For Prevention of Accidents due to Turbulence

FASTEN SEAT BELT

2015 JUNE

1. Preface

2. Statics

3. Case Studies of Accidents

4. Conclusion

Preface

19
245

Aircraft shaking accidents
Total aircraft accidents (Excluding Takeoff and Landing)

2001 OCT~2014 JUNE

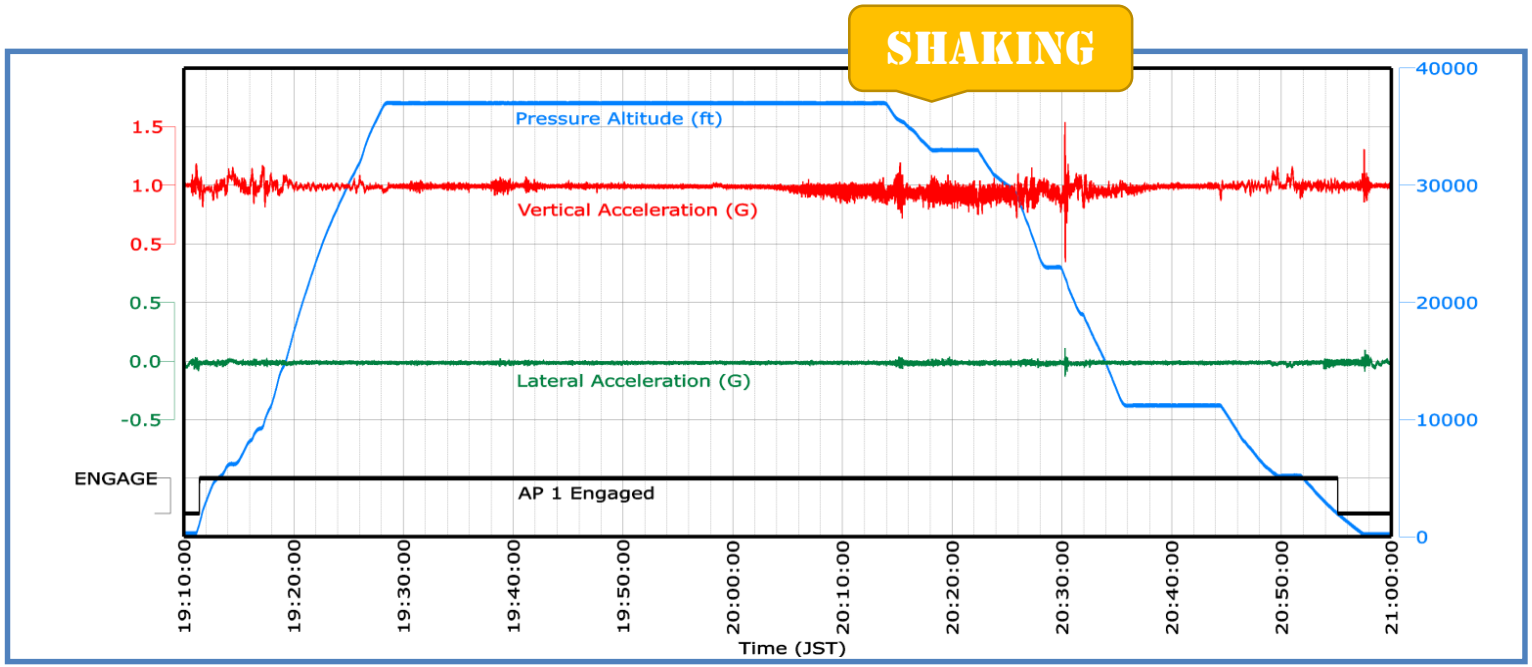


Fig1 FDR Data (sample)

Statistics

By year

Average (2001 OCT~2014 JUNE) 1.49 times/year

19/40 (Aircraft MTOW>5700kg)

