AA2023-7

AIRCRAFT ACCIDENT
INVESTIGATION REPORT

Japan Airlines Co., Ltd.
J A 6 0 3 J

October 26, 2023

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.

TAKEDA Nobuo
Chairperson
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.

《Reference》

The terms used to describe the results of the analysis in "3. ANALYSIS" of this report are as follows.

i) In case of being able to determine, the term "certain" or "certainly" is used.
ii) In case of being unable to determine but being almost certain, the term "highly probable" or "most likely" is used.
iii) In case of higher possibility, the term "probable" or "more likely" is used.
iv) In a case that there is a possibility, the term "likely" or "possible" is used.

AIRCRAFT ACCIDENT INVESTIGATION REPORT

FLIGHT ATTENDANT INJURY BY THE SHAKING OF THE AIRCRAFT

JAPAN AIRLINES CO., LTD.

BOEING 767-300, JA603J

AT AN ALTITUDE OF APPROX. 8,500 M (FL280)

OVER NAKATSUGAWA CITY, GIFU PREFECTURE

AT 17:35 JST, MARCH 26, 2022

October 6, 2023

Adopted by the Japan Transport Safety Board

Chairperson TAKEDA Nobuo
Member SHIMAMURA Atsushi
Member MARUI Yuichi
Member SODA Hisako
Member NAKANISHI Miwa
Member TSUDA Hiroka

1. PROCESS AND PROGRESS OF THE AIRCARFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident	On Saturday, March 26, 2022, a Boeing 767-300, registered JA603J, operated by Japan Airlines Co., Ltd. as scheduled flight 669, took off from Tokyo International Airport and flew to Oita Airport, where the aircraft encountered turbulence and a flight attendant was seriously injured by falling down.
1.2 Outline of the Accident Investigation	On March 28, 2022, the Japan Transport Safety Board (JTSB), upon receiving information about the occurrence of the accident, designated an investigator-in-charge and an investigator to investigate this accident. 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 State did not designate its accredited representative. Comments on the draft Final Report were invited from the parties relevant to the cause of the accident and the Relevant State.

2. FACTUAL INFORMATION

2.1 History of the Flight	According to the statements of the crew members and the records of the digital flight data recorder (DFDR), the history of the flight is summarized as follows. On March 26, 2022, at 17:15 Japan Standard Time (JST: UTC+9 hours; unless otherwise noted, all times are indicated in JST in this report on a 24-hour clock) a Boeing 767-300, registered JA603J, operated by Japan Airlines Co., Ltd. as its scheduled flight 669, took off from Tokyo International Airport

for Oita Airport, with a total of 70 persons on board, consisting of the Pilot in Charge (PIC), seven crew members, and 62 passengers.

In the cockpit, the PIC was in the left pilot's seat as PM*1, and the First Officer (FO) was in the right pilot's seat as PF*1.

On that day, there were two depressions with fronts in the vicinity of the Sea of Japan and the Shikoku region, and rough weather prevailed nationwide. The PIC decided to set the cruising altitude at 28,000 ft (approx. 8,500 m, Flight Level (FL*2)280) based on the meteorological information (see 2.6 Meteorological information described below) confirmed with the FO during the pre-flight briefing.

Figure 1: Estimated Flight Route

The PIC provided the following information to the flight attendants during the pre-flight briefing.

- Since turbulence is expected during climb, it is planned that the belt sign should be turned on for 10 minutes after takeoff and turned off after reaching cruising altitude.
- Since TB2*3, turbulence is expected to occur intermittently even during cruising, special attention must be paid to turbulence while providing in-flight services.

The aircraft reached cruising altitude (FL280) approx. 10 minutes after takeoff. During the cruise, the aircraft flew through thin clouds but encountered turbulence of less than TB2 intensity, but the Airborne Weather Radar Unit did not show any strong echoes during the cruise. The PIC determined that it was possible to provide in-flight services and then turned off the belt sign.

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*1 "PM" and "PF" are the terms used to identify pilots by their different roles in a two-pilot aircraft. PM is an abbreviation for Pilot Monitoring and is mainly responsible for monitoring the flight status of the airplane and cross-checking PF's maneuvers, as well as performing other non-operational tasks.PF is an abbreviation for Pilot Flying and is mainly responsible for maneuvering the airplane.

*2 "FL" (Flight Level) is the pressure altitude in the standard atmosphere. The FL is expressed in the value given by dividing the reading on the altimeter (the unit is ft) by 100 when the altimeter is set to 29.92 inHg. In Japan, flying altitudes of 14,000 ft or higher are usually indicated in the flight level. For example, FL 280 means an altitude of 28,000 ft.

