2. Statistics

There have been 19 aircraft shaking accidents, among which we have made accident investigation reports public for 18 cases and one accident is under investigation.

Shown below is the statistical information on the aircraft shaking accidents we have investigated.

* Figures 2 to 7, 12 to 14 show data for a total of 19 cases including accidents under investigation, and Figures 8 to 11, 15 show data for 18 cases whose investigation reports of accidents have been made public.

Statistics on the accidents

The changes in the number of accidents show that while there were some years without any accidents, the yearly average was 1.49 cases (one to three cases per year), with the most accidents occurring in 2012 (four cases). There were 40 aircraft accidents involving large aircraft, and 19 of these (nearly half) were aircraft shaking accidents. (See Figure 2)

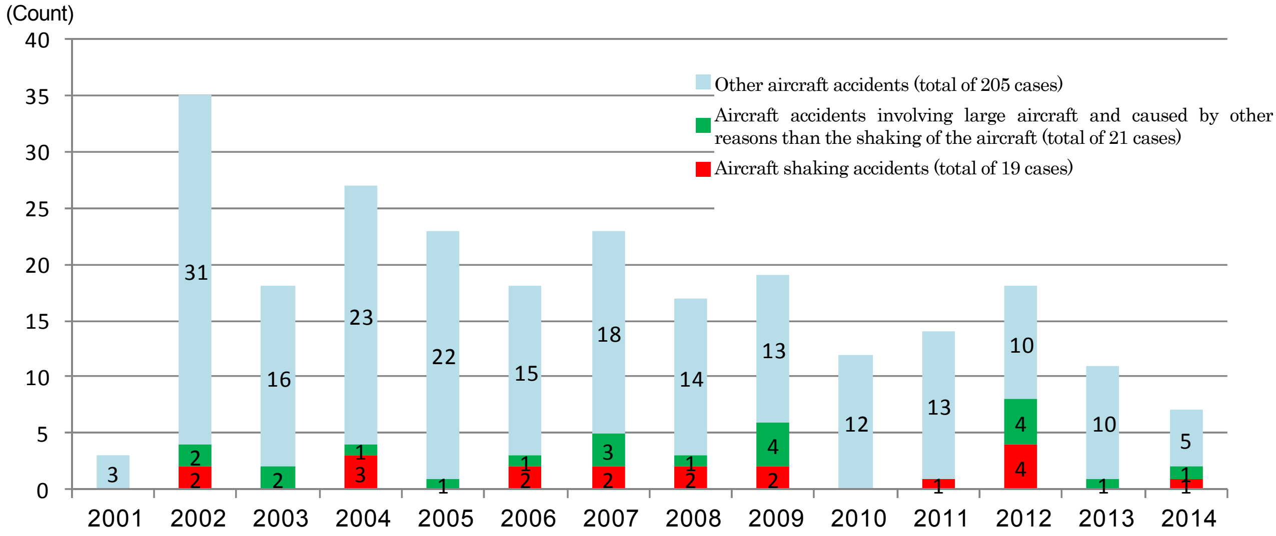


Figure 2　Changes in the number of accidents

Breakdown of accidents by site

The accident sites were widely distributed from the Tohoku to the Chugoku and Shikoku regions. Three cases occurred in the skies over Shimane Prefecture. (See Figure 3)