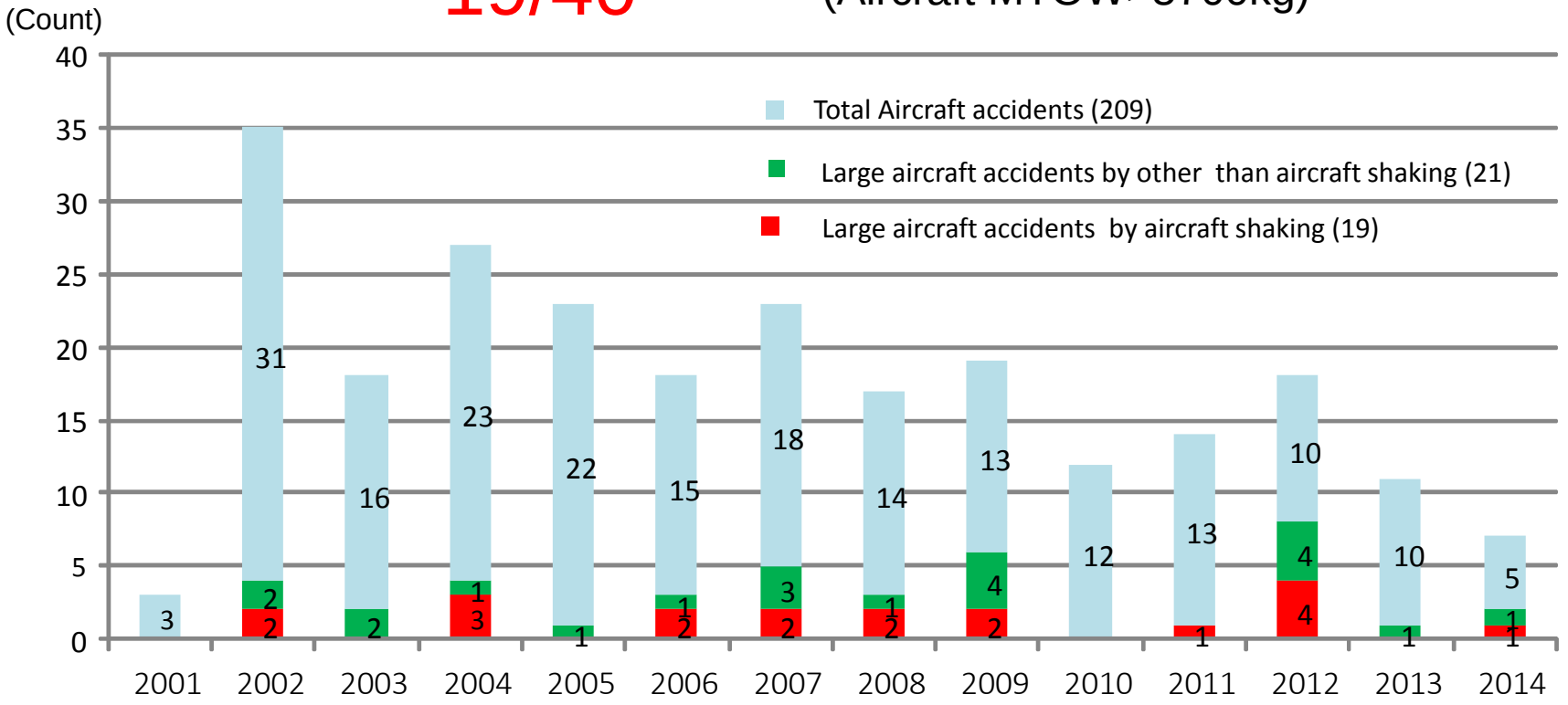


Fig.2: Changes in the number of accidents

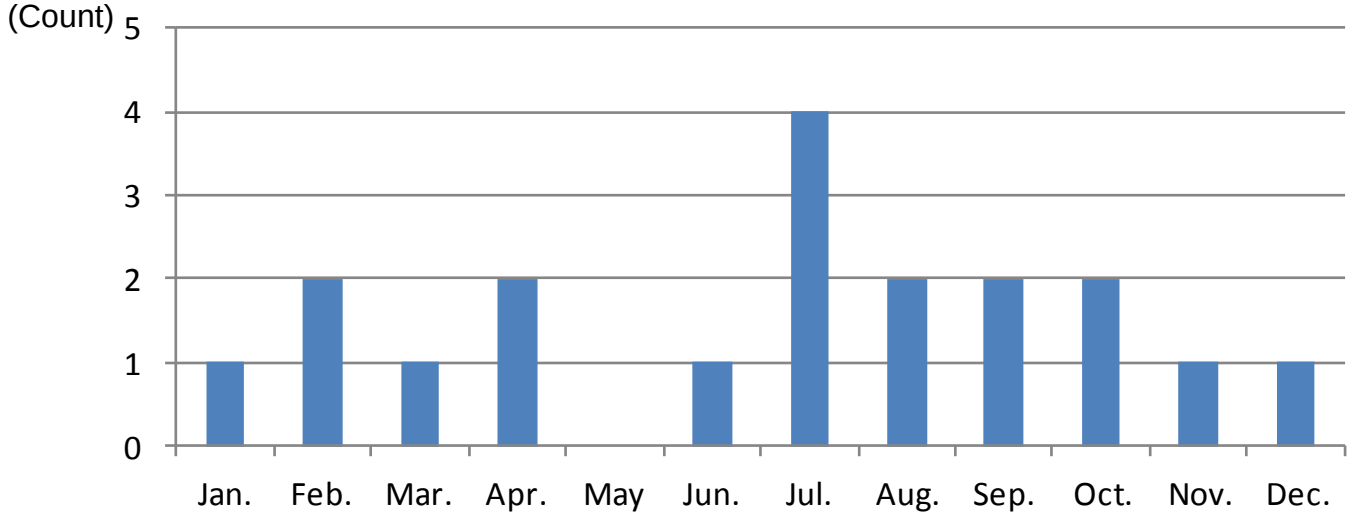


Fig.3 Monthly

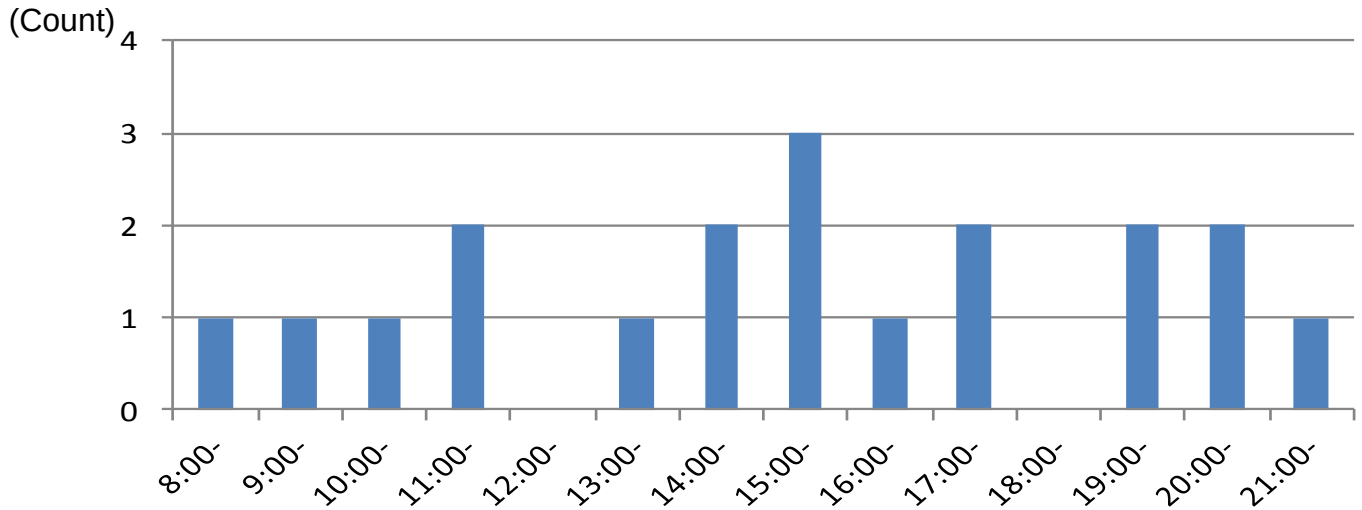


Fig.4 Hourly

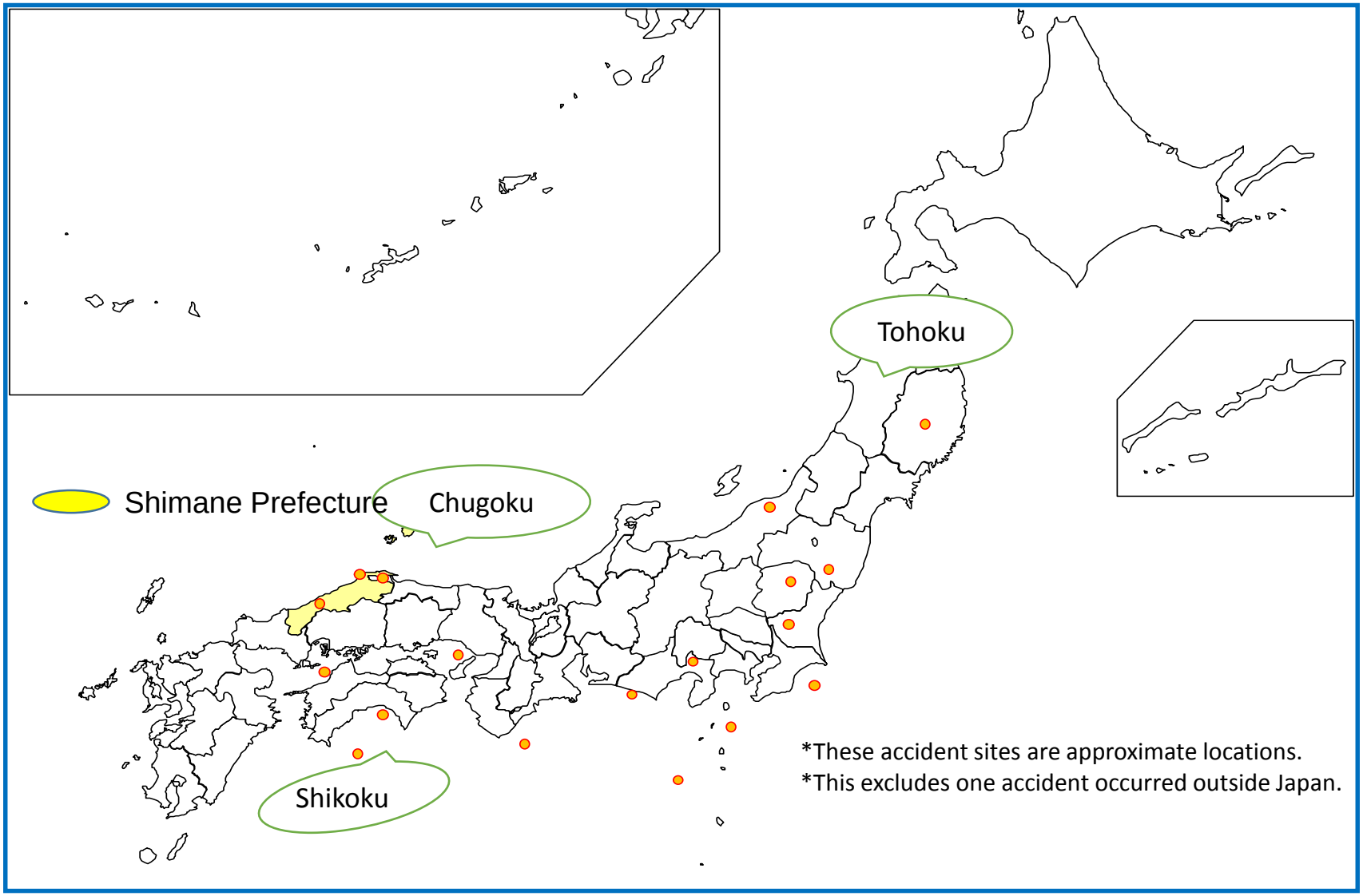


Fig.5 Location vs Accidents

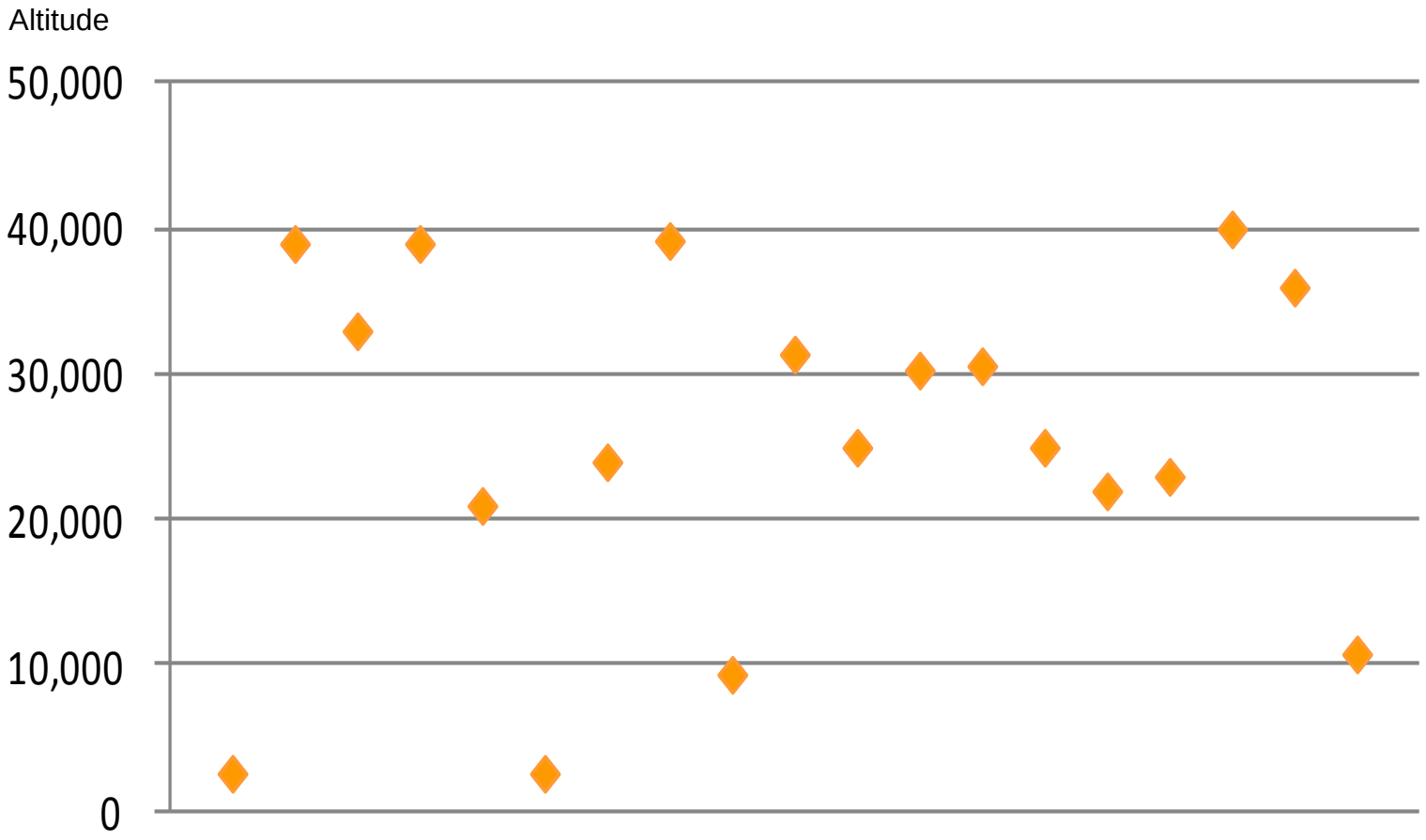


Fig.6 Altitude vs Accidents

Phase of flight Climb : 1
Cruise : 7
Descent (Approach) : 11

The number of injured

- 111 people injured in 19 aircraft shaking accidents
- 29 serious injuries and 82 minor injuries