*3 "TB" is a term the company uses to express the degree of turbulence (TB: turbulence) by judging from the change in aircraft movement and others. "TB1" refers to "LIGHT MINUS" (allows in-flight services without difficulty), TB2 refers to "LIGHT" (which allows in-flight services but requires attention, "TB3" refers to "LIGHT PLUS" (requires extreme caution for providing in-flight services and may require temporary disconnection or cancellation of in-flight services), and "TB4" refers to "MODERATE" (makes it difficult to provide in-flight services).

After the belt sign was turned off, the six flight attendants took two carts each from the forward and aft galleys (four carts total) and began their in-flight service.

At approx. 17:30, the aircraft received a PIREP*4 transmitted by other aircraft encountering TB4 turbulence approx. 120 nm ahead of the left side of the aircraft.

The captain, who was the PM, confirmed the radar echo conditions around the position of the turbulence encountered by airborne weather radar and observed weak echoes approx. 100 nm ahead of the aircraft. Assuming that it would take about 15 minutes to reach the position of the turbulence, and about three to five minutes to finish cleaning up in the cabin after the belt sign was turned on, the captain and the FO were confirming to make a turbulence avoidance judgment at about 80 nm ahead of the weak echoes, and then suddenly encountered vertical shaking of TB4 class. The captain immediately turned on the fasten seat seatbelt sign.

The flight attendant A, who was in charge of the cart aft of the right aisle, was returning to the aft galley with another flight attendant after completing in-flight service and stowing the cart and beverages when they encountered a large jolt. At that time, the flight attendant A fell on her buttocks after her body was lifted into the air before she could grab the galley bar. The other flight attendant, who had fallen backward after her body was lifted into the air with her arms first, could see the flight attendant A up to the point where she was in the air, but could not see that she was on the floor. They both fell but felt no pain.

The chief purser had just finished delivering beverages to passengers near the center of the cabin when he encountered a sudden "thump" downward. At the time, three of the four carts were near the center of the cabin, and the cart aft of the right aisle was being returned to the aft galley by two flight attendants, including the flight attendant A (see Figure 2).

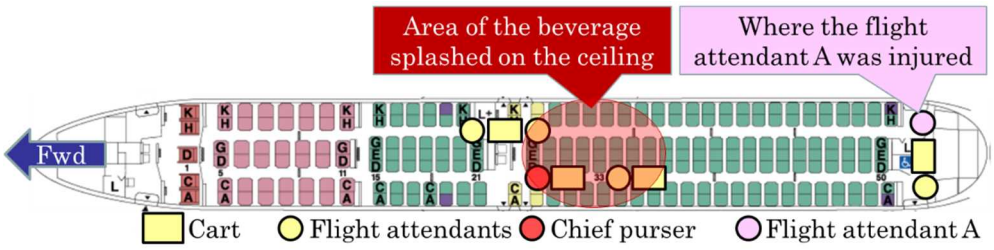

Figure 2: Situation at the Time of Occurrence of the Accident

At the time of the turbulence, the flight attendant near the center of the cabin grabbed the backrest of a nearby seat and held the cart so that neither her body nor the cart lifted, but the beverage being served to passengers could be seen splashing to the ceiling. After the turbulence, the belt sign turned on, and each flight attendant stowed the cart in their assigned position and made sure no passengers were using the lavatory before taking their seats.

*4 "PIREP" stands for Pilot Report and refers to an airborne report of weather conditions affecting flight safety during a pilot's flight.

	Approx. one minute after the belt sign was turned on, the captain acknowledged the signal that all flight attendants were seated. The chief purser checked the status of the passenger and all flight attendants over the intercom, but the flight attendant A did not report that she had fallen, although she did report that her body was slightly lifted as she was not in pain at the time. The chief purser reported to the captain that no passengers or flight attendants were injured. After encountering the vertical turbulence of TB4, the captain checked the onboard weather radar for radar echoes at close range (about 20 nm ahead) and observed a weak echo about 10 nm ahead, so he turned right with ATC approval. At that time, he encountered a second turbulence (TB3) so he requested ATC to climb to FL320. The captain turned off the belt sign because the aircraft was stable after climbing to FL320. The flight attendant A continued to work on the return flight because she was not in pain. The flight Attendant A reported to the company that she felt she could not safely fly the scheduled flight the next day because her legs were gradually becoming immobile after the flight. The flight attendant A was diagnosed with a sacral fracture on Monday, March 28, after visiting several medical facilities from Saturday, March 26 to Monday, March 28. According to the DFDR recordings of the aircraft, at 17:35:27, just before the accident, the vertical acceleration increased slightly from about 1.0G to 1.26G, then changed to -0.02G in the next 1 second, and then returned to 1.28G in the next 1 second (Figure 3).

