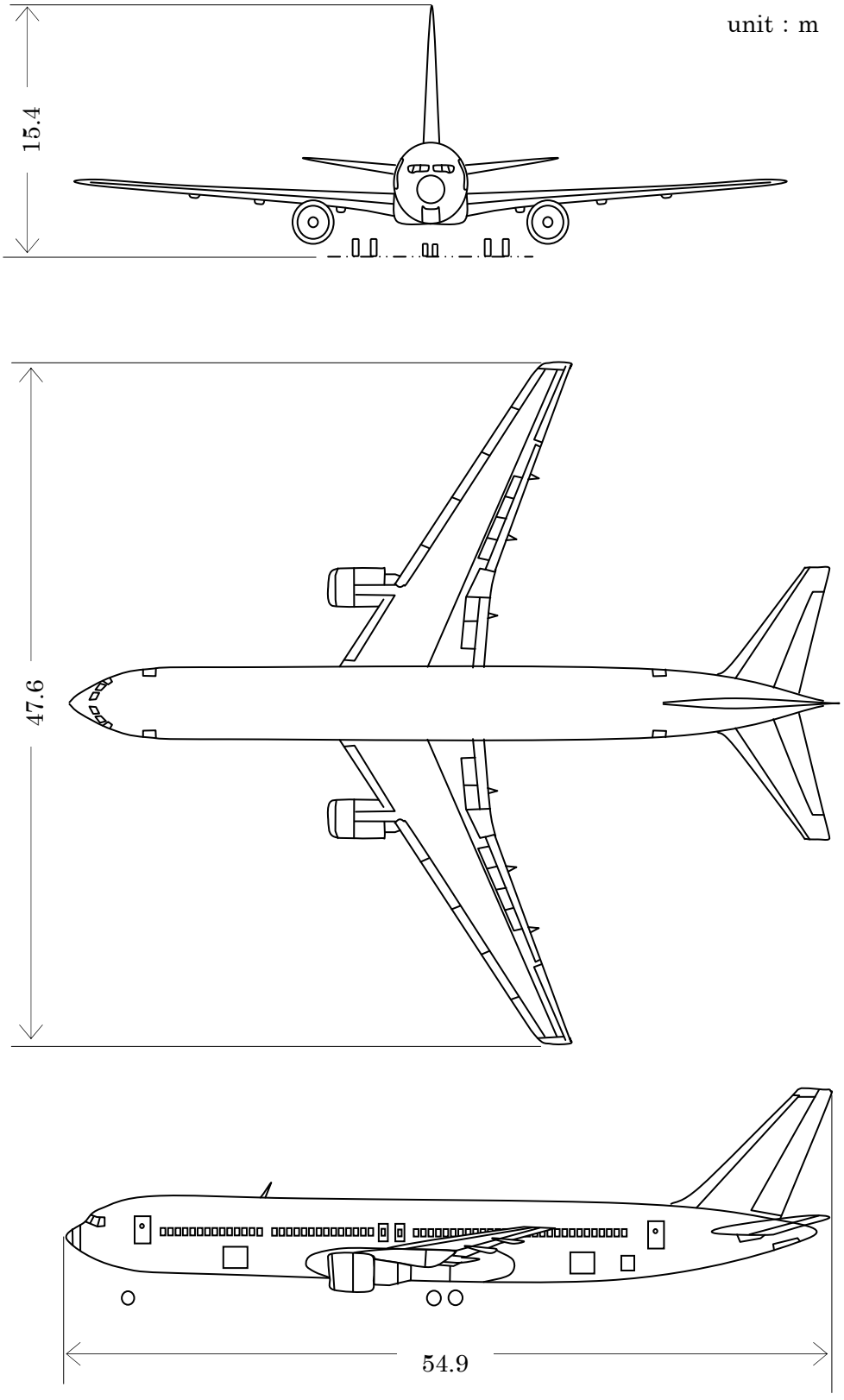

Figure 5　Locations of the Injured when the Accident Occurred