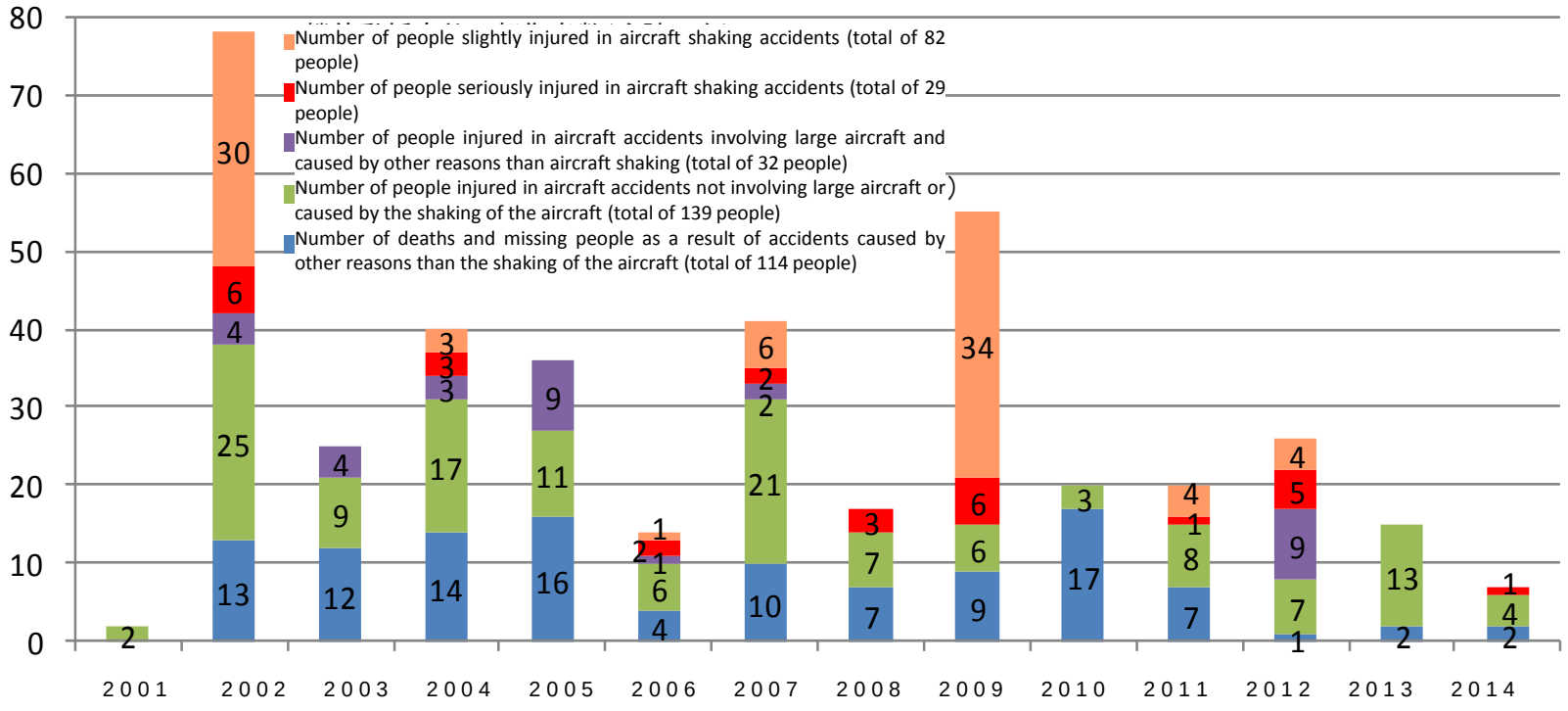


Fig.7 : Changes in the number of injuries

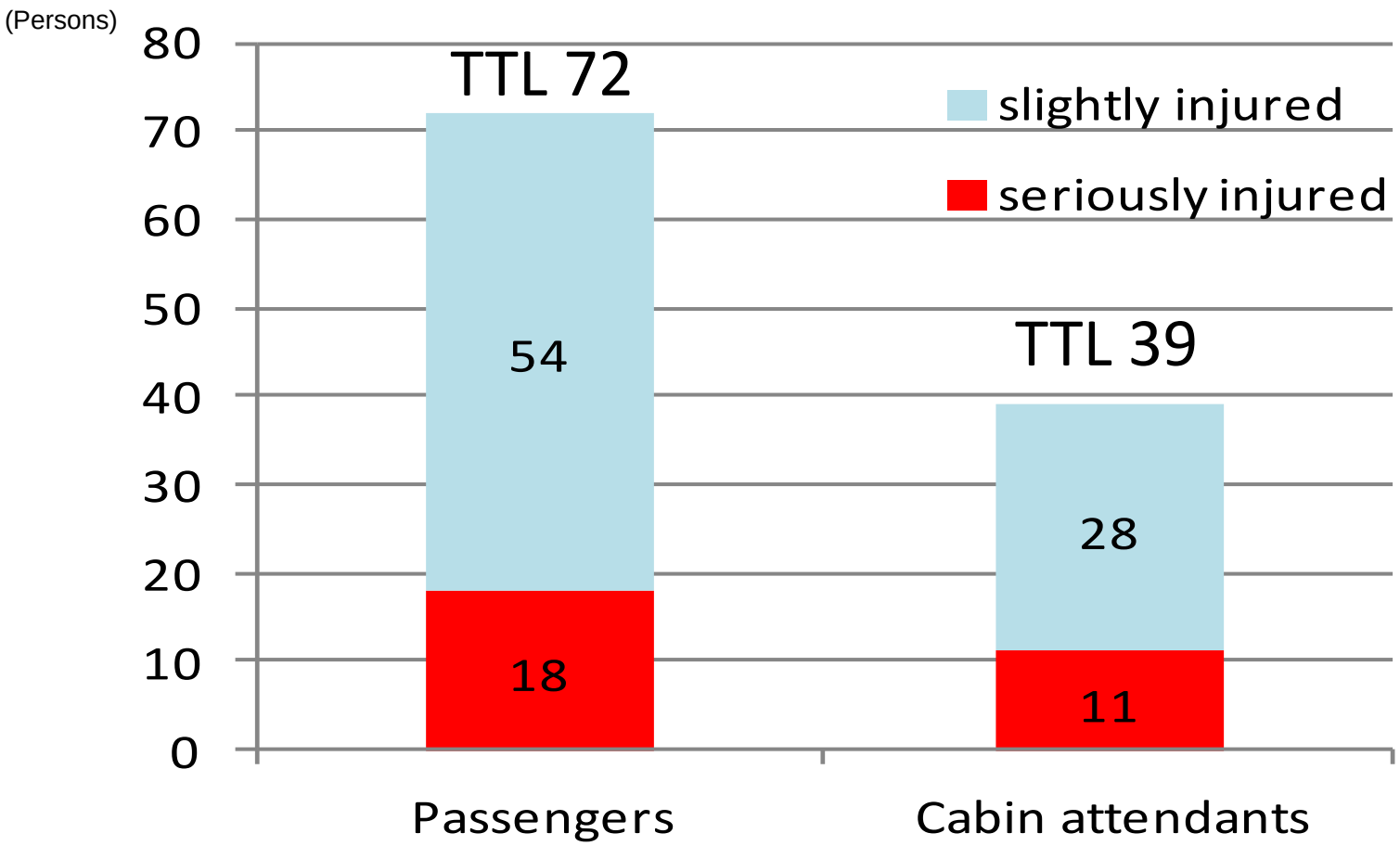


Fig.8: Attribute

Injury rate : cabin attendant > passenger

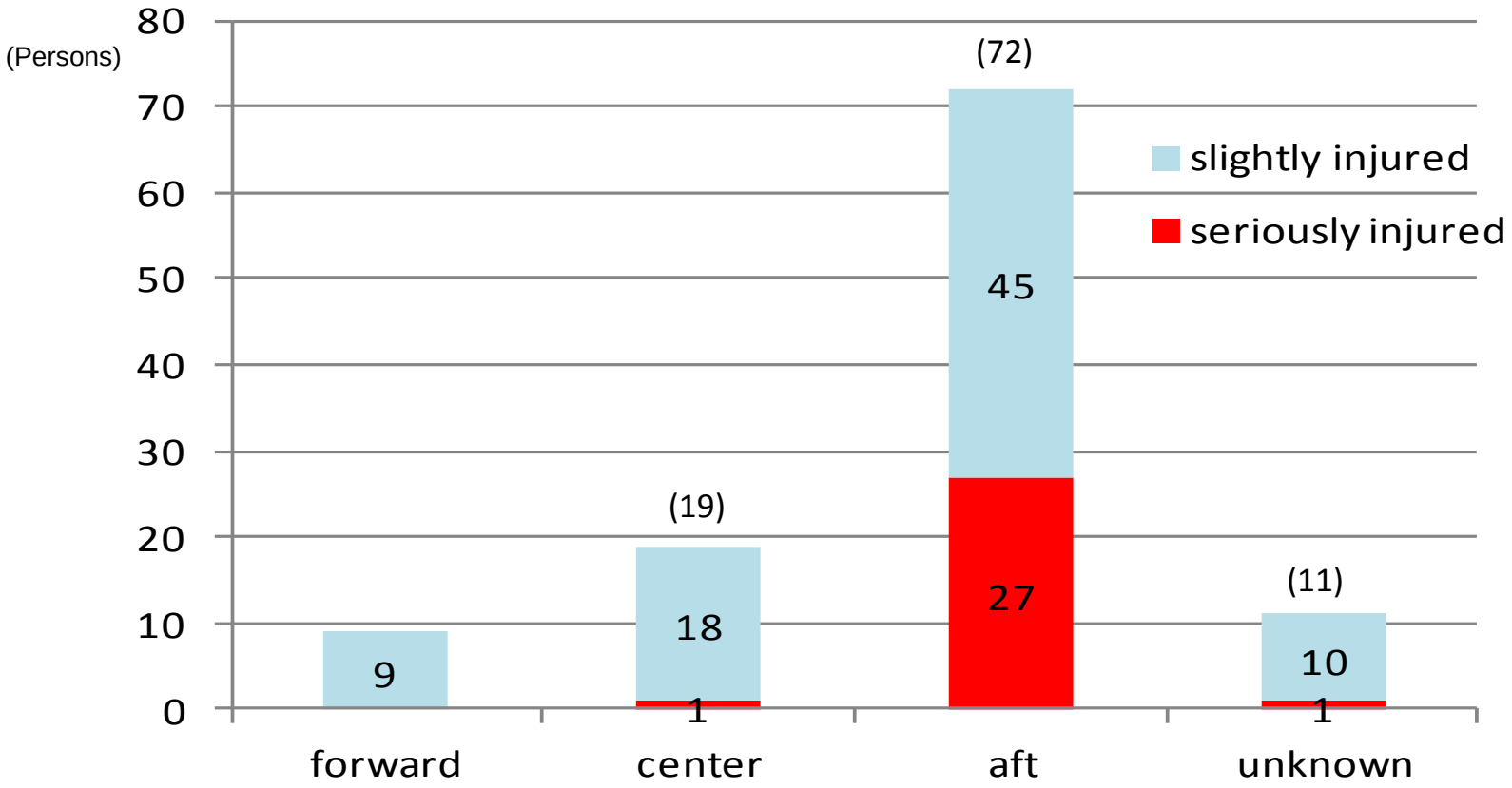


Fig.9 : Positions

AFT > CENTER > FORWARD (Excluding 11 unknown cases)

JTSB Analysis: Negative vertical acceleration affected more on the aft than the foreside when the pitch angle(*1) of the aircraft changed rapidly.

(*1)This refers on the vertical inclination angle of the nose of the aircraft.

The nose rises when positive and falls when negative.

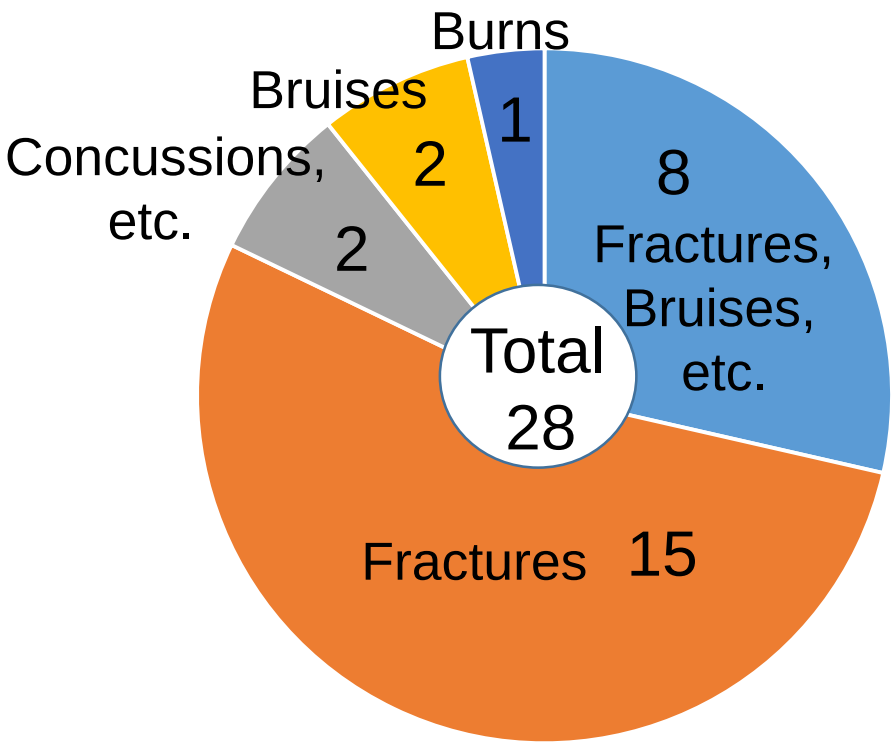


Fig.10 Type of serious injuries

(Details revealed regarding 28.)

> Fracrures:23
(Cervical, Collarbone, Ribs, Thoracic vertebrae)

> Concussions:2
(Brain, Cervical vertebra)

> Bruise:2
(Face, abdomen)

> Burns (Infant):1
(Right upper extremity, abdomen, etc.)

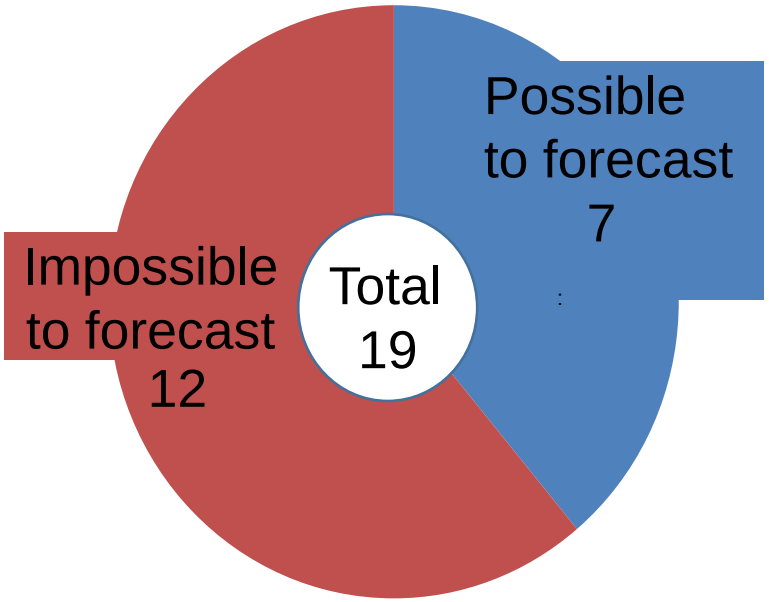


Fig 11 Turbulence Forecast

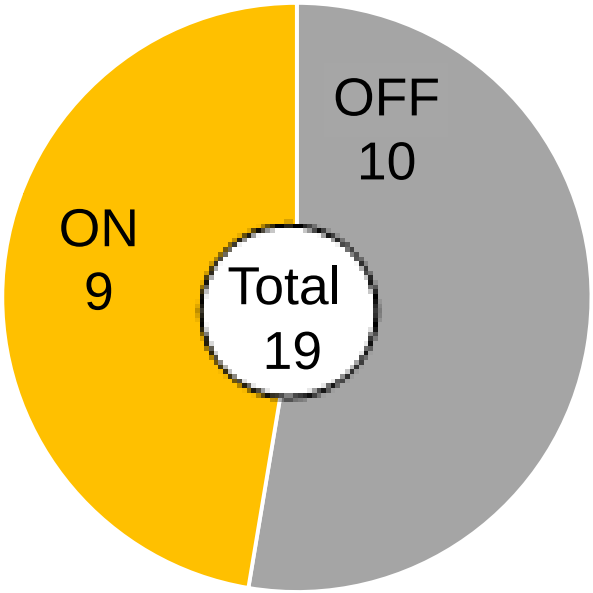
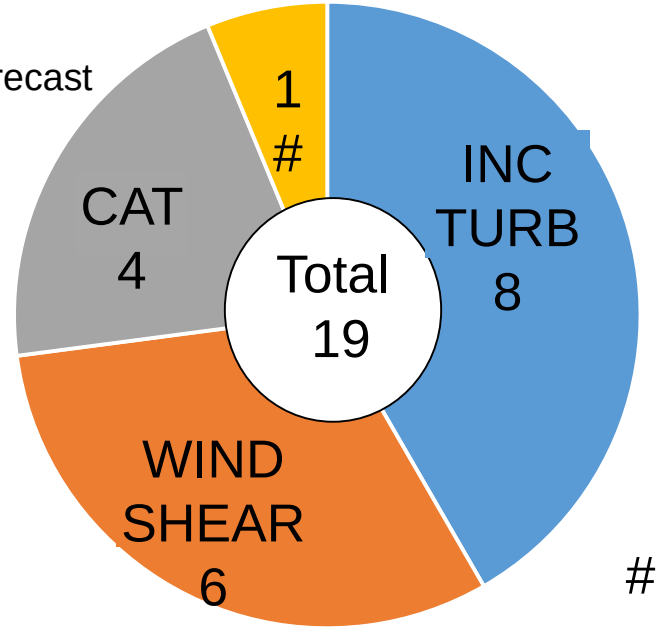


Fig.12 Seatbelt Sign



WAKE TURBULENCE

Fig 13 Weather

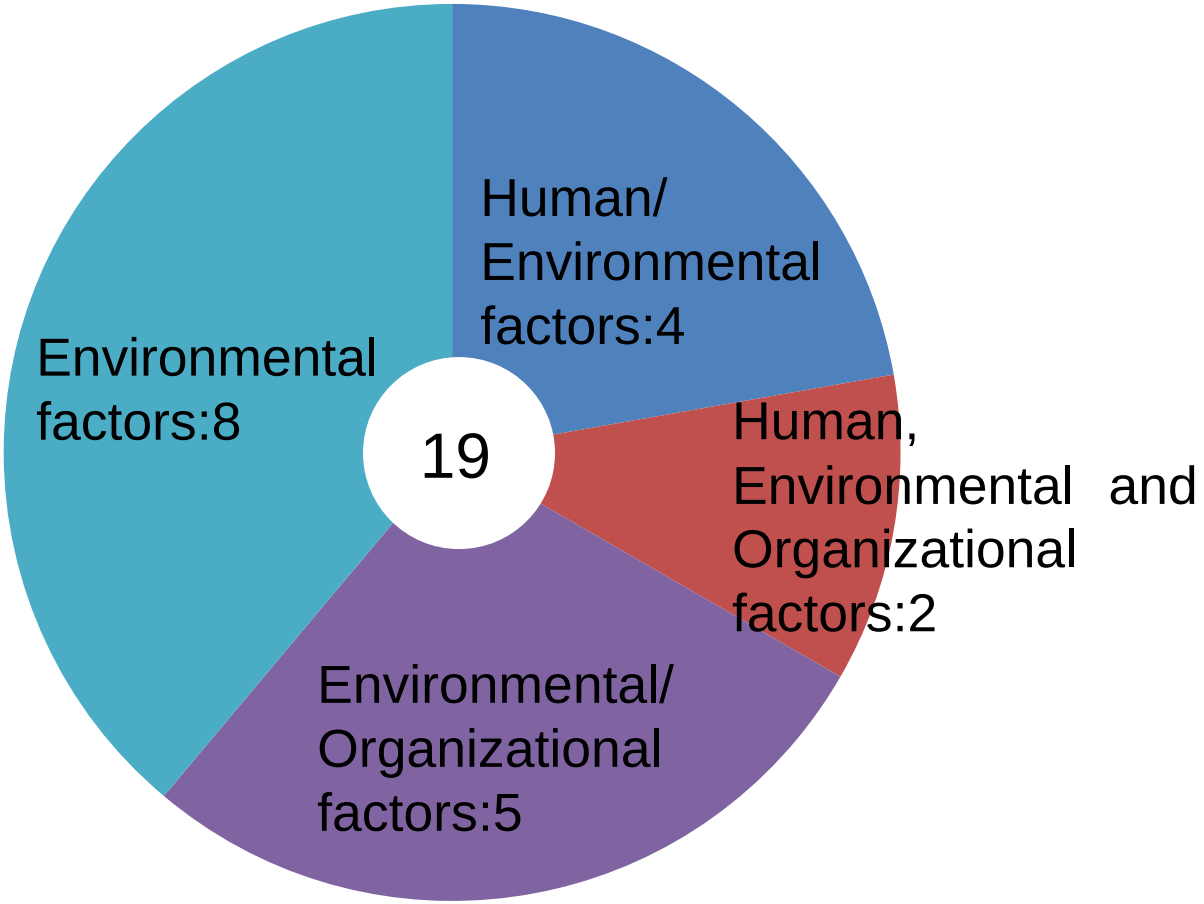


Fig.14 Categories

Example of human factors

>Excessive input on column in response to a nose-up movement.