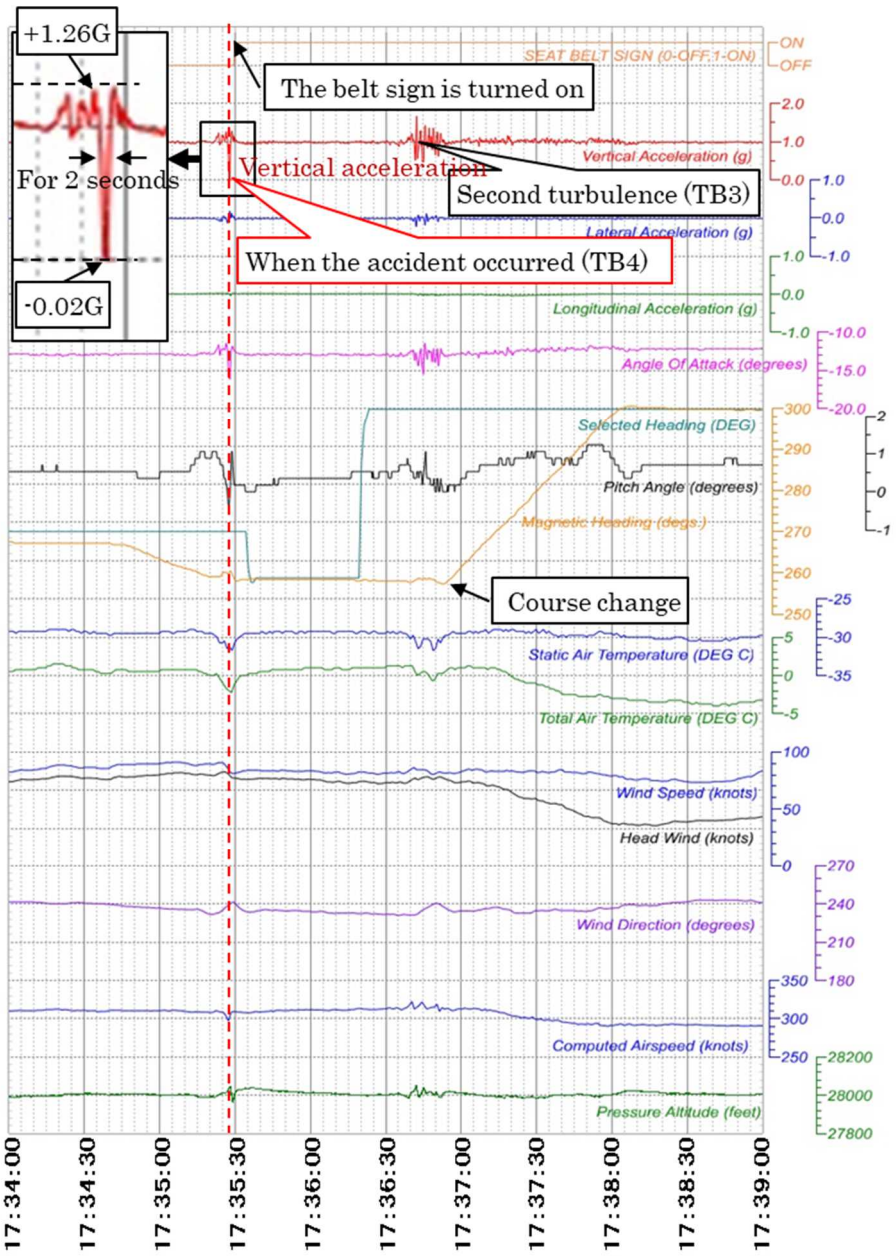

Figure 3: DFDR Records

This accident occurred at 17:35, on March 26, 2022, at approx.8,500 m (FL 280) over Nakatsugawa City, Gifu Prefecture (Lat.35° 23' 40" N, Long.137° 30' 05" E).