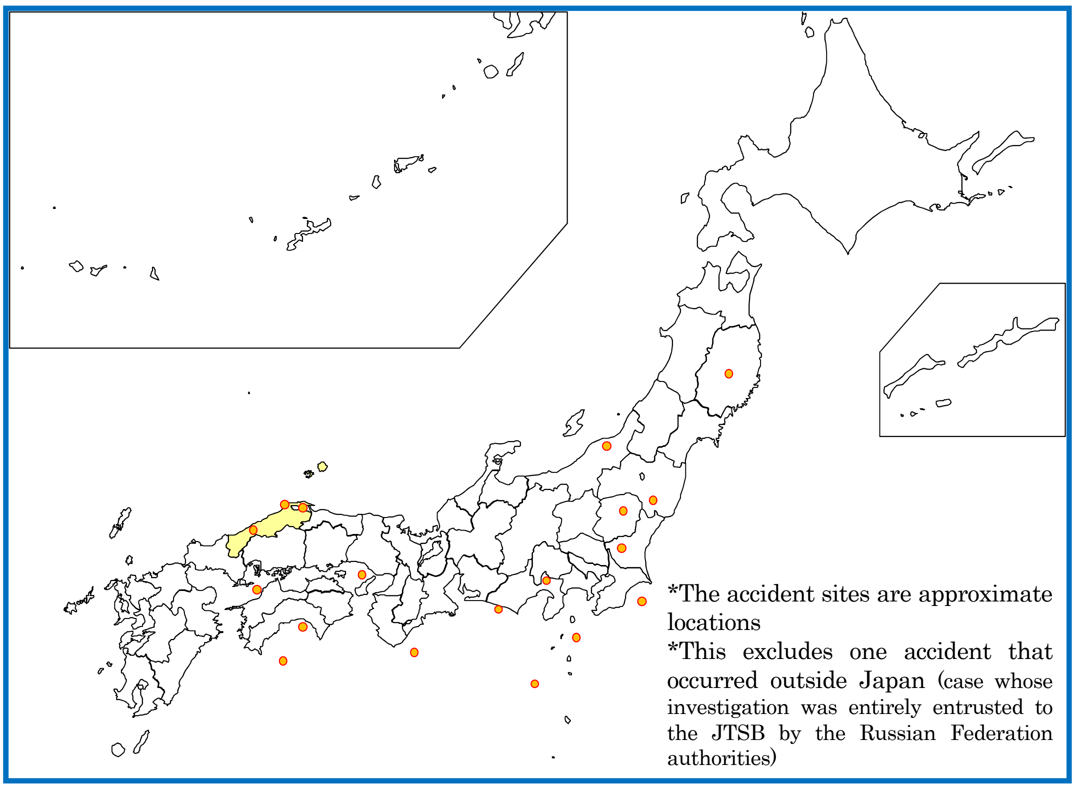


Figure 3　Breakdown of accident sites

Breakdown of the injuried

The breakdown of the number of injuries shows that there was a total of 111 people injured in the 19 aircraft shaking accidents, with 29 people suffering serious injuries and 82 people suffering slight injuries, and that there were about 5.8 people injured per accident. Meanwhile, there was a total of 32 people injured in the 21 aircraft accidents involving large aircraft and caused by other reasons than the shaking of the aircraft, with an average of 1.5 people injured per accident. This indicates that the injury occurrence rate is higher for aircraft shaking accidents than other accidents. During 2002 and 2009 there were cases in which one accident resulted in nearly 40 people injured. (See Figure 4)

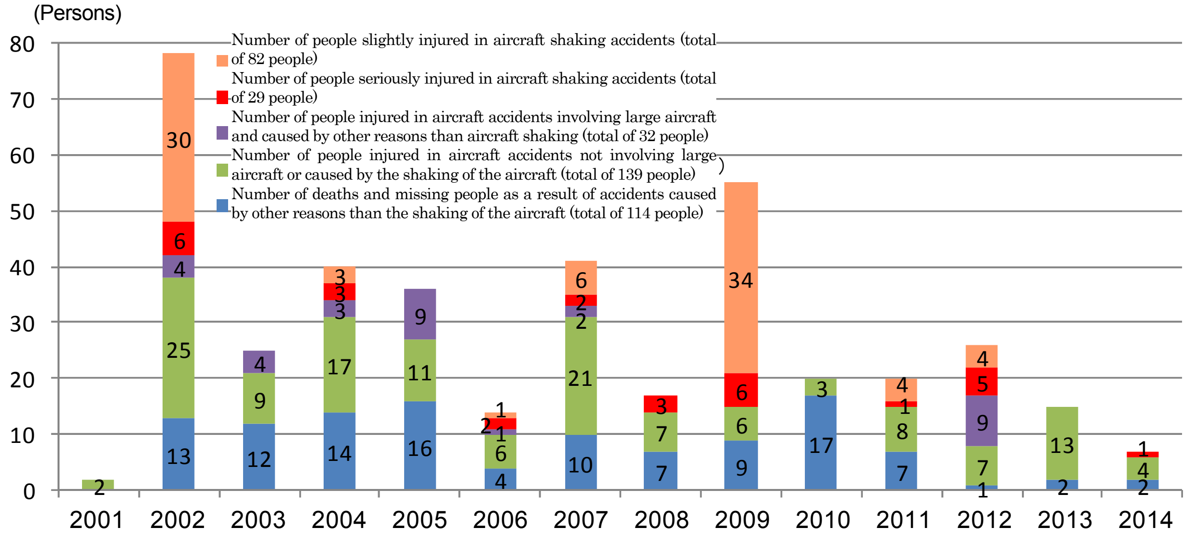


Figure 4 Changes in the number of injuries

Looking at attributes of people injured, we can see that 72 passengers were injured (18 seriously injured, 54 slightly injured) and 39 cabin attendants were injured (11 seriously injured, 28 slightly injured). It is believed that the number of injuries for cabin attendants is high because they often stand while working. (See Figure 5)