>Autopilot disengaged during the shaking of the aircraft

>Lack of awareness that the weather radar was off.

etc.

Example of Environmental factor

>Active cumulonimbus cloud
>Local turbulence occurring within stratus cloud.
>Turbulence not forecasted due to fine weather.
>Frontal zone occurring on the north side of a typhoon.
>Large vertical wind shear.
etc.

Example of Organizational factor

>Lack of latest information in pre-flight briefing.
>Lack of sharing important information between crew.
>Lack of communication between crew and operation support staff.
etc.

Case Study(1) The shaking of the aircraft by CAT(APR 2001)

B767-300 took off from Miyazaki Airport at 16:16JST for Tokyo International Airport as a schedule flight.
While flying at FL250, 27NM ESE of Kushimoto, around 16:53, the aircraft encountered turbulence.
One cabin attendant was seriously injured in front of the left aft lavatory.2passenger and other 2 cabin Attendants were slightly injured.
119 people were on board(2pilots, 6cabin attendants, 111passengers) The aircraft was not damaged.

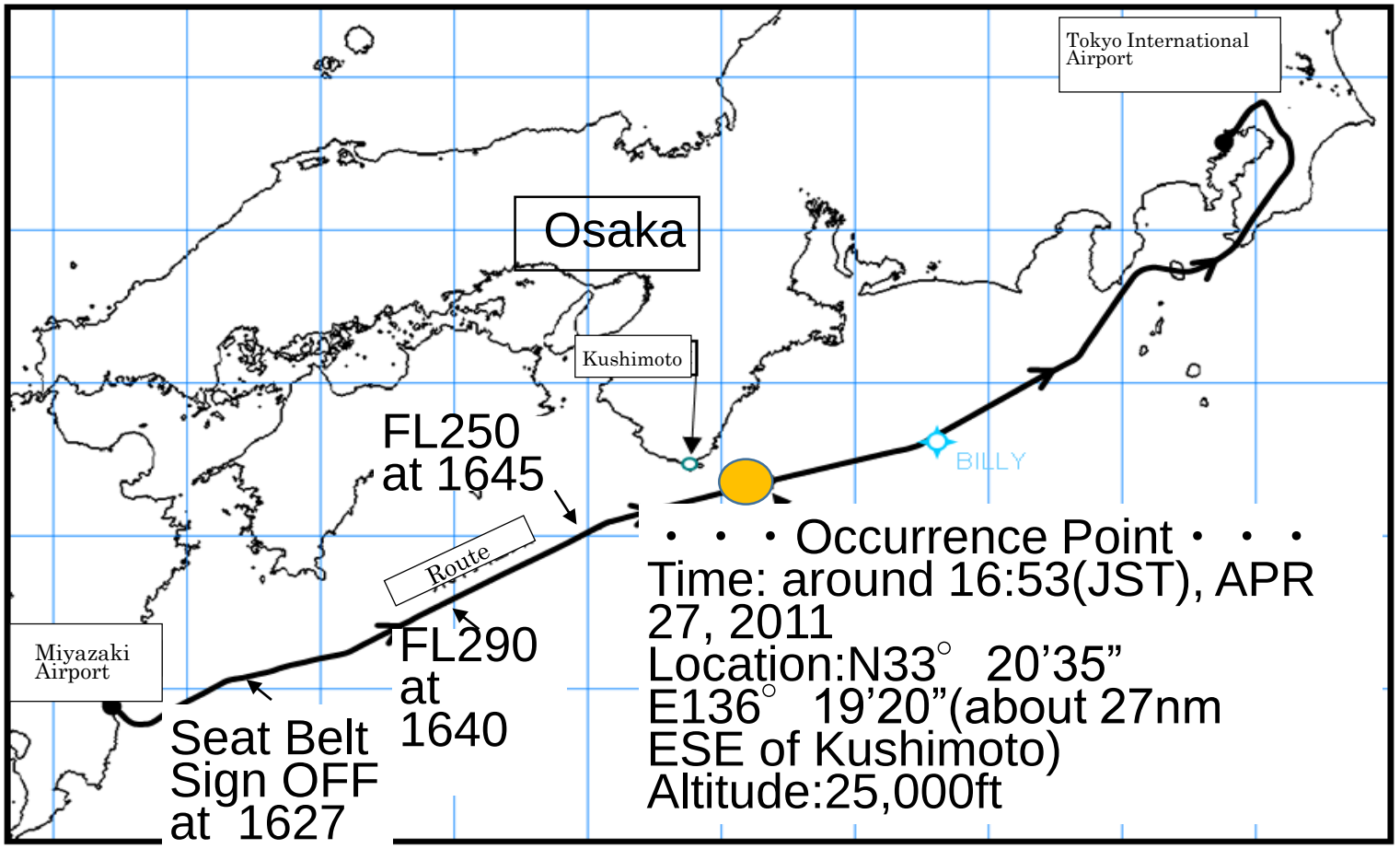


Fig.1 Summary of Flight

Domestic Significant Weather Analysis Chart(1500JST)

*This chart is issued 6 times a day. (VALID TIME:03,06,09,12,15,18JST)

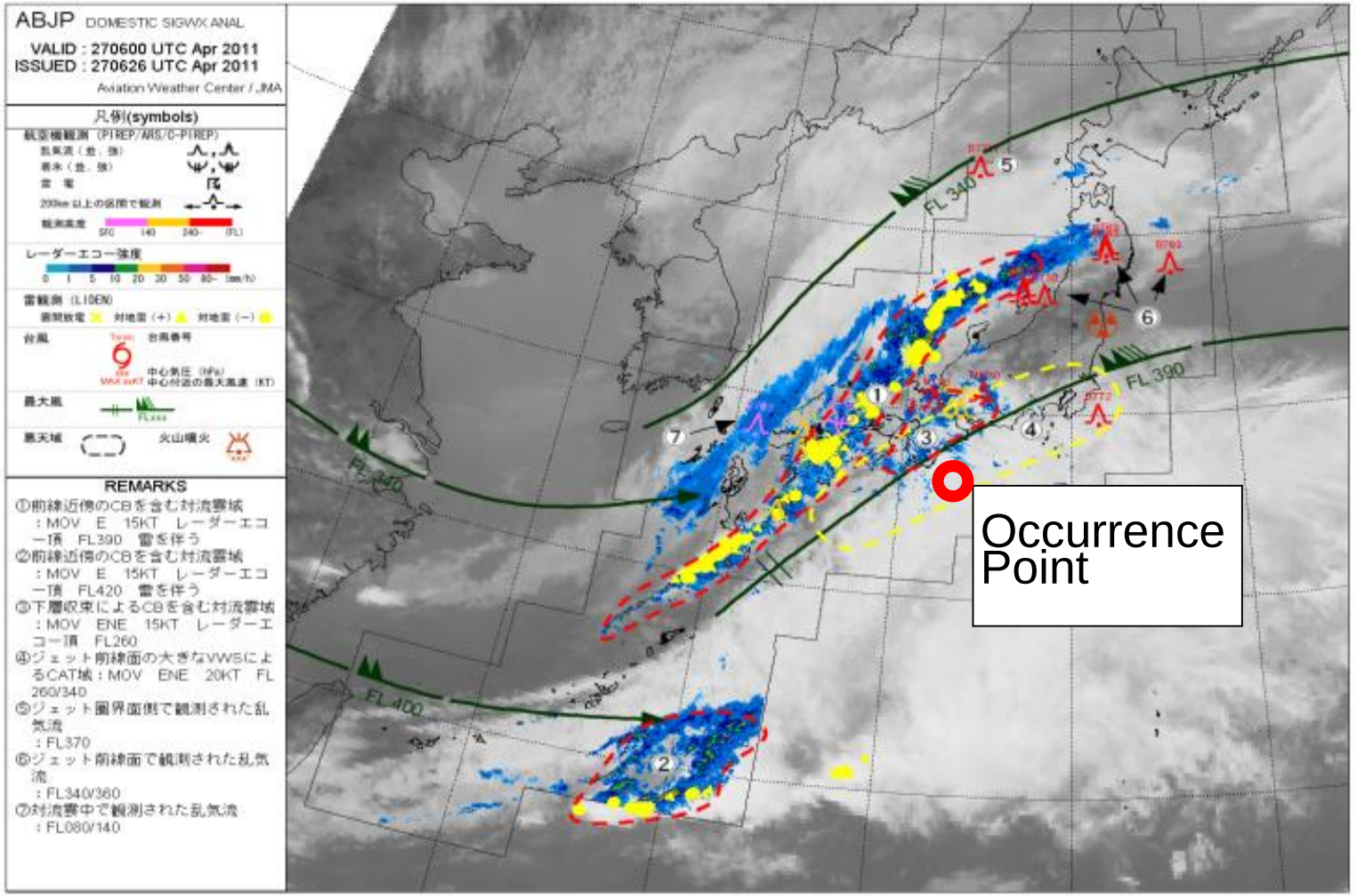


Fig .2

Hourly Analysis Chart (Vertical Cross Section)