2.2 Injuries to Persons	Serious injury: One flight attendant (Sacral fracture)
2.3 Damage to the Aircraft	None
2.4 Personnel Information	(1) PIC: Age 52 Airline transport pilot certificate (Airplane) November 16, 2005 Type rating for Boeing 767 January 13, 2005 Class 1 aviation medical certificate Validity October 1, 2022 Total flight time 14,342 hours 32 minutes

	Total flight time on the type of the aircraft 10,612 hours 55 minutes Flight time in the last 30 days 24 hours 28 minutes (2) FO: Age 40 Commercial pilot certificate (Airplane) January 15, 2008 Type rating for Boeing 767 December 8, 2009 Instrument flight certificate (Airplane) July 23, 2008 Class 1 aviation medical certificate Validity January 7, 2023 Total flight time 7,235 hours 43 minutes Total flight time on the type of the aircraft 4,102 hours 51 minutes Flight time in the last 30 days 27 hours 46 minutes
2.5 Aircraft Information	Aircraft type: Boeing 767-300, Serial number: 32888, Date of manufacture: May 31, 2002 Certificate of airworthiness: No. 2009-121 Validity: Period during which, the Maintenance Management Manual (JAL Engineering Co., Ltd.) approved based on the permission of Article 113-2 of the Civil Aeronautics Act has been effective. Category of airworthiness : Airplane Transport T Total flight time: 59,618 hours 33 minutes At the time of the accident, the weight and position of the center of gravity of the aircraft were within the allowable ranges.
2.6 Meteorological Information	(1) General Weather Conditions According to the preliminary weather chart (Figure 4) at 15:00 on March 26, 2022, the areas near the Sea of Japan and the Shikoku region had low pressure systems with fronts moving to the northeast and east, respectively, and the weather was rough nationwide. (2) Weather Information Confirmed before the Flight According to the domestic significant weather analysis chart (ABJP) at 12:00 on March 26, 2022, which was confirmed by the flight crew, a MODERATE turbulence (equivalent to TB4) and a clear air turbulence (CAT) (Figure 5 ① and ⑦) were observed above FL 330 near the flight path, and cumulonimbus and cumulus clouds at an echo top altitude*5 of FL290 near a low-pressure area in the vicinity of the Shikoku region at FL290 (Figure 5 ⑥), but the turbulence in the vicinity of the accident site was analyzed as occurring at FL130 or below (Figure 5 ④). According to the domestic significant weather prognostic chart (FBJP) at 15:00 that day, a precipitation intensity of 30 mm/h or more, and radar echoes at echo top altitudes of FL160 and FL230 were observed in the Shikoku and Tokai regions

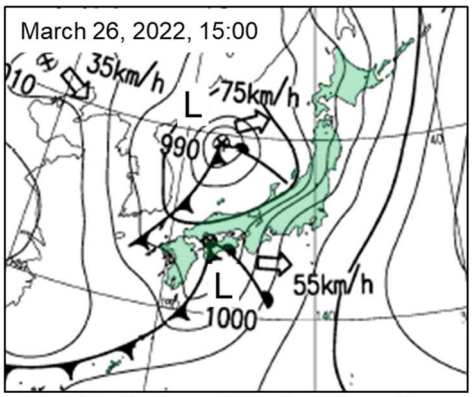

Figure 4: Preliminary Weather Chart (Excerpt)

*5 "Echo top altitude" means the maximum altitude where drops of rain (flakes of snow) are observed with the weather radar.

near the low pressure area, and turbulence was expected to occur near the accident site at altitudes between FL130 and FL170.