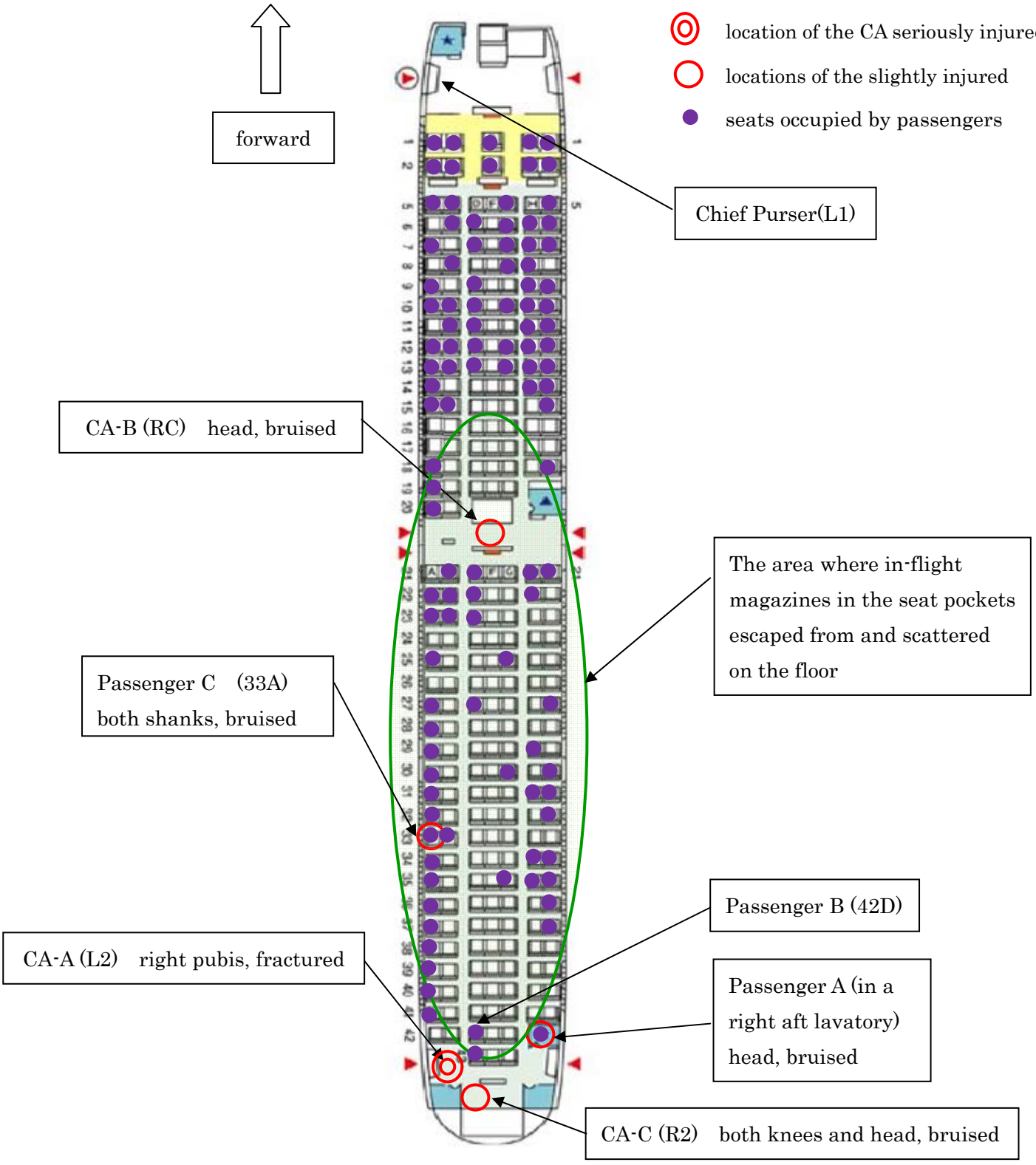

Figure 6　Asian Surface Weather Chart