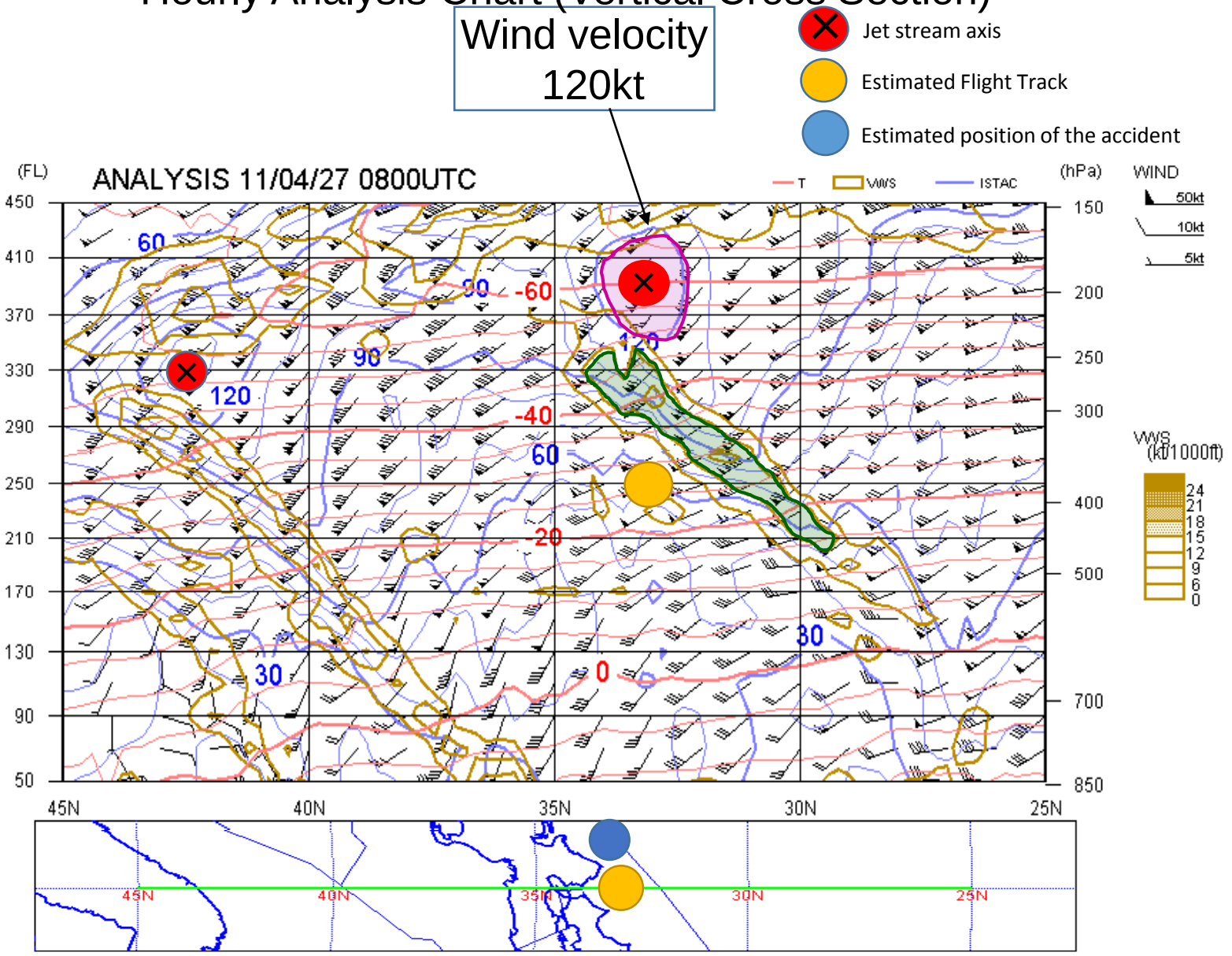


Fig.3

Locations of the Injured when the Accident Occurred

◎ location of the CA seriously injured

○ location of the slightly injured

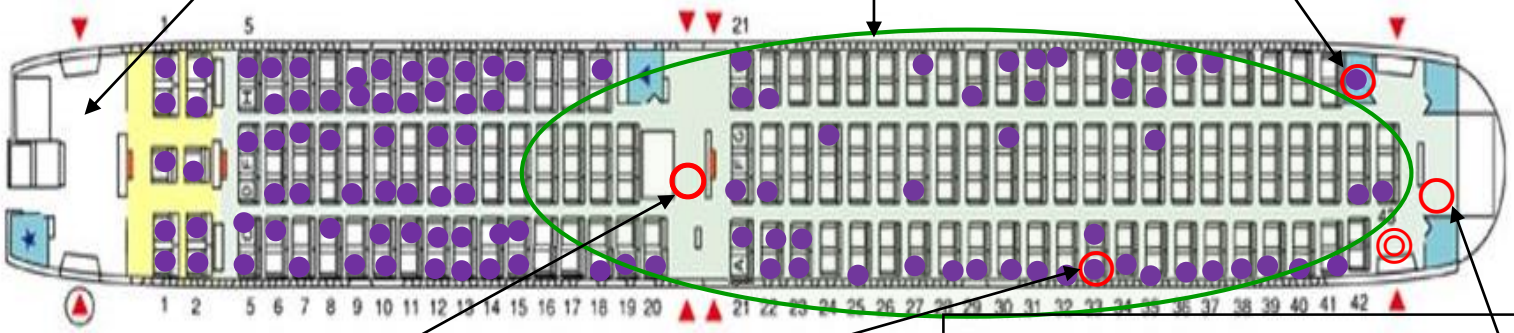
● Seat occupied by passengers

The area where in-flight Magazine in seat pockets escaped and scattered On the floor

Passenger A (in a lavatory) Head, bruised

Right aft lavatory

Chief Purser



CA-B head, bruised

CA-C
Both knees and head, bruised

FWD

Passenger B
Both shanks, bruised

CA-A(◎)
Right pubis, fractured

Left aft lavatory

Location where a CA was seriously injured

Fig.4

Causal Factors of the Accident

Convective Clouds

No clouds at their FL while flying between the thin cloud layers.

It is highly possible the aircraft was not shaken by convective clouds.

Winds

Temperature and atmospheric pressure values different, accompanied by wind velocity difference(wind shear), generated the unsteady air conditions where turbulence was likely to occur near the layer boundary.

It is possible that the unsteady airspace generated the turbulence and shock the aircraft with a downdraft, judging from the fact that at the moment of the turbulence.

The Turbulence

The aircraft gradually approached the frontal zone under the jet stream.

Nothing more than a weak vertical shear with 0 to 6kt was analyzed at the occurrence point.

The strong shaking lasted only for a very short period and ended without recurring.

The flight encountered it while flying through cloudless airspace.

It is highly possible that the aircraft encountered a local and temporary, strong CAT induced by wind shear judging from the findings.

The Shaking

The combination of the aircraft motion around the center of gravity caused by the increase in the pitch angle and the sharp descent of the aircraft by 80 ft gave the aft section of the aircraft a sudden lowering.

It is highly possible that the CA near the left aft lavatory flew up into the air and suffered a serious injury upon the fall to the floor.

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 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.

In order to Prevent Recurrence

➢ It would be recommended to continue to examine the effectiveness of measures such as the installation of handrails at locations where passengers pass by and consider taking further safety measures to prevent accidents.

➢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.

➢ It would be recommended to promote studies on and development of an airborne Doppler light detection and ranging (LIDAR) to detect CAT.

➢It is expected that providing meteorological organizations with access to 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.

Case Study(2) **The shaking of the aircraft by CB**(JULY 2012)

B777-200 took off from Incheon International Airport(Republic of Korea) around 12:55JST.
At 14:18JST the aircraft was shaken at approximately 150km north of Narita international Airport around FL230.One flight attendant was seriously injured and other three flight attendants were slightly injured.256 people were on board.
(2 pilots, 10 flight attendant, 244 passengers)
The aircraft was not damaged.

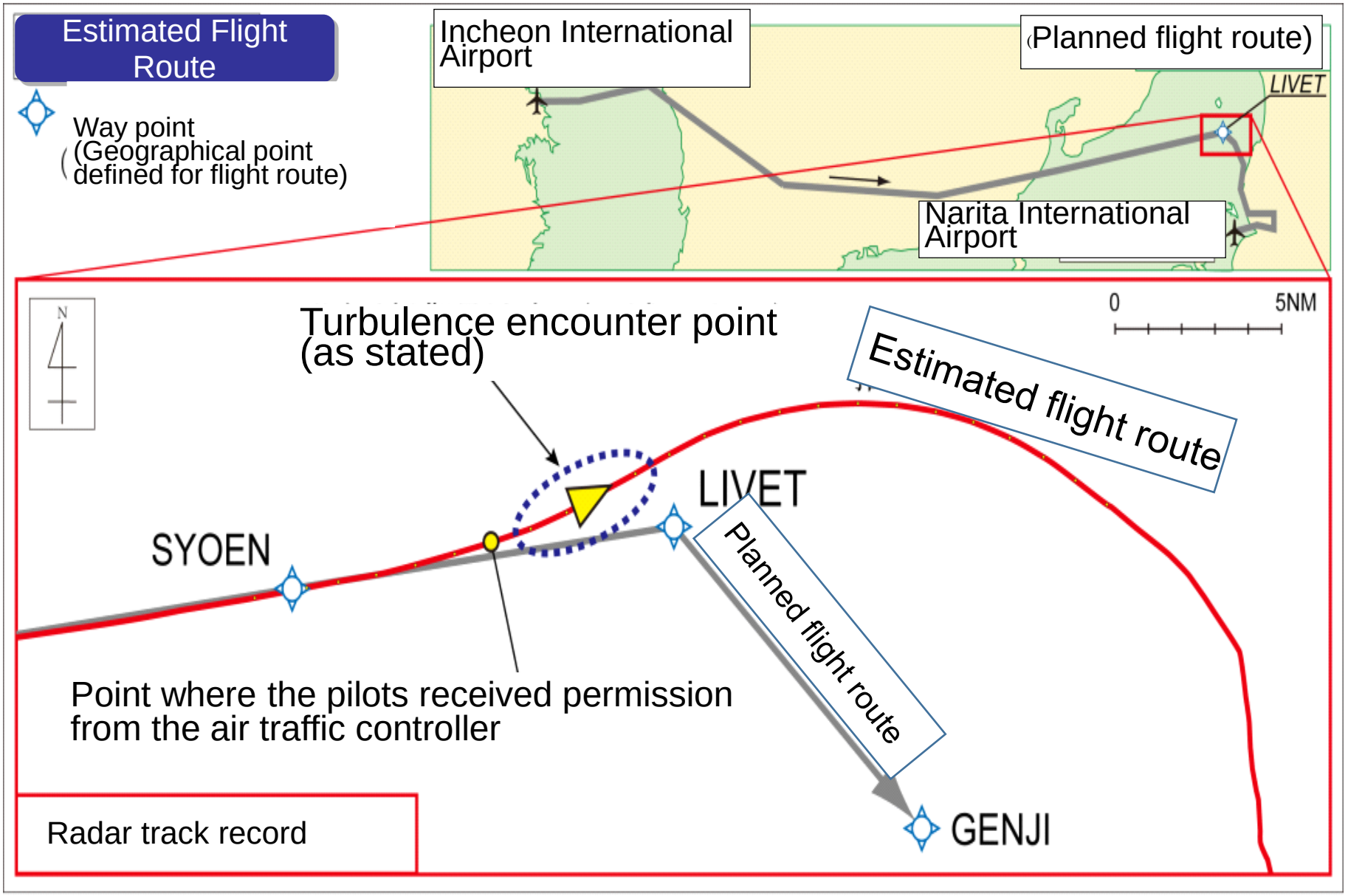

Estimated Flight Route
Way point
(Geographical point defined for flight route)
Incheon International Airport
(Planned flight route)
LIVET
Narita International Airport
N
0
5NM
Turbulence encounter point
(as stated)
Estimated flight route
LIVET
SYOEN
Planned flight route
Point where the pilots received permission from the air traffic controller
Radar track record
GENJI

Fig.1

>Handhold designed specifically for the shaking aircraft were no equipped.

>Fixed objects such as the counters and the cart handles stored in the lower part of the galley on four side were available to hang on as substitute for handholds.
(All carts had been stored when the accident occurred.)

>Making the FAs and the fixed objects, when were substitute for handholds, slightly far apart.

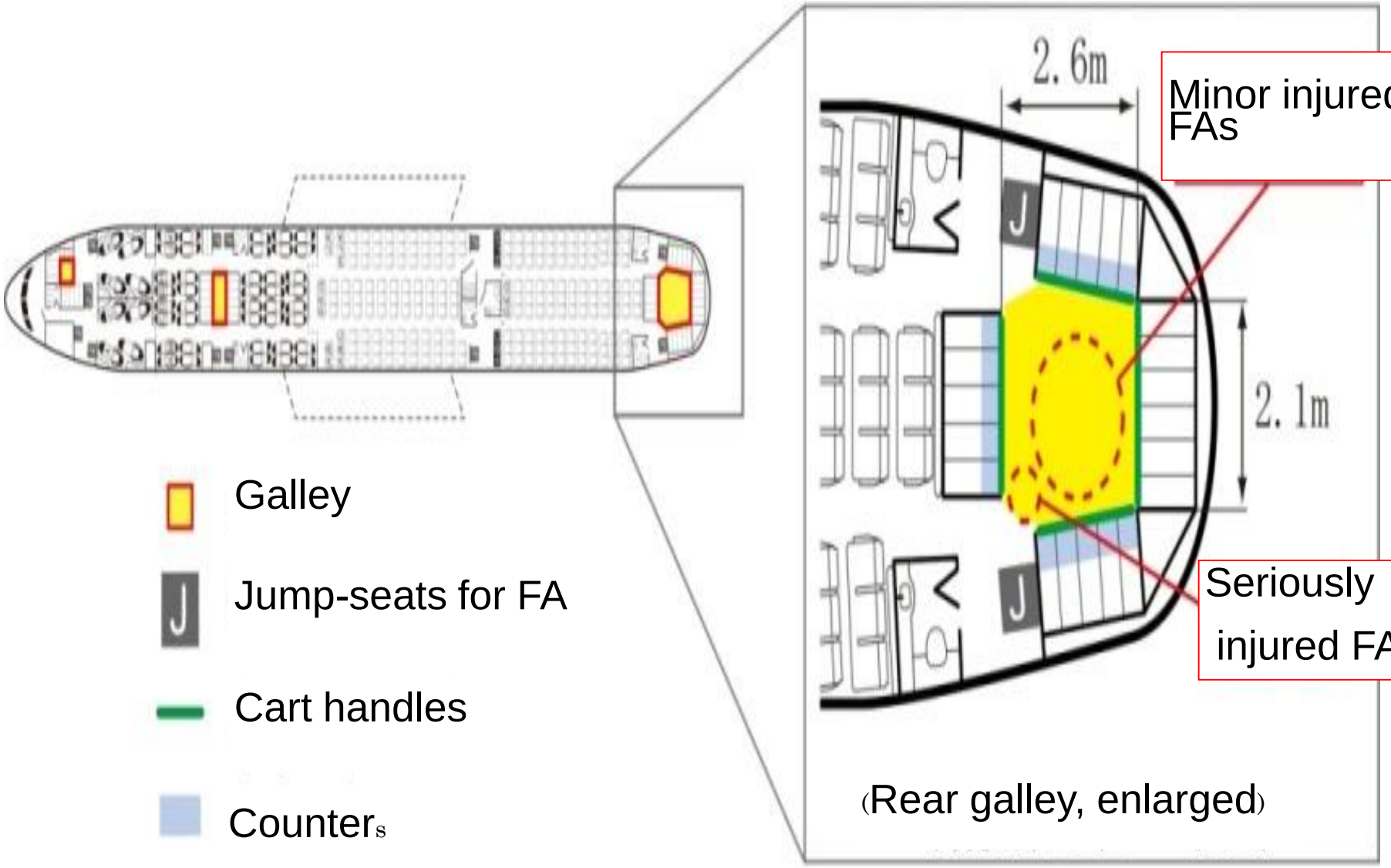

Galley
J
Jump-seats for FA
Cart handles
Counters
2. 6m
2. 1m
Minor injured FAs
Seriously injured FA
(Rear galley, enlarged)

Fig.2

Meteorological Information

Weather Radar Imagery (Strength: indicates precipitation intensity)