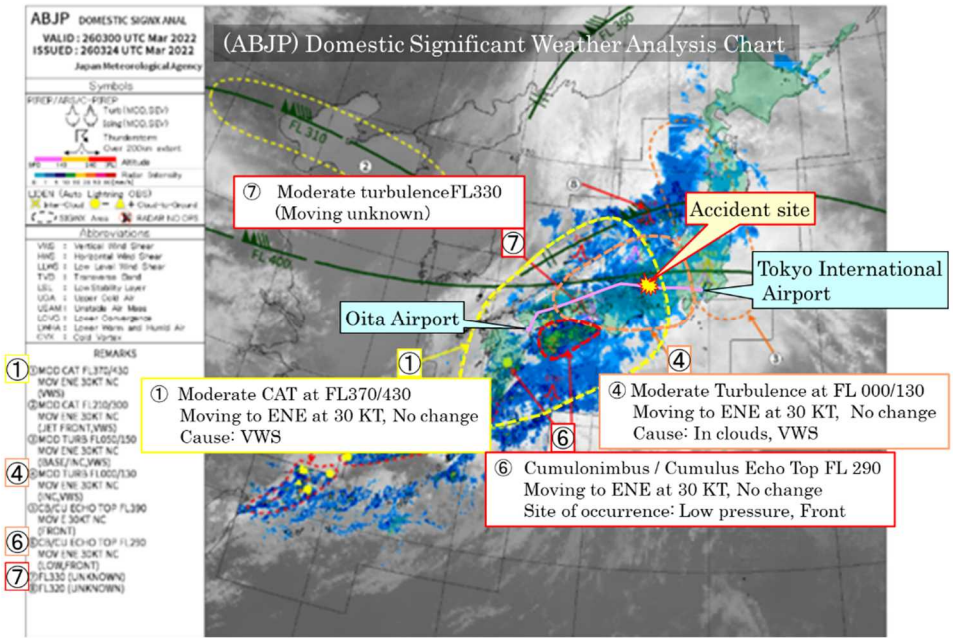

Figure 5: Domestic Significant Weather Analysis Chart (ABJP) (partly edited)

The flight crew checked the cross-section chart on the tablet terminal provided by the company, which allows them to check the weather forecast and PIREP for the target time, it was expected that the area of vertical wind shear*6 area above 12kt, which is considered the threshold of CAT, would expand at altitudes higher than FL330 in the vicinity of the aircraft's flight path. In addition, according to the PIREP (Figure 6), from 14:21 to 15:21, turbulence TB1 to TB2 was reported by aircraft of the same size as the aircraft flying at cruising altitude around FL280, and many turbulence TB3 to TB4 was reported by aircraft arriving at or departing from the Kansai area airport below FL200.

*6 "Vertical wind shear" is the difference in wind direction and velocity at locations obtained through wind analysis, between the top and bottom layers converted into the difference per 1,000 ft. It becomes larger as the change in wind direction or velocity, or both in accordance with altitude change.

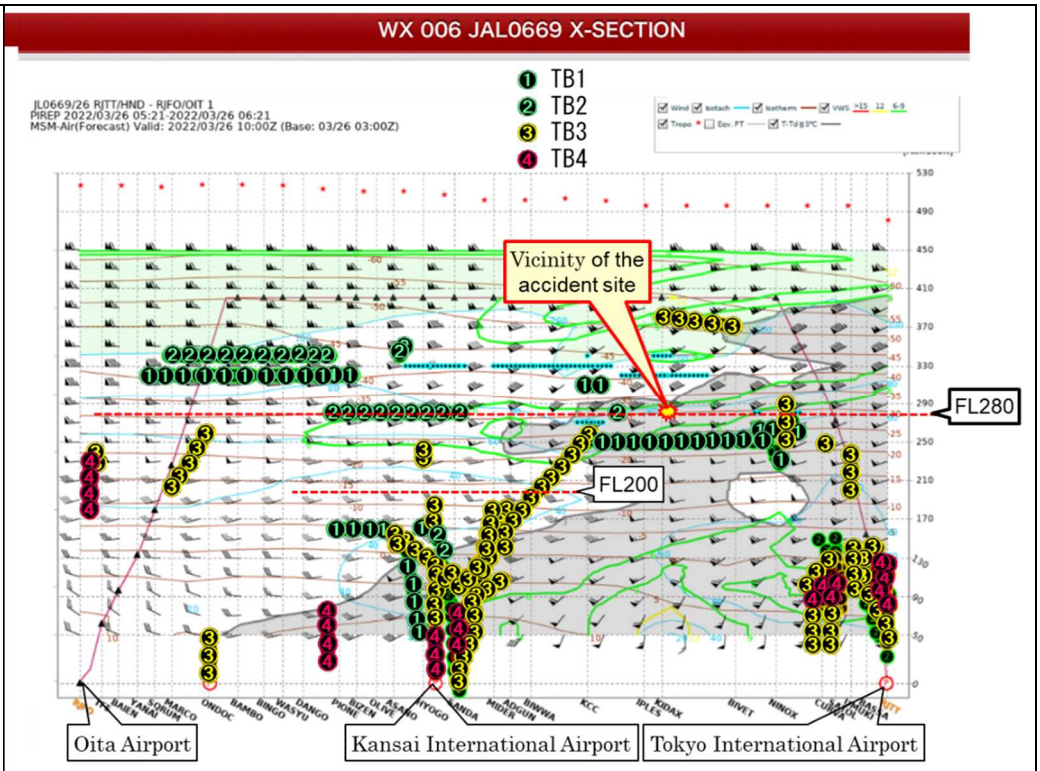

Figure 6: PIREP on Cross-Section Chart (partly edited)

2.7 Additional Information

(1) Guidelines for the Operations of the Belt sign

In order to prevent injuries to passengers and flight attendants during flight, the Company has issued "Guidelines for the Operations of the Belt sign" as "SUPPLEMENTARY DOCUMENTS" for flight crews and "Cabin Safety Information Archive" with the same contents for flight attendants.