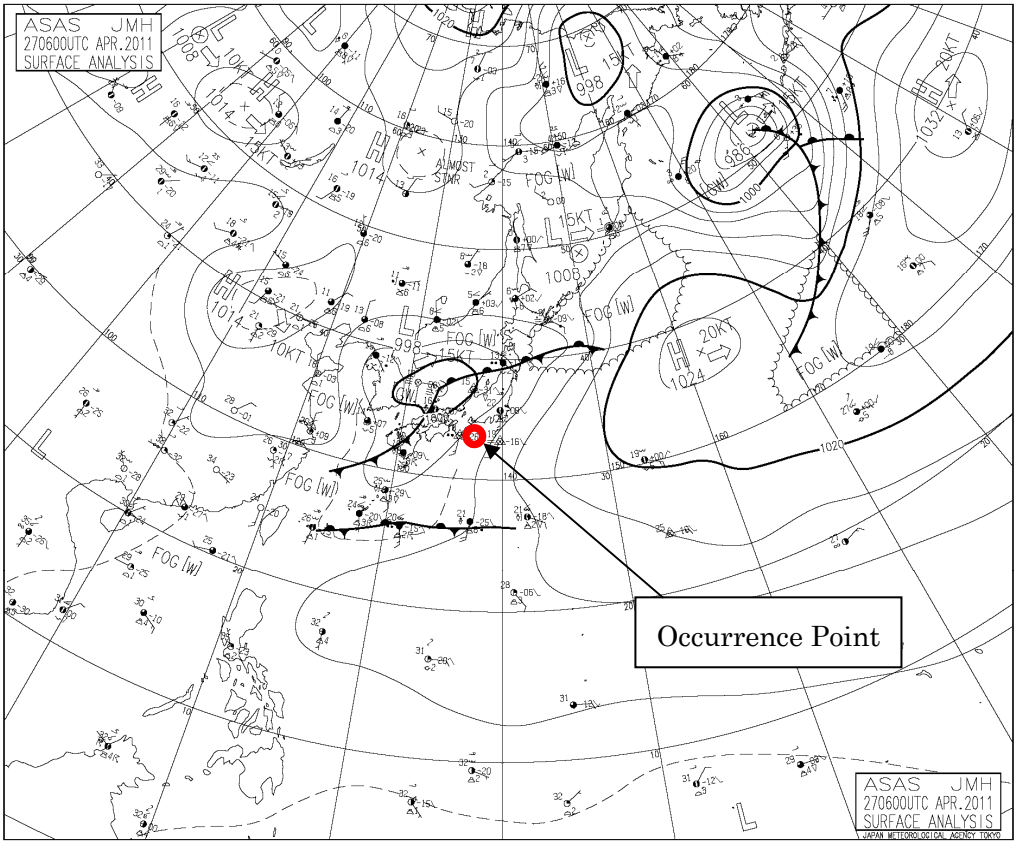

Figure 7　Domestic Significant Weather Analysis Chart