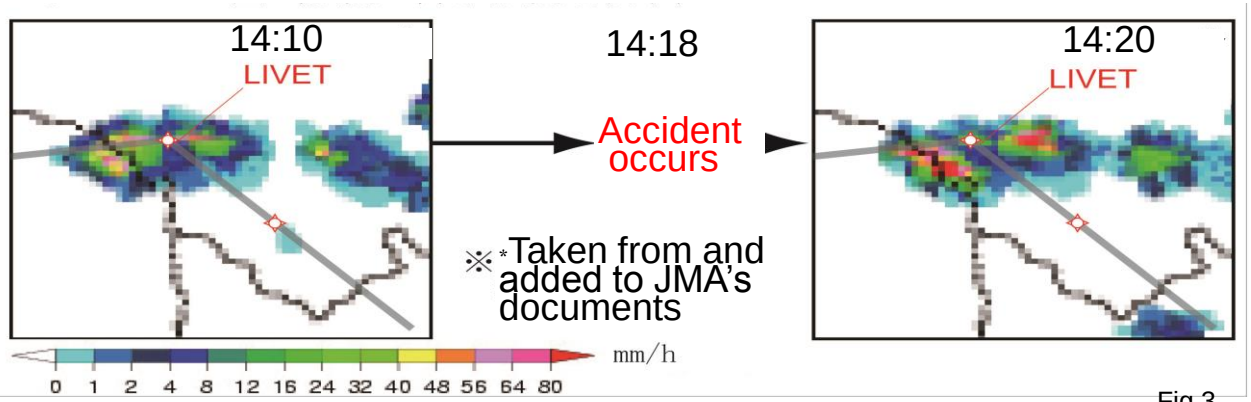
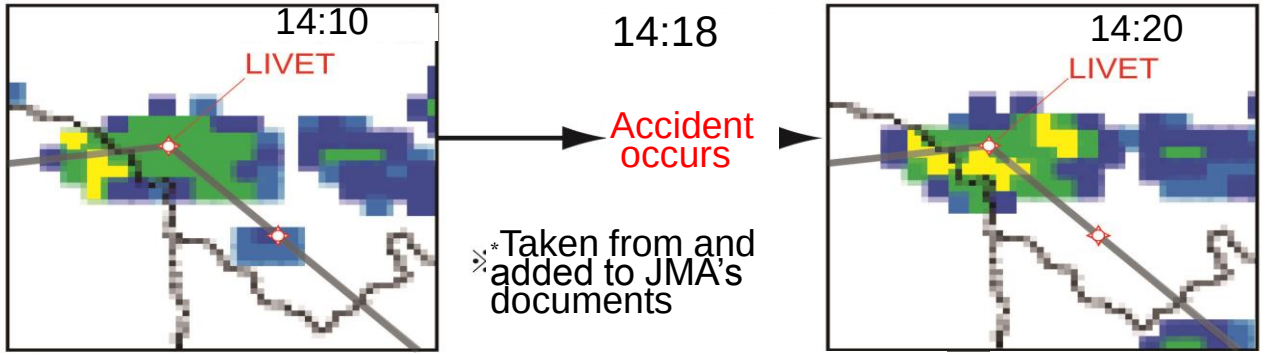


Fig.3

Weather Radar Imagery (Top height: indicates cloud height)



Causal Factors of the Accident

- **Flight Crew members' Judgment on the Weather**

It is highly probable that judging from the weather information before and during the flight, the fact that the cumulonimbus discovered before LIVET did not appear to be developing, with its cloud top being low, and the fact that it was indicated as a weak return on the weather radar display, crew members expected no significant turbulence to affect the flight, but only light turbulence, during the deviation from cumulonimbus, and that they did not inform the FAs of any information about the turbulence.

- **Development of Cumulonimbus**

It is highly probable that the cumulonimbus the aircraft avoided had developed quickly immediately before the time of the accident.
It is probable that the aircraft took detour the cumulonimbus to avoid it, but was forced into a part of the cloud which had developed rapidly, and then encountered its disturbance.

- **Injured FAs' Response to the Shaking of the aircraft**

It is probable that the four FAs working in the rear galley were thrown into the air because they had not been informed by the PIC of the turbulence in advance and were unable to hang onto fixed objects around them when the rear of the airframe sank suddenly.

It is considered somewhat likely that the FAs could have responded to the shaking of the aircraft if the PIC had informed them of some information about the turbulence.

Probable Causes

It is highly probable that the accident occurred when the FA in the rear section of the aircraft was seriously injured because it was shaken heavily.

It is probable that the aircraft was shaken heavily because it was unable to avoid the cumulonimbus which had developed so rapidly, and then entered a part of the cloud.

It is probable that the FA was seriously injured because she was unable to hang onto the fixed objects around her when the aircraft was shaken suddenly.

In order to Prevent Recurrence

Safety Actions taken by Company A after the accident occurred

➢After the occurrence of this accident, Company A strengthened the contents of Flight Attendant Operations Manual (UNEXPECTED TURBULENCE).

Case Study (3)

Injuries suffered by CA from the shaking of the aircraft by wake turbulence caused by the heavier category aircraft. (APR 2014)

<Summary of the Accident**>**

On Tuesday, April 29, 2014, at 09:16 Japan Standard Time (JST, UTC+9h), an Embraer ERJ170-100STD took off from Yamagata Airport as the scheduled flight. At around 09:45 JST when the aircraft was descending for Tokyo International Airport, it was shaken at an altitude of approximately 10,600 ft over Ishioka City, Ibaraki Prefecture. One cabin attendant was seriously injured and one other cabin attendant was slightly injured who were in the aft galley.

- There were 39 people on board, consisting of the pilot in command (PIC), three
- other crew members and 35 passengers.
- The aircraft was not damaged.

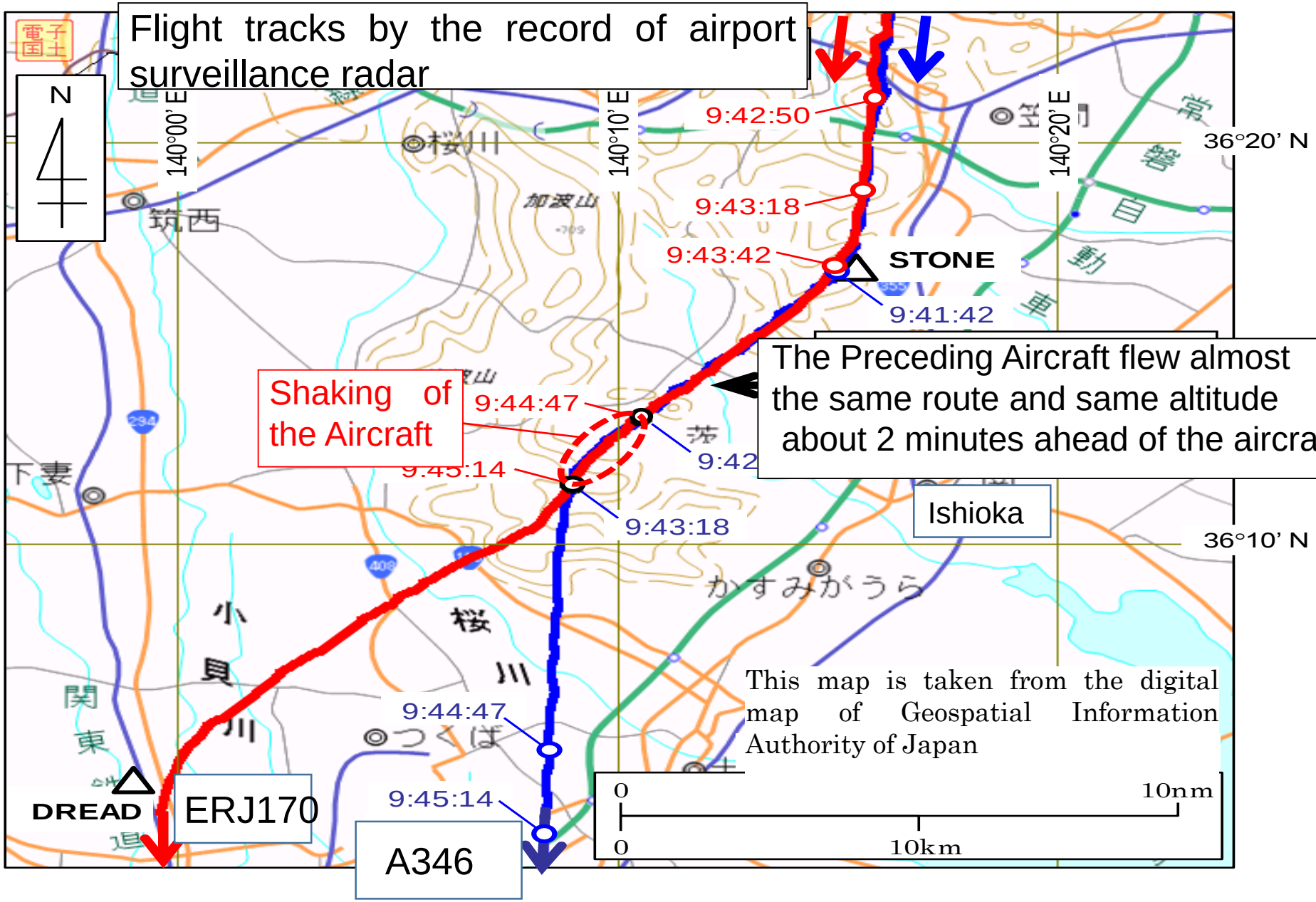
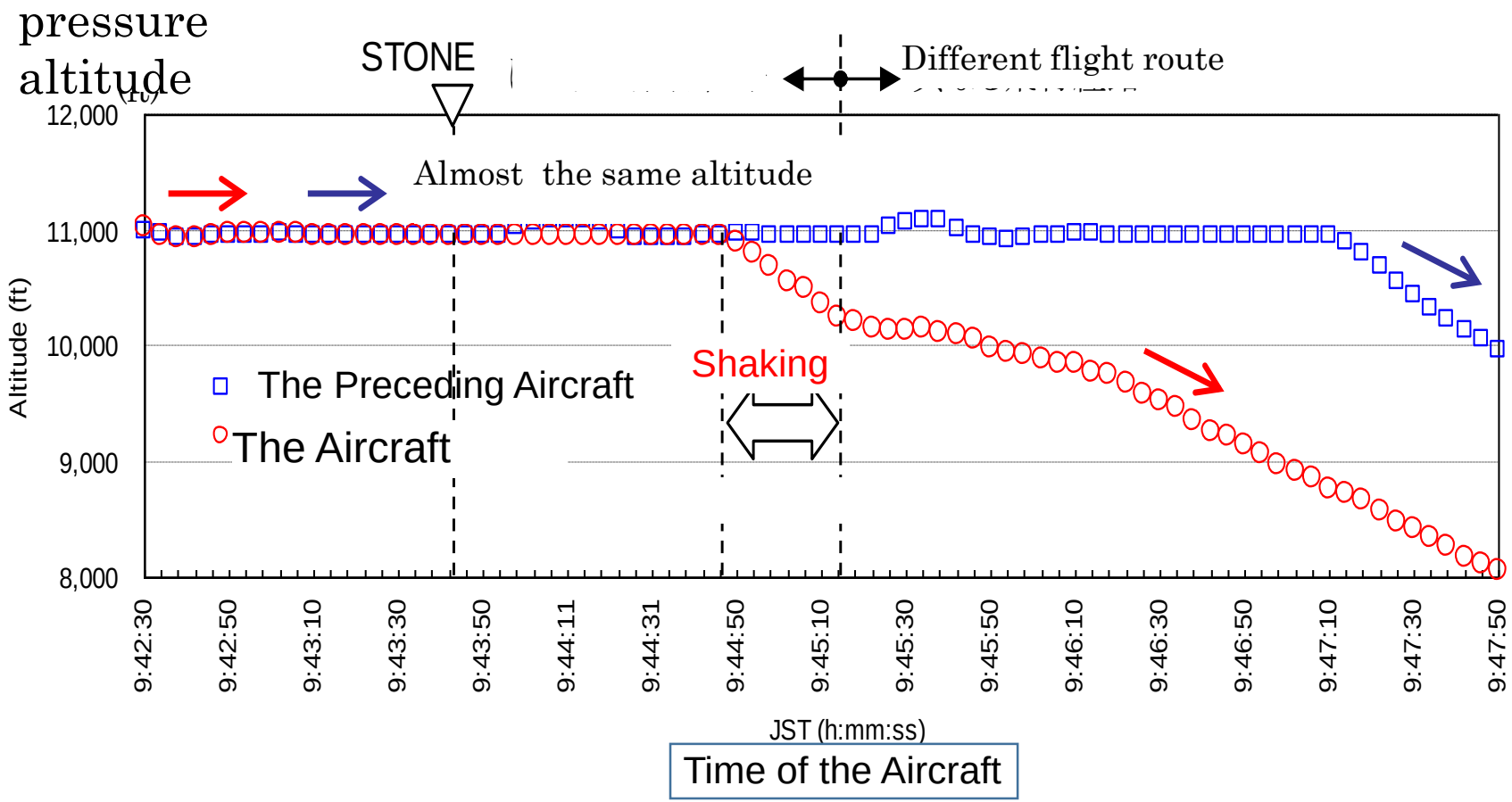

Flight tracks by the record of airport surveillance radar
N
140°00' E
140°10' E
140°20' E
36°20' N
36°10' N
9:42:50
9:43:18
9:43:42
STONE
9:41:42
The Preceding Aircraft flew almost the same route and same altitude about 2 minutes ahead of the aircraft
Shaking of the Aircraft
9:44:47
9:45:14
9:43:18
Ishioka
This map is taken from the digital map of Geospatial Information Authority of Japan
0
10nm
0
10km
9:44:47
9:45:14
DREAD
ERJ170
A346

Fig. 1

Estimated Flight Altitude



Smoothed altitude after correction of the atmospheric pressure by the record of airport surveillance radar.