The "Guidelines for the Operations of the Belt sign" contains the following descriptions (excerpt).

(Omitted)

9.2.1.1.2 Characteristics of past cases and countermeasures

9.2.1.1.2.1 Characteristics of past turbulence-related accidents

Turbulence may encounter unexpectedly, without forecast or signs. It may also be unavoidable even when its presence is predicted.

Most injuries have occurred under the following circumstances:

(Omitted)

3. Flight attendants working in the galleys or aisles

4. Passengers and flight attendants especially in the aft cabin section

(Omitted)

9.2.1.1.2.2 Effective measures to prevent turbulence-related injuries

Past experience has shown that turbulence is difficult to predict accurately, and passengers and flight attendants will inevitably have to leave their seats during flight to use the lavatories or for other services. In addition, not only weather conditions, but also unavoidable aircraft maneuvers can cause shakes.

So what can be done to prevent turbulence-related injuries?

Flight attendants should be prepared for the possibility of shakes at any

	time during the flight. *Encourage passengers to always fasten their seatbelts while seated in case of unexpected shaking.* *Ensure that all passengers and flight attendants remain seated and fasten their seatbelts when a shaking event is expected or encountered.* *In the event of a sudden shaking, the flight attendants should lower their center of gravity and crouch, hold the seat armrests, etc., from below, or hold the seat armrests, etc., from below. In the galley, hold the galley bar from below with your hands shoulder-width apart.* *Close communication between flight crew and flight attendants based on a common understanding* (Omitted) (2) Wind Shear The United States Department of Transportation FEDERAL AVIATION ADMINISTRATION Flight Standards Service "Aviation Weather Handbook 2022", (hereinafter referred to as "FAA Handbook") describes wind shear as follows: (Excerpt) *Wind shear is the sudden, drastic change in wind speed and/or direction over a small area, from one level or point to another, usually in the vertical. Wind shear occurs in all directions, but for convenience, it is measured along vertical and horizontal axes, thus becoming horizontal and vertical wind shear.* *Wind shear can subject an aircraft to violent updrafts and downdrafts, as well as abrupt changes to the horizontal movement of the aircraft. While wind shear may be reported, it often remains undetected and is a silent aviation weather hazard.* (3) CAT: Clear Air Turbulence FAA handbook describes CAT as follows: (Excerpt) *CAT is defined as sudden severe turbulence occurring in cloudless regions that causes violent buffeting of aircraft.* (Omitted) *This includes turbulence in cirrus clouds, within and in the vicinity of standing lenticular clouds and, in some cases, in clear air in the vicinity of thunderstorms.* *CAT is a recognized problem that affects all aircraft operations. CAT is especially troublesome because it is often encountered unexpectedly and frequently without visual clues to warn pilots of the hazard.*

3. ANALYSIS

(1) Effect of Meteorological Conditions

The JTSB concludes that the weather information reviewed by the flight crew prior to the flight indicates that TB1 to TB2 turbulence was reported at cruising altitude FL280, but there was no analysis of turbulence to the extent that it would have caused significant shaking of the aircraft, therefore it was most likely difficult to predict.

Figure 7 shows the data observed from 12:00 to 18:00 on the day of the accident by the wind

profiler*7 (Nagoya Observation Station) located about 60 km west of the accident location. The left figure shows a cross section of wind direction and speed with vertical shear added, and the area framed in red indicates the altitude at which vertical shear of 12 kt/1,000 ft or greater was observed, which is the threshold for the occurrence of CAT. The right figure shows wind direction and speed with corrected spectral width*8 added, and the area below the red line indicates the altitude at which a corrected spectral width of 2.0 m/s or greater was observed, which is the threshold for MODERATE (TB4 equivalent) turbulence based on PIREP's statistical analysis.

Using the wind profiler at the Nagoya Observatory Station, it can be confirmed that in Nagoya, along with the values of vertical wind shear and corrected spectral width, the altitude that is supposed to be the threshold of CAT and MODERATE turbulence increased with time, reaching about FL 280 at about 18:00. From this, it is likely that these turbulences also occurred in the vicinity of the accident site, about 60 km east of Nagoya Observatory Station, at the time of the accident.