Looking at the positions in the aircraft where injuries occurred, we can see that out of the 100 cases for which the position was ascertained, the most occurred in the aft (72), followed by the center (19) and forward (9). There were cases that suggested the possibility that there were many injuries in the aft because negative vertical acceleration affected more on the aft than on the foreside when the pitch angle (*1) of the aircraft changed rapidly. (See Figure 6) (*1: This refers to the vertical inclination angle of the nose of the aircraft. The nose rises when positive and falls when negative.)

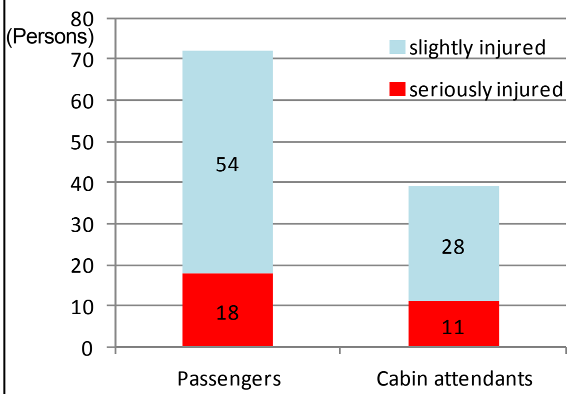


Figure 5 Attributes of people injured

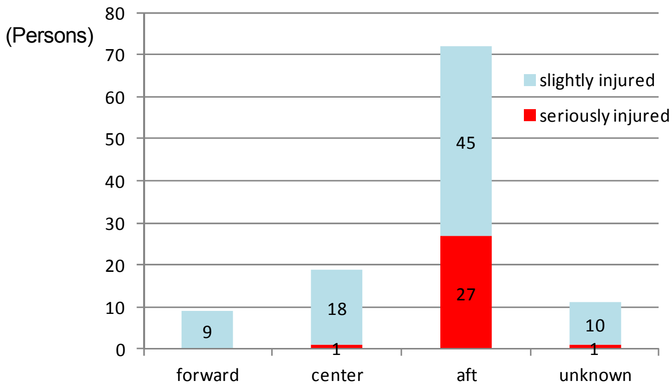


Figure 6 Positions of people injured in aircraft

Among the 28 seriously injured people for which the injury details have been revealed, 23 people suffered fractures (cervical, collarbone, ribs, thoracic vertebrae, sternum, lumbar spine, fibula, ankle, etc.), followed by concussions (brain and cervical vertebra), bruises (face, abdomen), and burns (right upper extremity, abdomen, etc. (suffered by an infant)). (See Figure 7)

In terms of situations leading to injuries, there were cases of the shaking of the aircraft causing people to fly up in the air and hit their heads on the ceiling, to fall on the floor after flying up in the air, to lose their balance while walking, and to get sprayed with hot coffee.

In terms of how people who suffered injuries were acting prior to the shaking of the aircraft, passengers were seated or using the lavatory (fastening or not fastening a seat belt), while cabin attendants were conducting activities such as preparations for in-flight service or cleaning. While injuries to the head or cervical vertebra were not observed among people fastening seat belts, there were cases of serious injuries even among people fastening seat belts due to severe horizontal shaking.

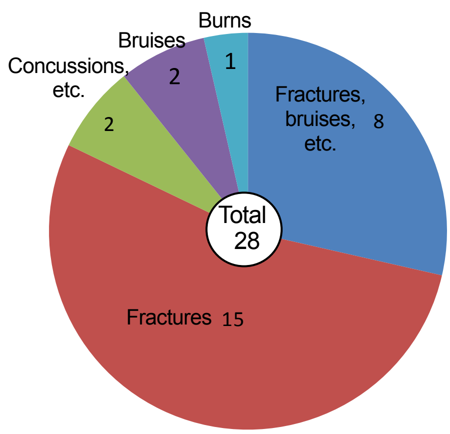


Figure 7 Injuries of people with serious injuries

Turbulence and vertical wind shear

○ Turbulence is classified as light, moderate, or severe as shown in Table 1 depending on the magnitude of the shaking as felt by the pilot.