Fig. 2

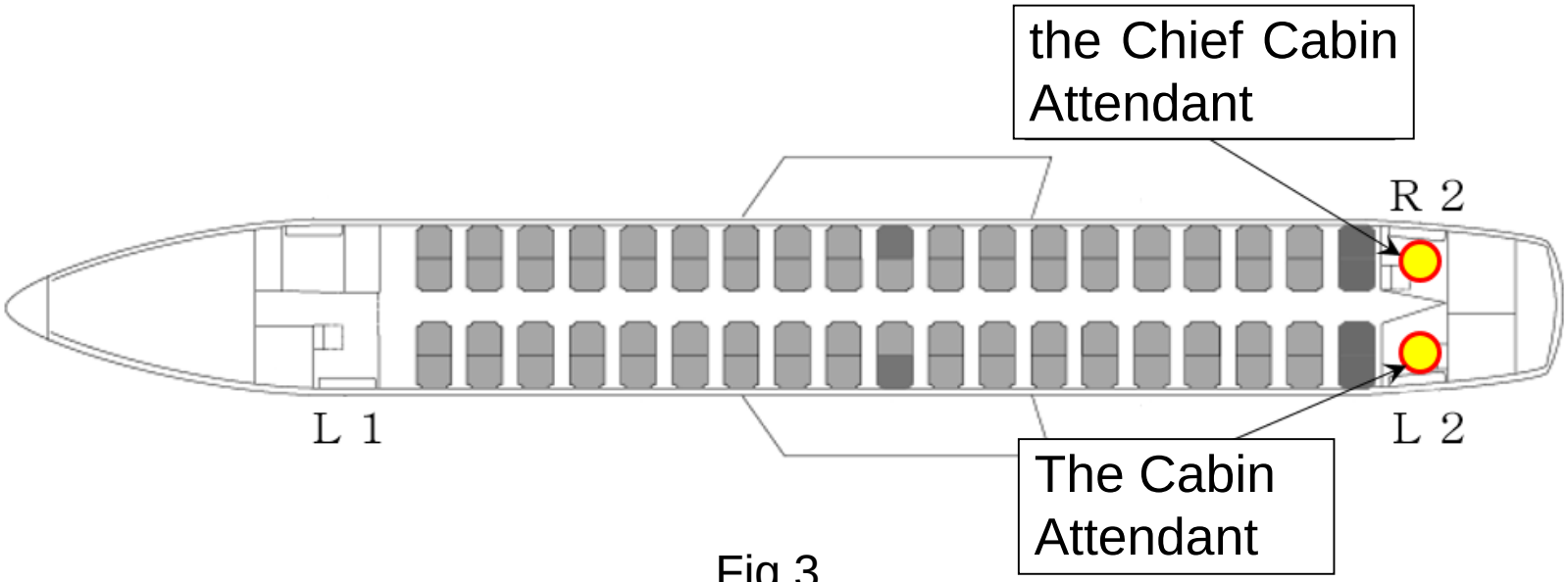
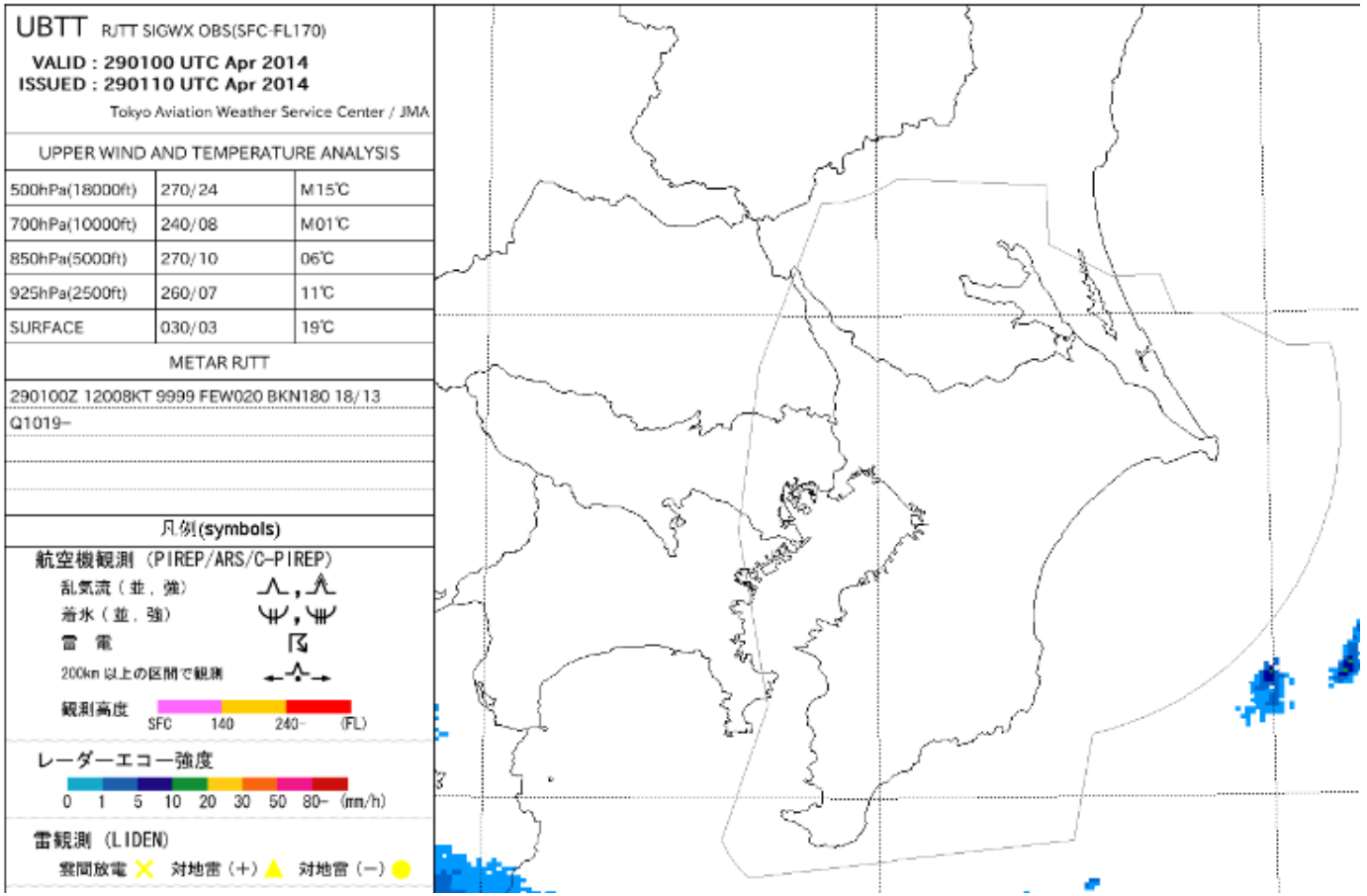


Fig.3

※The Chief Cabin Attendant fell down with her head toward the L2 side on the aft galley floor with the Cabin Attendant (L2), laying on top of each other, and confirmed that the passengers were sitting from there.

Fig. 4 Regional Significant Weather Prognostic Chart (Kanto) 1000JST APR 29



UBTT RJTT SIGWX OBS(SFC-FL170)

VALID : 290100 UTC Apr 2014
ISSUED : 290110 UTC Apr 2014

Tokyo Aviation Weather Service Center / JMA

UPPER WIND AND TEMPERATURE ANALYSIS

500hPa(18000ft)	270/24	M15℃
700hPa(10000ft)	240/08	M01℃
850hPa(5000ft)	270/10	06℃
925hPa(2500ft)	260/07	11℃
SURFACE	030/03	19℃

METAR RJTT

290100Z 12008KT 9999 FEW020 BKN180 18/13
Q1019=

凡例(symbols)

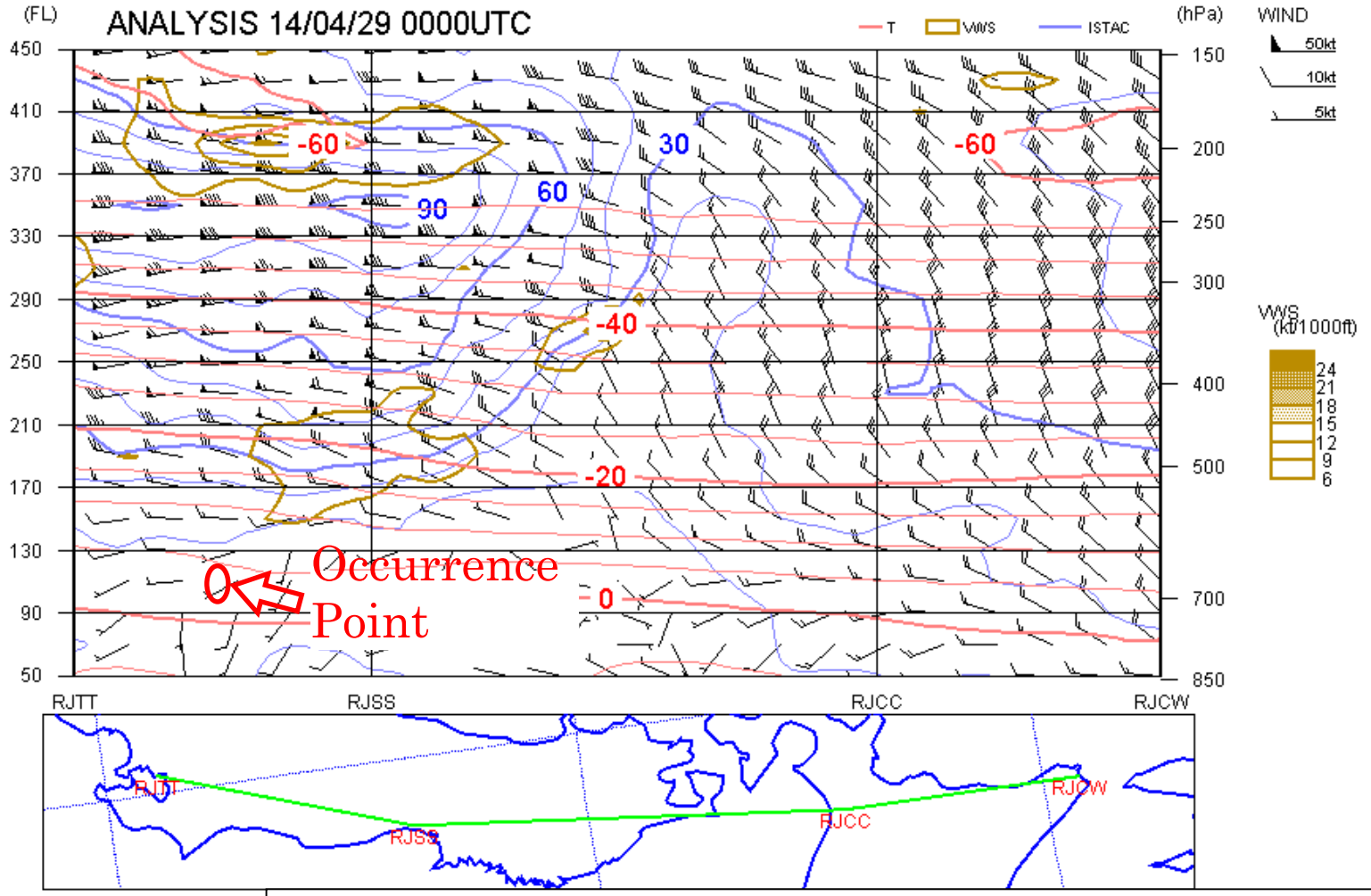
航空機観測 (PIREP/ARS/C-PIREP)
乱気流 (並 , 強)
着氷 (並 , 強)
雷 電
200km 以上の区間で観測
観測高度 SFC 140 240- (FL)

レーダーエコー強度
0 1 5 10 20 30 50 80- (mm/h)

雷観測 (LIDEN)
雲間放電 対地雷 (+) 対地雷 (−)