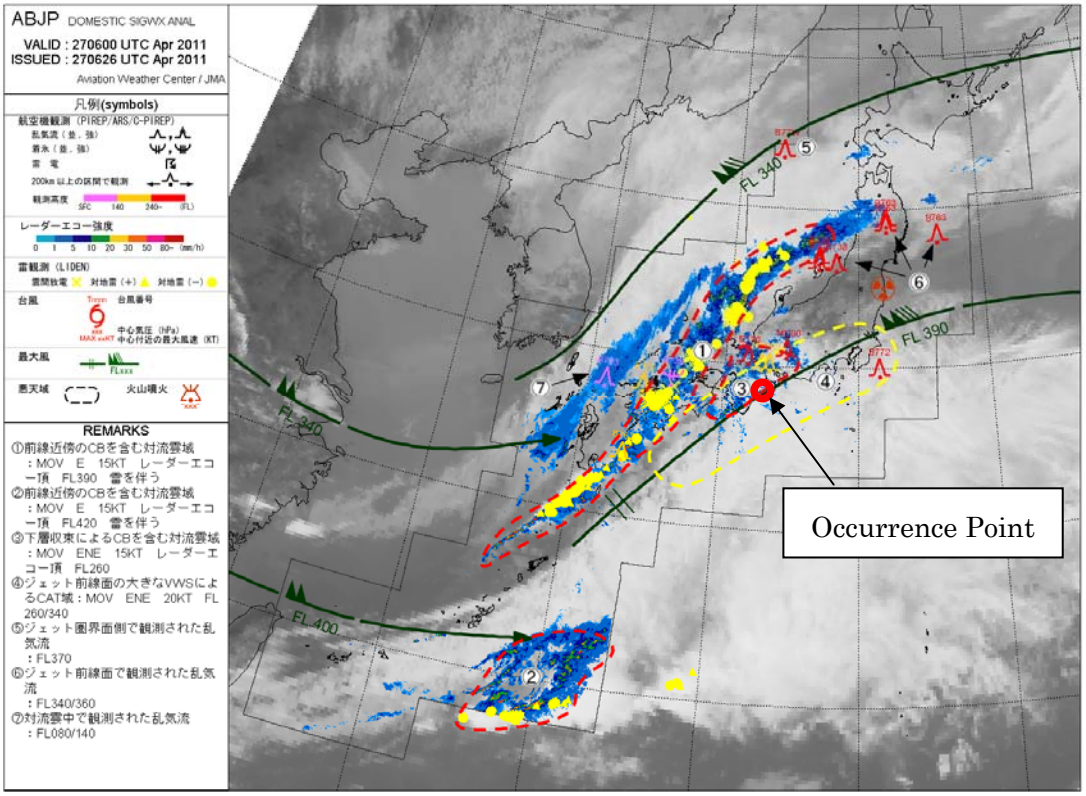

Figure 8　Hourly Analysis Chart (vertical cross section)