There are three types of turbulence: INC TURB (in-cloud turbulence) that occurs in clouds such as cumulonimbus clouds, CAT (clear-air turbulence) that occurs in clear air without clouds (excluding high level clouds), and MTW (mountain wave) that occurs as a result of winds arising from the leeward side of mountains.

Table 1. Turbulence Intensity

Turbulence intensity	Feeling
Light	Occupants may feel some shaking, but it is not enough to fly up from the seat
Moderate	Conditions in which moderate changes in aircraft attitude and/or attitude may occur but the aircraft remains in positive control at all times. Usually, small variations in airspped. Difficulty in walking. Occupants feel strain against seat belts. Loose objects move about.
Severe	Conditions in which abrupt changes in aircraft attitude and/or attitude occur; aircraft may be out of control for short periods. Usually, large variations in airspeed. Occupants are forced violently against seat belts. Loose objects are tossed about.

By ICAO (International Civil Aviation Organization) Aeronautical Board

From *Haneda Airport Weather Topics* (Issue nine) (http://www.jma-net.go.jp/haneda-airport/)

○ 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 (Extracted from notes to an Aircraft Accident Investigation Report).

Turbulence forecasts

In terms of whether it was possible to forecast the turbulence in the aircraft before occurrence, it was possible to forecast the turbulence in seven cases and impossible to do so in 11 cases. While there were cases of it being difficult to forecast the signs of turbulence, there were also cases of not being able to detect cumulonimbus clouds due to the weather radar being off. (See Figure 8)

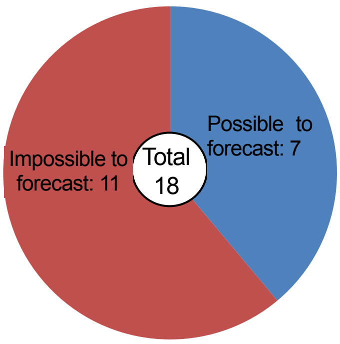


Figure 8 Turbulence forecasts

Breakdown of weather

In terms of the principal weather conditions at the time of accident occurrence, there were eight cases of INC TURB, six cases of wind shear (*2), and four cases of CAT. (See Figure 10)

(*2: Differences in wind level, in which there are differences in wind direction or velocity in horizontal or vertical directions.)

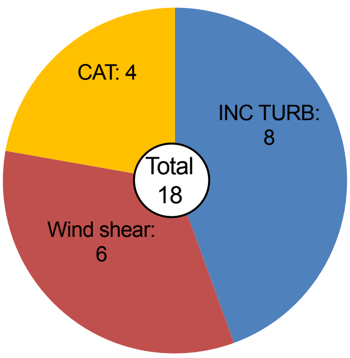


Figure 10 Breakdown of weather

Illumination of the seatbelt sign at the time of accident occurrence

In terms of the seatbelt sign at the time of accident occurrence, there were nine cases of it being lit and nine cases of it not being lit.

There were various cases of it being lit as the aircraft were in the approach phase, not being lit as the air current was stable, and being lit so immediately before the shaking of the aircraft that there was not sufficient time to fasten seat belts resulting in injuries. (See Figure 9)

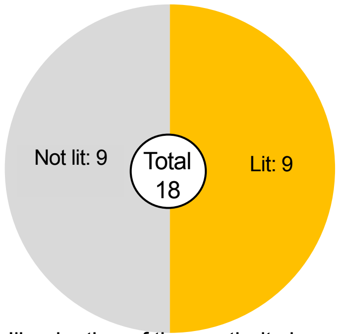
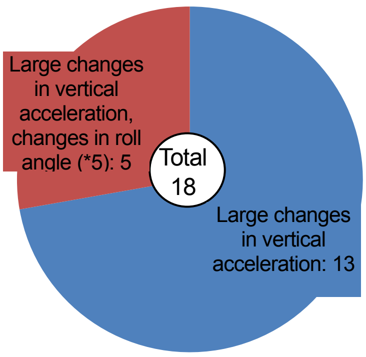


Figure 9 Illumination of the seatbelt sign at the time of accident occurrence

Changes to aircraft at the time of accident occurrence

In terms of changes to aircraft at the time of accident occurrence, there were large changes in vertical acceleration in 18 cases, with the majority consisting of vertical changes in the pitch angle, and five cases of rolling (*3) being combined with pitching (*4). (See Figure 11)



(*3: The tilting of the aircraft to the left or right, horizontal shaking.)