Fig. 5: Hourly Atmospheric Analysis Chart

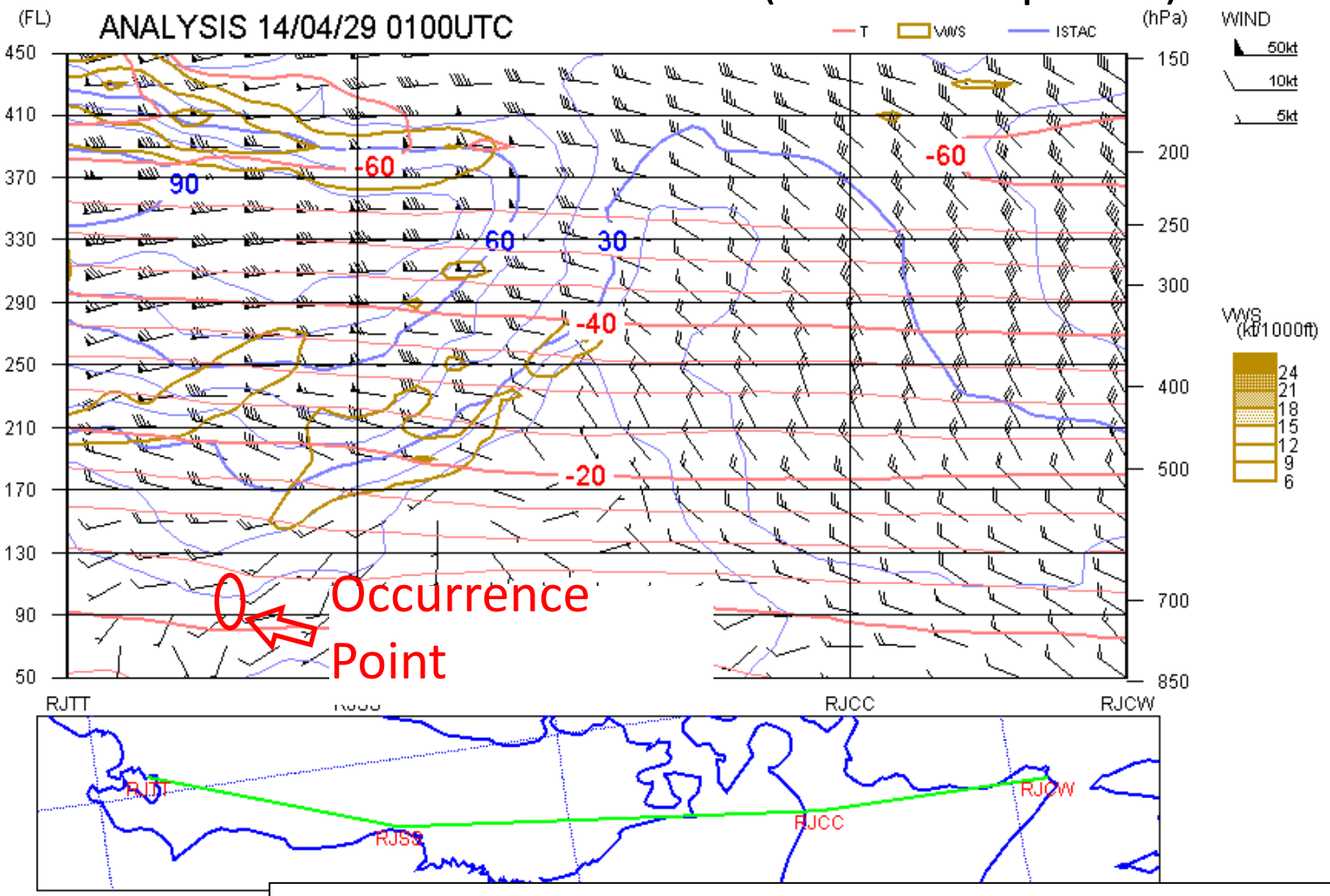
(09:00 on April 29)



Added to Japan Meteorological Agency material

Fig. 6: Hourly Atmospheric Analysis Chart

(10:00 on April 29)



Added to Japan Meteorological Agency material

Airbus A340-600
Maximum takeoff weight:
Approximately 368 tons
Wake turbulence classification:
Heavy aircraft

Embraer ERJ170-100STD
Maximum takeoff weight:
Approximately 35 tons
Wake turbulence classification:
Medium aircraft

Fig.7

- Radar Separations (Underlines in the table are added.)

In the case that the following aircraft flies at the same altitude or under 1,000 ft below the preceding aircraft and is situated in the same track as the preceding aircraft or passes in the 6 o'clock position of the preceding aircraft, the separations of more than the following figures should be set between the two aircraft. (JCAB)

Preceding aircraft	Following aircraft	Minimum separation
A380	Heavy aircraft (Excluding A380)	6 nm
	Medium aircraft	7 nm
	Light aircraft	8 nm
Heavy aircraft (Excluding A380)	Heavy aircraft (Excluding A380)	4 nm
	Medium aircraft	5 nm
	Light aircraft	6 nm
Medium aircraft	Light aircraft	5 nm

Fig.8

Wake Turbulence Category(JCAB)

Heavy (A340)	Maximum Takeoff Weight≧300000lbs(136ton)
Medium (E170)	300000lbs(136ton)＞Maximum Takeoff Weight＞15500lbs(7ton)
Light	15500lbs(7ton) ≧ Maximum Takeoff Weight

Aircraft Wake Turbulence (Excerpts from FAA Advisory Circular No.90-23G)

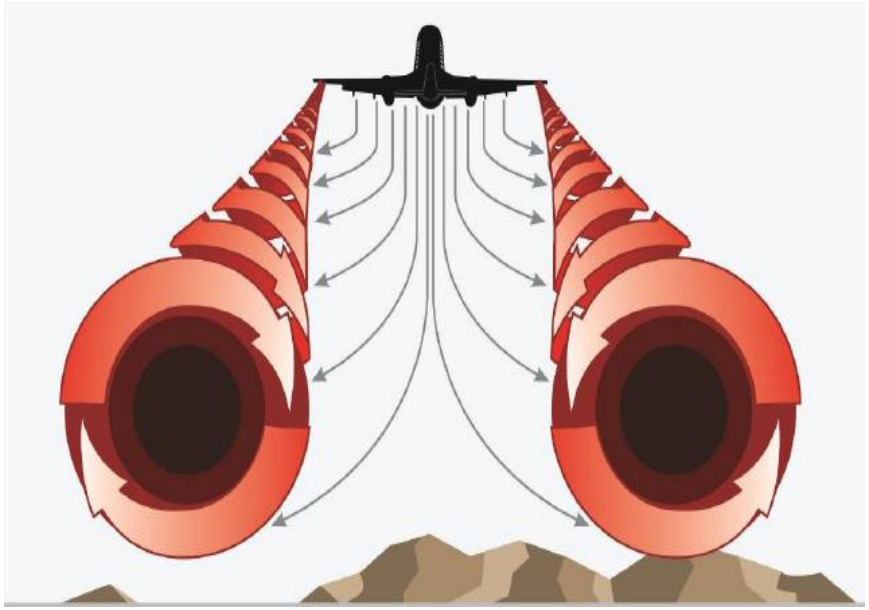


Fig.9 The Rollup Process

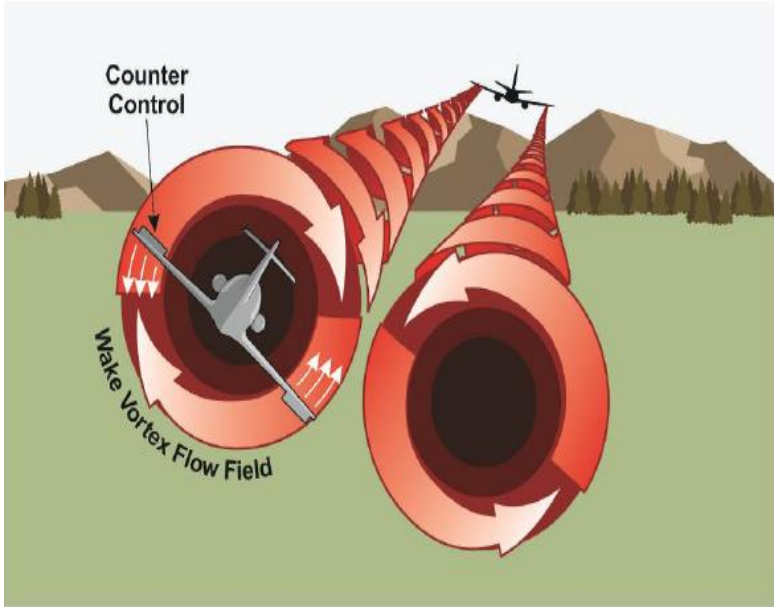


Fig.10 Induced Roll

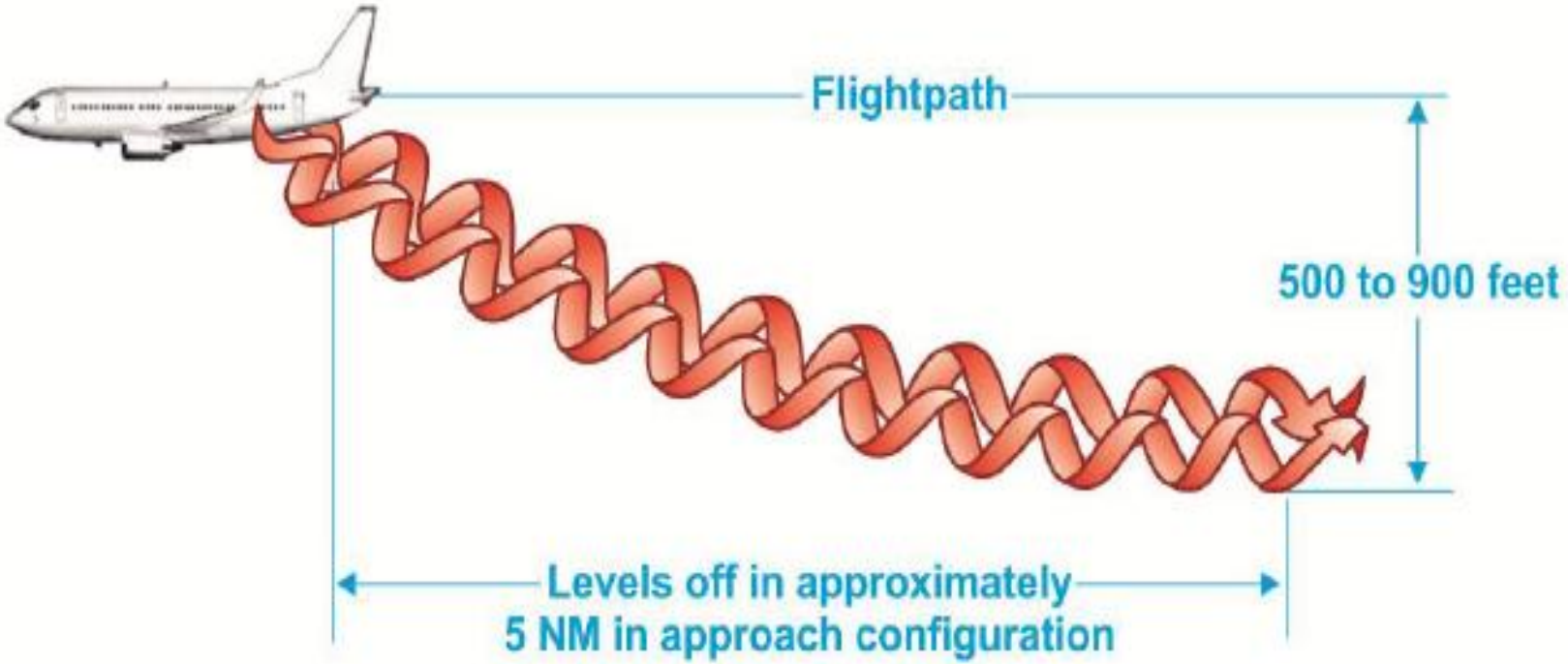


Fig.11 Descent of Vortices from Large Aircraft

<Probable Causes>

- It is probable that this accident occurred by the shaking of the Aircraft which encountered the strong wake turbulence from the Preceding Aircraft while the aircraft was descending; accordingly, two cabin attendants in the aft galley fell down and one of them was seriously injured..

It is probable that the strong wake turbulence that the Aircraft encountered persisted longer than usual because of the stable weather condition with calm wind.

- **Conclusion**
- The occurrence conditions and lessons learned for recurrence prevention from these accident investigations and other accident investigations are summarized below.
- **Occurrence conditions for aircraft shaking accidents**

◆Statistics on the accidents

- There were 40 accidents involving large aircraft, and 19 of these (nearly half) were aircraft shaking accidents.

◆Breakdown of the injured

- The number of people injured per aircraft shaking accident was approximately four times larger than other aircraft accidents involving large aircraft.
- The aft accounted for approximately 72% of the results for the position in aircraft where accidents occurred (excluding cases in which the position was unknown).

Categories of Causes

- **Not only environmental factors but also organizational and other factors contributed to accidents**

- In terms of categories of causes, seven cases were caused by environmental factors, five cases by environmental and organizational factors, four cases by human and environmental factors, and two cases by human, environmental, and organizational factors, indicating that not only environmental factors but also organizational and other factors contributed to accidents.

- **Lessons learned from the accident investigation**

Flight crew members

When aircraft is anticipated to encounter turbulence, the cockpit crew should turn on the seat belt sign at the earliest possible time so that FAs may have enough time to finish their duties before the encounter, because a lot of time is necessary for them to provide services to passengers, clean up and confirm the safety of passengers.

- Flight attendants

>When informed by the PIC of the possible turbulence and the need to be seated during the descent in the pre-flight briefing, FAs should plan to finish in-flight services well before the anticipated encounter with turbulence.

>Pay attention to the seatbelt sign to ensure that passengers properly wear their seatbelts.

>Remind passengers to carefully listen to in-flight announcements.

>Consider discontinuing or canceling in-flight services depending on the circumstances.

>When the seat belt sign is illuminated, FAs are required to urge non-seated passengers to be seated.

>Perform safety checks mainly by confirming their seat belt fastening manner.

- Other

>Some aircraft have taken safety measures such as installing handrails at locations where passengers pass by. Continue to examine the effectiveness of such measures and consider taking further safety measures to prevent accidents.

>Consider educating passengers on the response they should take in the event of the shaking of the aircraft.

A tip from Director for Analysis, Recommendation and Opinion

Aircraft shaking accidents occur when aircraft encounter sudden turbulence that is difficult for even aircraft operation and weather professionals to forecast.

- While there are hopes that technologies for forecasting turbulence will be further developed, because there is always the possibility of such accidents occurring on aircraft that operate day and night, both operators and passengers should prepare as best they can in order to prevent these accidents from occurring and to mitigate damage in the event of their occurrence.

- We hope that you act to protect yourself when boarding aircraft by properly fastening your seatbelt as much as possible, regardless of whether or not the seatbelt sign is on.

FASTEN SEAT BELT

Thank you for your patience

END