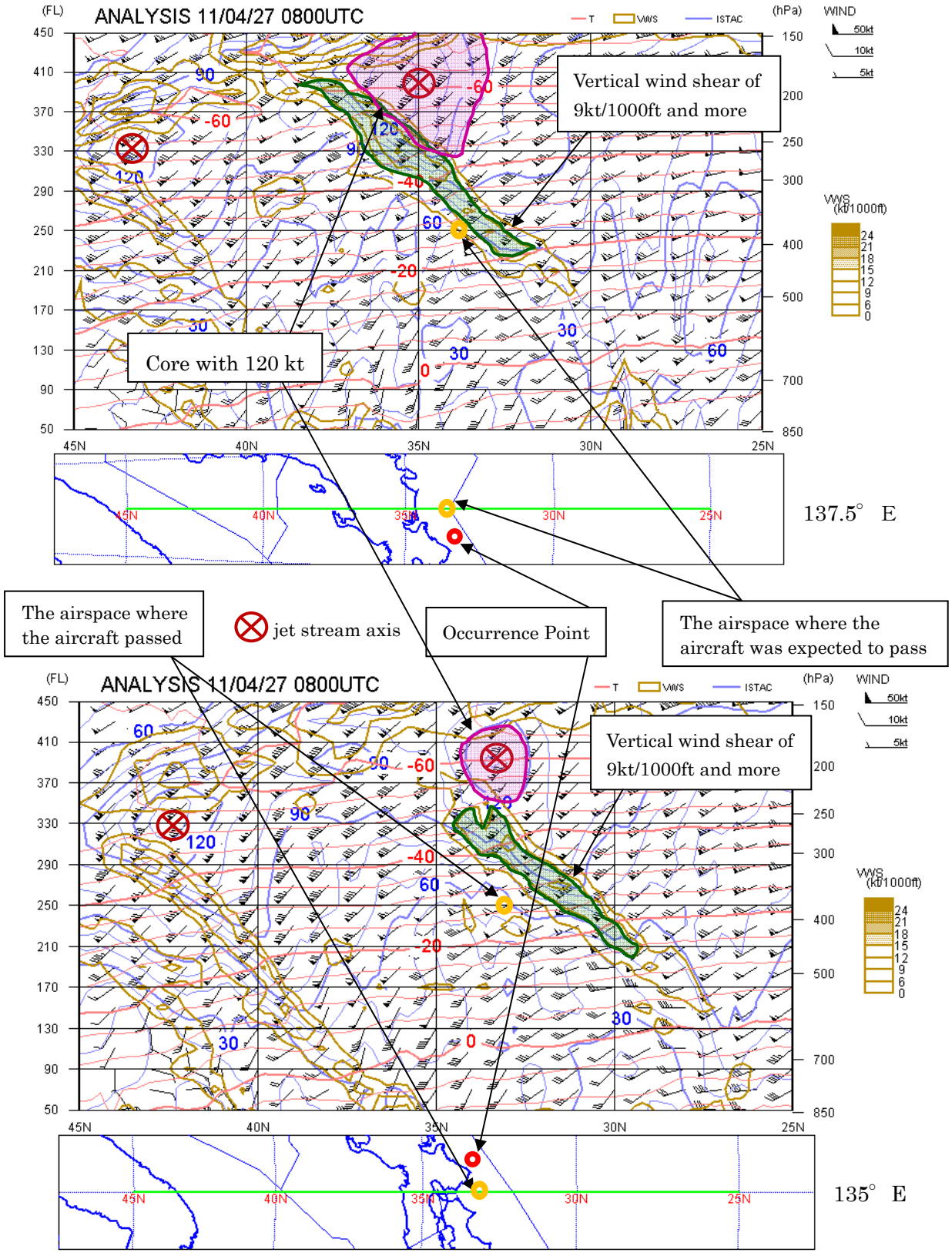

Figure 9　Hourly Analysis Chart (horizontal cross section)