(*4. The moving of the aircraft's nose up or down, vertical shaking)

(*5: The left or right inclination angle of the aircraft)

Figure 11 Changes to aircraft at the time of accident occurrence

Breakdown of accidents by altitude

The breakdown of accidents by altitude shows that a large number occurred at 20,000ft or above, with the most accidents occurring at 30,000ft or above (nine cases), followed by 20,000ft to 29,999ft (six cases). (See Figure 12)

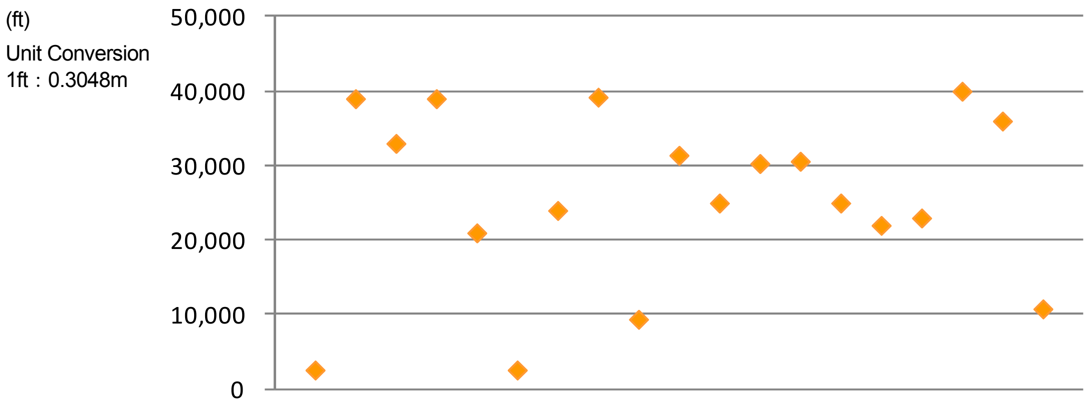


Figure 12　Breakdown of accidents by altitude

Breakdown of accidents by month

The breakdown of accidents by month indicates that accidents occurred throughout the year regardless of the season, with the most accidents occurring during July (four cases), and one to two accidents occurring in the other months. (See Figure 13)

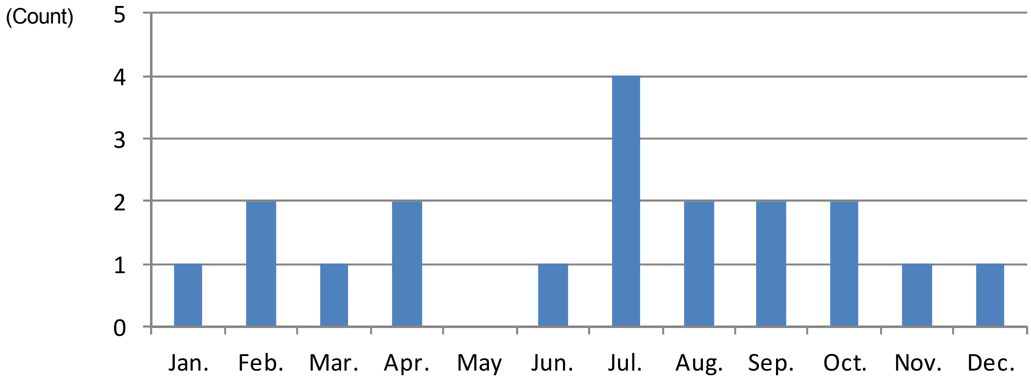


Figure 13　Number of accidents by month

Breakdown of accidents by the time of day

The breakdown of accidents by the time of day reveals that while accidents occurred at the highest frequency from 15:00 to 16:00 (three cases), one to two accidents occurred per hour from 8:00 to 22:00. (See Figure 14)

Looking at the relationship between the time of accident occurrence and the time of take-off and landing, we can see that nine accidents occurred within 30 minutes before or after take-off and landing, that six accidents occurred over 30 minutes before or after take-off and landing, and that there were four cases without information on this point.