However, these possibilities are the result of analysis based on weather analyses published after the accident, and it is more likely that it was difficult for the flight crew to predict these turbulences even on board the aircraft in flight, since there were no echoes from the airborne weather radar or related PIREPs in the vicinity of the accident site during the flight before the accident occurred, where shaking could be expected.

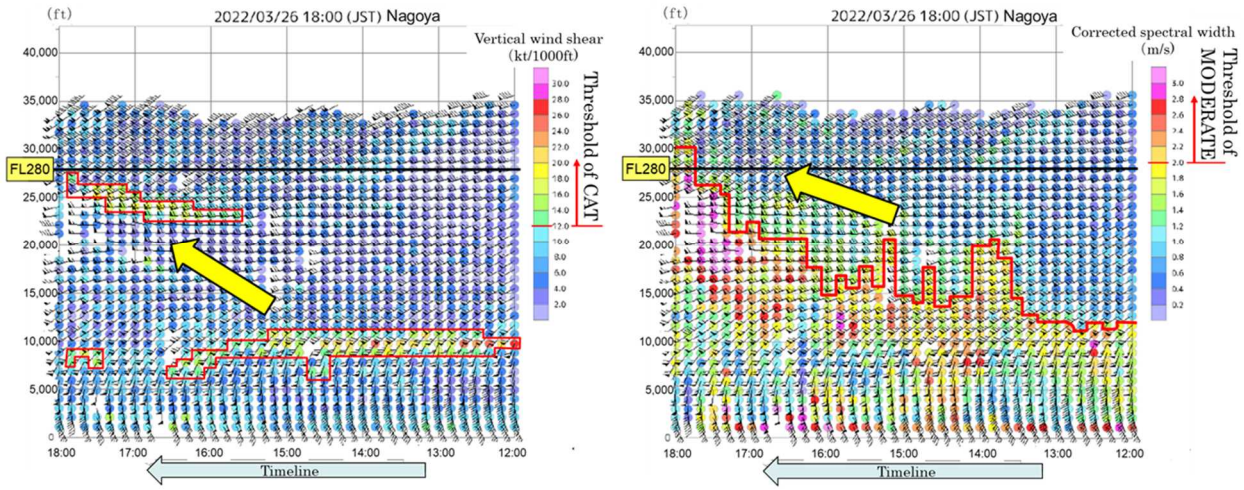

Figure 7: Observation Data from the Wind Profiler, Nagoya Observatory Station (partly edited)
(Left: Vertical Wind Shear, Right: Corrected Spectral Width)

(2) Analysis of DFDR Data

The DFDR data at the time of the accident, when TB4 turbulence was encountered, were analyzed from the perspective of external factors and aircraft motion, and then the time of the change in aircraft motion and the airborne weather radar echo conditions were added to the analysis. Among the results of the analysis, Table 1 shows the results of the vertical aircraft motion related to the flight attendant's injury.

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*7 "Wind profiler" is a type of radar that emits radio waves to the sky and receives the returning waves after they are scattered as a result of uneven temperature and humidity caused by precipitation particles and turbulence in the air, which makes it possible to obtain information about upper air wind direction/speed up to an altitude of 40,000 ft at maximum.

*8 "Corrected Spectral width" is an observed elements to indicate the Doppler velocity width in the wind profiler receiving signal, and an indicator of turbulence showing that wider the spectral width correction, larger the fluctuations in the air.

The JTSB concludes that the characteristics at the time of the accident confirmed as the external factors were decreased outside air temperature, decreased calibrated airspeed*9, decreased wind speed, and decreased angle of attack.

The changes in outside air temperature, wind speed, and angle of attack are characteristics of atmospheric disturbances, and it is likely that turbulence occurred in the vicinity of this accident site.

The decrease in calibrated airspeed and angle of attack acts as an aerodynamic force to reduce the lift of the wings (main wings and horizontal stabilizer), whose effects are mainly seen in vertical acceleration and pitch angle. The vertical acceleration recorded on the DFDR at the time of this accident was 1.28 G of negative G from 1.26 G to -0.02 G in about one second, which highly probable caused the aircraft to "thud " and sink, and the flight attendant A to float. In addition, there was a positive G of 1.30 G from -0.02 G to 1.28 G in the next second. It is most likely that the flight attendant A was injured when her body was lifted by the negative G and she fell when she lost her body balance and was hit hard by the aircraft floor which was lifted by the positive G.

Furthermore, based on the DFDR records, the effect of the wing lift reduction on the pitch angle was probably only ±1° or less.

Others are that no echoes were observed on the onboard weather radar, so it is possible that the aircraft did not encounter cumulonimbus clouds or a heavy precipitation area, but rather turbulence (wind shear, CAT, etc.) that could not be predicted or detected.