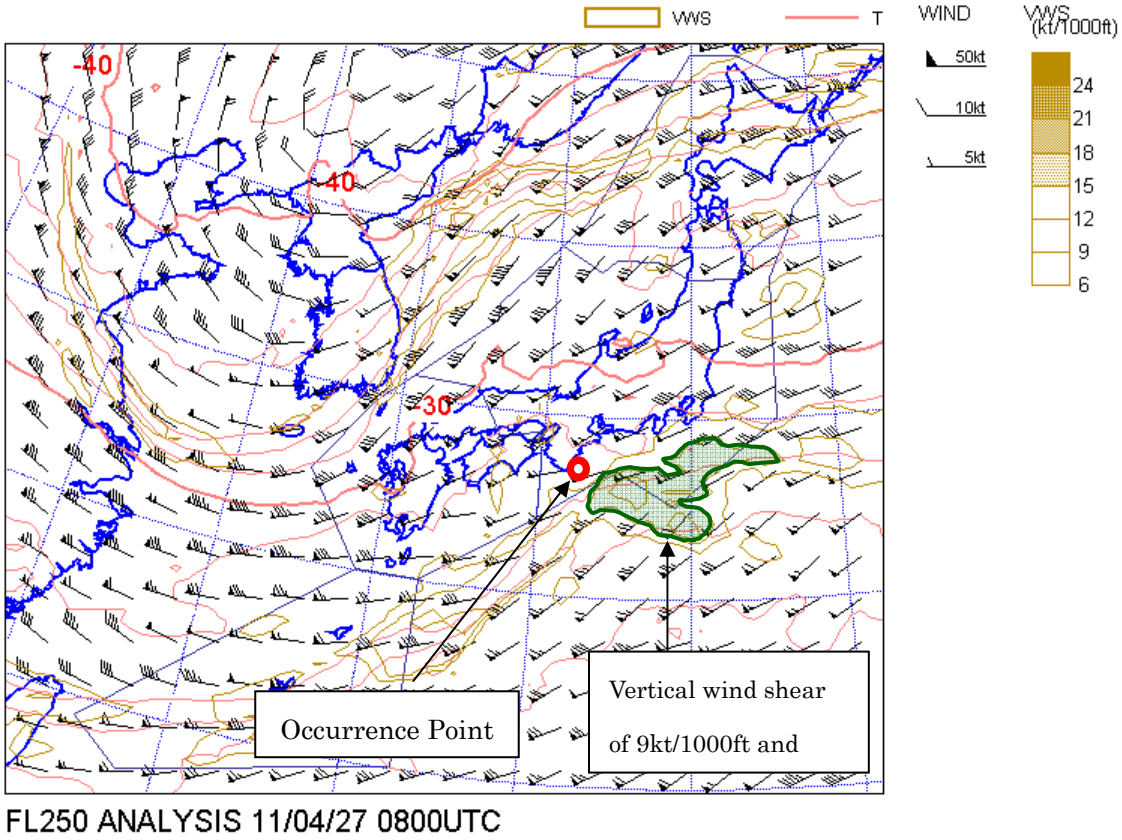

Figure 10　Hourly Analysis Chart (vertical cross section) for　Tokyo - Kagoshima

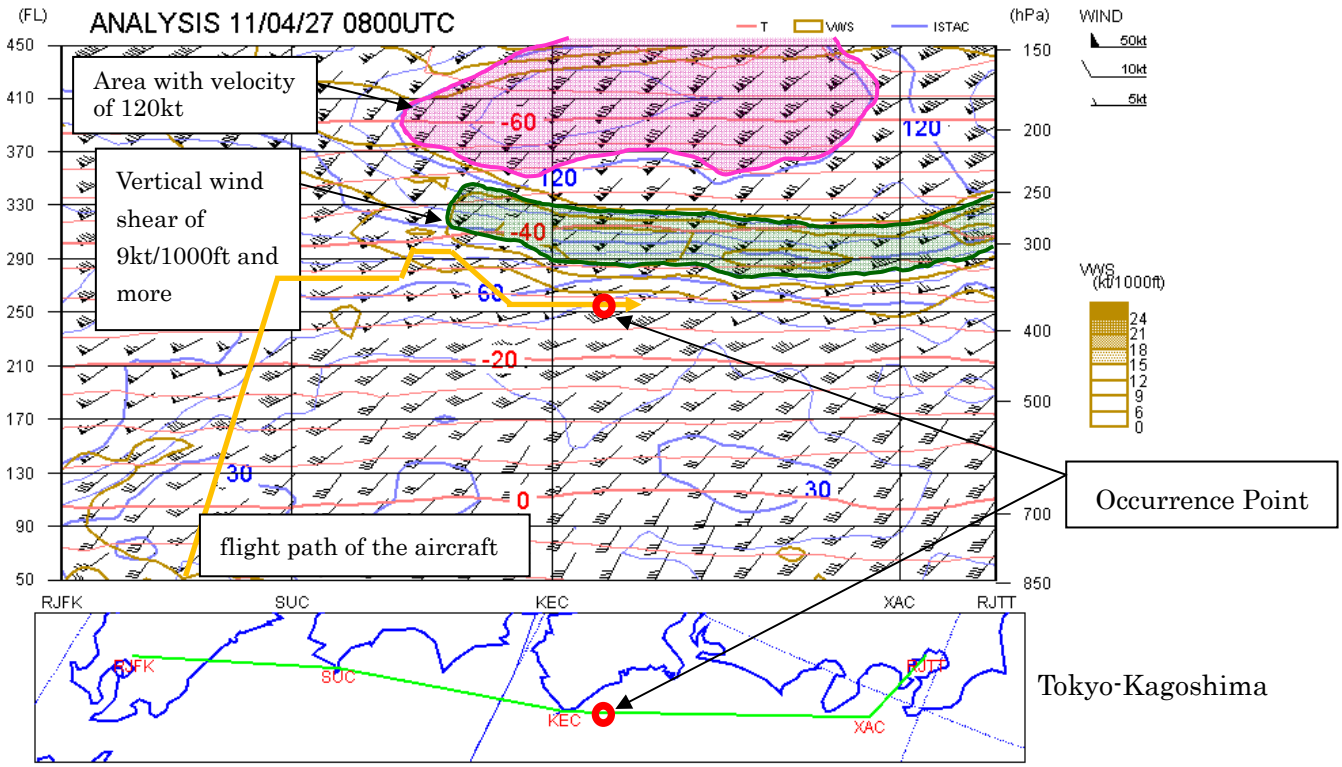