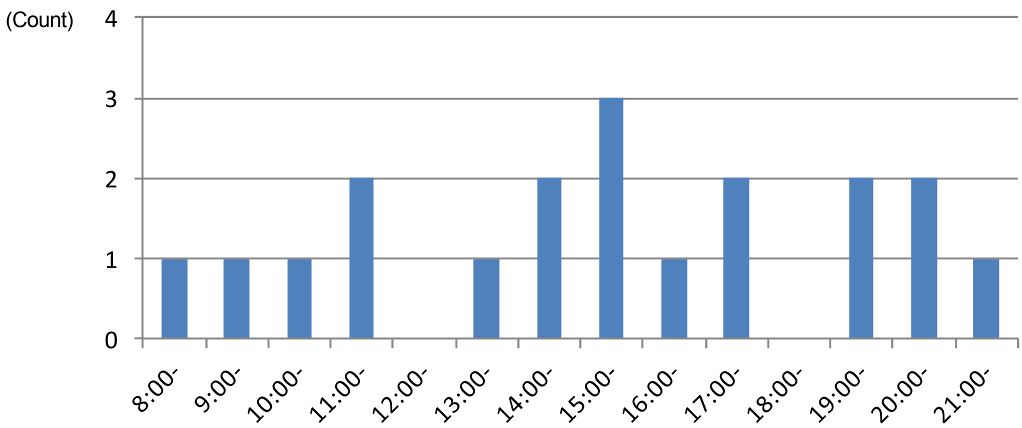


Figure 14　Number of accidents by the time of day

Categories of Causes

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

When the causes of accidents described in Aircraft Accident Investigation Reports are classified into the categories of human factors, mechanical factors, environmental factors, and organizational factors, 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. This indicates that not only environmental factors but also organizational and other factors contributed to accidents. (See Figure 15)

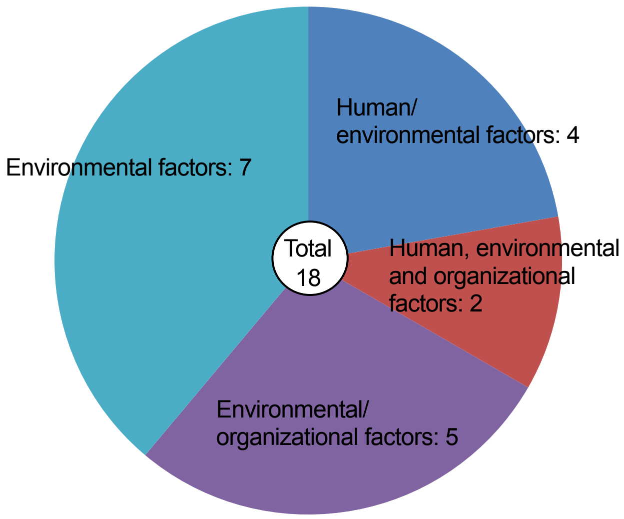


Figure 15 Breakdown of cause categories

A close analysis of these causes reveals that environmental factors consisted of aircraft shaking intensely as a result of weather conditions.

Organizational factors consisted of cases where the latest information were not provided to the flight in pre-flight briefings and when in-flight and where crew members information were not shared between flight crew members and cabin attendants when in-flight.

Human factors included cases where the aircraft weather radar was not used properly and which are related to aircraft piloting when the aircraft was affected by weather conditions.

Examples 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 aircraft weather radar was off

Examples of environmental factors

- ○ Active cumulonimbus cloud
- ○ Local turbulence occurring within stratus clouds
- ○ Turbulence not forecast due to fine weather
- ○ Frontal zone occurring on the north side of a typhoon
- ○ Large vertical wind shear

Examples of organizational factors

- ○ Cabin attendants were not warned of the large attitude changes of the aircraft such as turning while there was shaking.
- ○ Enough information was not provided by operation support staff.
- ○ The TB4 (*7) information input in J-PIREP (*6) was not communicated from the OCC (operation control center) to the airport flight division or the aircraft
- ○ The OCC did not provide the updated information to the aircraft in-flight

(*6: A system for entering and displaying turbulence information from pilot reports)

(*7: The intensity of turbulence is expressed on a scale of TB 0 to 7)

Fastening seat belts

The website of each airline informs passengers that they should always fasten their seatbelt in preparation for sudden turbulence even if the seatbelt sign is turn off.

Because your body may be tossed around or intensely shaken by the shaking of the aircraft if your seat belt is loose, it is important to fasten your seatbelt firmly and low.

Because you may fall or fly up into the air when encountering sudden turbulence, you should support your body immediately in these situations by sitting down in an empty seat and tightening your seat belt or lowering your body and holding onto a fixed seat. Moreover, you may hold on to handles near or within the lavatory if available.