Table 1: Analytical Result of DFDR DATA and Others at the Time of the Accident (Excerpt)

Category	Parameter	Change	Cause or effect of change
External factors	Outside temperature	Decreased	(Cause) Possible atmospheric disturbance
	Calibrated airspeed	Decreased	(Effect) Change in vertical acceleration and pitch angle due to decrease in wing lift (Effect) Backward acceleration due to deceleration
	Wind speed	Increased gradually from about 90 seconds before the accident, and about 10 % decreased at the time of the accident.	(Cause) Possible atmospheric disturbance
	Angle of Attack	Decreased	(Cause) Possible atmospheric disturbance (Effect) Change in vertical acceleration and pitch angle due to decrease in wing lift
Aircraft movement	Vertical acceleration	To the minus side	(Effect) Shaking due to the sink of the aircraft (Effect) Unfixed objects or bodies lifted up into the air.

*9 "Calibrated airspeed" refers to the airspeed obtained after the position error and instrument errors of the airspeed system are calibrated and added to the indicated airspeed.

	Pitch angle	A small change within ±1°	(Effect) Very small
Others	Aircraft movement change time	Short time (Negative G for about the first second, and positive G for about one second after that)	(Effect) Sudden shaking of the aircraft (lifted after sinking)
	Echoes on airborne weather radar	None	(Cause) Possibility of encountering undetectable turbulence

(3) Flight Attendant Responses

The JTSB concludes that the two flight attendants responsible for the cart aft of the right aisle were in the process of stowing the cart and beverages in the aft galley when the aircraft encountered shaking (sudden descent); in addition, because the aft galley of the aircraft is a large space and the beverages and carts are stored in different directions and at different heights, it was probably difficult for the flight attendants to grab the galley bar at a moment's notice because the relative positions of the galley bar and themselves changed depending on their task.

The DFDR recordings prior to the accident did not show a significant change in each acceleration such that the flight attendants would have sensed a sign of a big shake, in addition, the duration of the aircraft shaking was short, about two seconds, therefore, it is probable that the two flight attendants in the aft galley did not have enough time between the time they felt a big shake and were lifted up into the air and the time they fell to take a preventive posture against injury as described in the "Guidelines for the Operation of the Belt sign" established by the company.

On the other hand, the flight attendants near the center of the cabin grabbed the backrest of nearby seats and held the cart as the aircraft was shaken, so that neither their bodies nor the cart were lifted. In the cabin, there were seats on both sides of the aisle, and the flight attendants could have grabbed a seat with either hand and immediately assumed an injury-preventing position.

In the company, it is probably useful to re-disseminate and raise awareness of the characteristics and countermeasures of this accident and similar cases in the past to prevent the recurrence of similar accidents.

(4) Ensuring Passengers Safety

The JTSB concludes that it is highly probable that when the aircraft was violently shaken, all 62 passengers were seated and fastened their seatbelts even when the belt sign was turned off, therefore, no passengers were injured, to which the safety measures usually taken for encouraging passengers to fasten their seatbelts while seated probably contributed.

4. PROBABLE CAUSES

The JTSB concludes that the probable cause of this accident was that the aircraft was shaken as it encountered turbulence that was difficult to predict, therefore the flight attendant working in the aft galley probably lifted into the air, lost her balance and fell, resulting in injuries.

5. SAFETY ACTIONS

5.1 Safety Actions Required	As described in the ANALYSIS, in the company, it is probably useful to re-disseminate and call attention to the characteristics and countermeasures of the case of this accident and similar cases in the past in order to prevent the recurrence of similar accidents.
5.2 Safety Actions Taken after the Accident	Measures Taken by the Company after the Accident (1) Notification to the Employees of All the Company's Group The Corporate Safety (safety news of the company's group) addressed to all the company's group was issued in order to notify the all employees of the occurrence of this accident (involving the fracture of a flight attendant of the company) (March 28, 2022). (2) Alert and Education for the Company's Flight Attendants The CABIN NOTICE with the following contents was issued to all flight attendants of the company in order to alert and educate them (June 8, 2022). ① Overview of this accident and the circumstances at the time when the flight attendant A was injured ② Previous cases of turbulence-related injuries that have occurred in the company's group and their characteristics ③ Response procedures in the event of sudden and unpredictable turbulence (including videos and related documents for each model) ④ Special precautions and procedures for exchanging information with flight crew to confirm the situation in the cabin and the presence of casualties after the flight attendants are seated at the time of the turbulence