Figure 11　Domestic Significant Weather Prognostic Chart

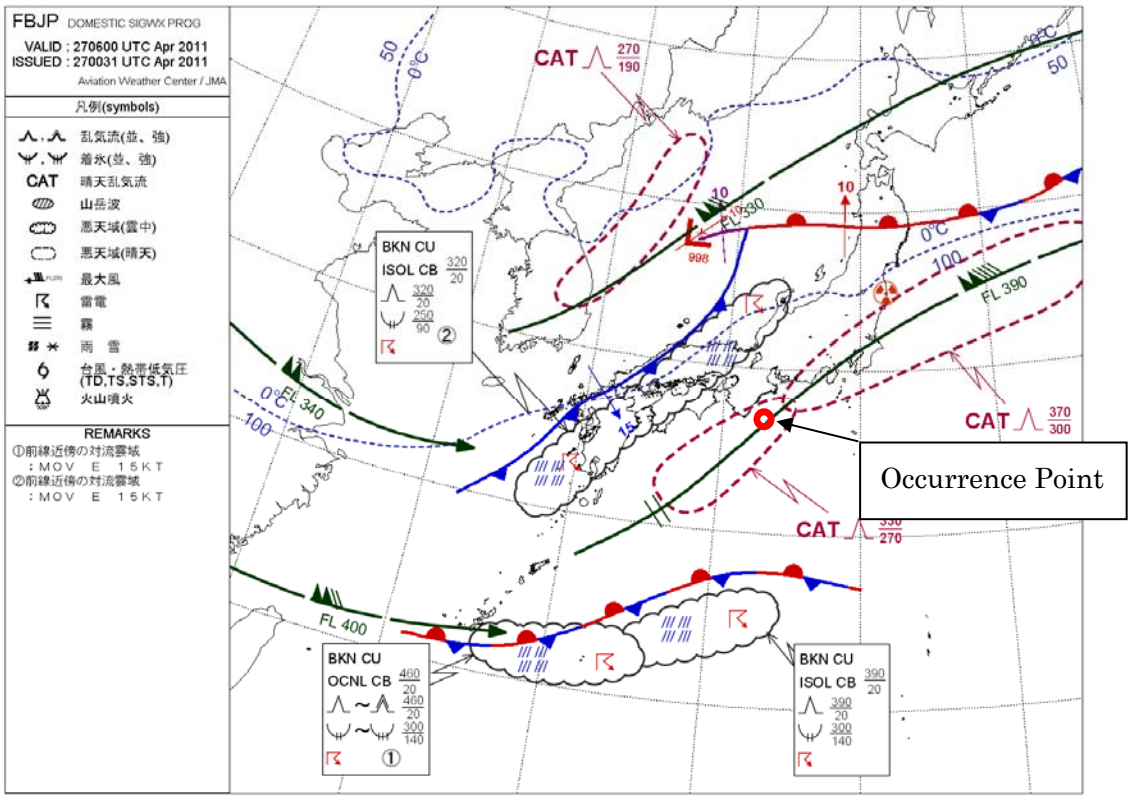

Photo 1　The Aircraft Involved in the Accident

Photo 2　Right aft lavatory

Photo 3　Left aft lavatory