AI2014-4

AIRCRAFT SERIOUS INCIDENT
INVESTIGATION REPORT

AIR NIPPON CO., LTD.
J A 1 6 A N

September 25, 2014

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 prevent future accidents and incidents. 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 SERIOUS INCIDENT
INVESTIGATION REPORT

AIR NIPPON CO., LTD.
BOEING 737-700, JA16AN
NOSEDIVE FROM UPSET (LOC-I)
AT AN ALTITUDE OF 41,000 FT, APPROX. 69NM EAST OF KUSHIMOTO, WAKAYAMA PREFECTURE, JAPAN
AROUND 22:49 JST, SEPTEMBER 6, 2011

September 19, 2014

Adopted by the Japan Transport Safety Board

Chairman	Norihiro Goto
Member	Shinsuke Endoh
Member	Toshiyuki Ishikawa
Member	Sadao Tamura
Member	Yuki Shuto
Member	Kenji Tanaka

SYNOPSIS

<Summary of the Incident>

On September 6 (Tuesday) 2011, a Boeing 737-700, registered JA16AN, operated by Air Nippon Co., Ltd., nosedived after having an unusual attitude (upset) at around 22:49 Japan Standard Time (JST: UTC+9hr, unless otherwise stated all times are indicated in JST) at an altitude of 41,000 ft about 69 nm east of Kushimoto while flying from Naha Airport to Tokyo International Airport as the scheduled flight 140 of the All Nippon Airways Co., Ltd.

There were 117 people on board the aircraft, consisting of the captain, the first officer, three cabin attendants and 112 passengers. Of these people, two cabin attendants sustained slight injuries.

There was no damage to the aircraft.

<Probable Causes>

It is highly probable that this serious incident occurred in the following circumstances: During the flight, the first officer erroneously operated the rudder trim control while having an intention of operating the switch for the door lock control in order to let the captain reenter the cockpit. The aircraft attitude became unusual beyond a threshold for maintaining the aircraft attitude under the autopilot control. The first officer's recognition of the unusual situation was delayed and his subsequent recovery operations were partially inappropriate or insufficient; therefore, the aircraft attitude became even more unusual, causing the aircraft to lose its lifting force and went into nosedive. This led to a situation which is equivalent to "a case where aircraft operation is impeded."

It is probable that the followings contributed to the first officer's erroneous operation of the rudder trim control while having an intention of operating the door lock control; he had not been fully corrected his memories of operation about the door lock control of the Boeing 737-500 on which he was previously on duty; the door lock control of the Boeing 737-500 series aircraft was similar to the rudder trim control of the Boeing 737-700 series aircraft in their placement, shape, size and operability. It is somewhat likely that his memories of operation about the switch for the door lock control of the Boeing 737-500 aircraft had not been fully corrected because he failed to be fully accustomed with the change in the location of the switch for the door lock control. It is somewhat likely that this resulted from lack of effectiveness in the current system for determining the differences training contents and its check method, under which the Air Nippon Co., Ltd. and other airlines considered and adopted specific training programs to train pilots about how to operate the flight deck switches when their locations changed and the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism reviewed and approved them. It is probable that the first officer's failure to properly manage tasks contributed to his erroneous operation of the rudder trim control.

It is somewhat likely that the similarities between the switches for the door lock control and the rudder trim control in their operability contributed to the delay in his recognition of the erroneous operation. Moreover, he was excessively dependent on autopilot flight and he failed to be fully aware of monitoring the flight condition.

It is somewhat likely that the first officer's recovery operations were partially inappropriate or insufficient because he was startled and confused on the occurrence of an unexpected unusual situation in which the stick shaker was activated during the upset recovery maneuver. It is somewhat likely that the followings contributed to his startle and confusion: he had not received upset recovery training accompanied with a stall warning and in unexpected situations, thereby he lacked the experience of performing duties in such situations before the serious incident, and he had not received upset recovery training at a high altitude.

<Recommendations>

1. Recommendations to All Nippon Airways

The Japan Transport Safety Board recommends All Nippon Airways, which has taken over the operational duties for Boeing 737 series aircraft from Air Nippon Co., Ltd. to take the following measures:

- Thorough implementation of basic compliance matters for cases when the aircraft is operated by a single pilot and training to this end
- Implementation of high altitude upset recovery training accompanied with stall warning and other events

2. Recommendations to the Minister of Land, Infrastructure, Transport and Tourism

The Japan Transport Safety Board recommends the Minister of Land, Infrastructure, Transport and Tourism to take the following measures:

- Guidance for air carriers for implementation of upset recovery training

3. Safety Recommendations to Federal Aviation Administration (FAA)

The Japan Transport Safety Board recommends the Federal Aviation Administration (FAA) of the United States of America to urge the aircraft design and manufacturing organization, (the Boeing Company,) to take the following measures:

- Studies about the necessity of reducing or eliminating similarities of the switch for the door lock control and the rudder trim control for the Boeing 737 series aircraft

Abbreviations used in this report are as follows:

AC	: Advisory Circular
ACMS	: Aircraft Condition Monitoring System
AE Panel	: Aft Electronic Panel
AOA	: Angle of Attack
AOM	: Airplane Operations Manual
ATC	: Air Traffic Controller
CA	: Cabin Attendant
CCW	: Counterclockwise
CDU	: Control Display Unit
CVR	: Cockpit Voice Recorder
CRM	: Crew Resource Management
CW	: Clockwise
CWS	: Control Wheel Steering
DFDR	: Digital Flight Data Recorder
EASA	: European Aviation Safety Agency
FAA	: Federal Aviation Administration
FAR	: Federal Aviation Regulation
FL	: Flight Level
FMC	: Flight Management Computer
FO	: First Officer
FRMS	: Fatigue Risk Management Systems
FSB	: Flight Standardization Board
FSTD	: Flight Simulation Training Device
JTSB	: Japan Transport Safety Board
GPWS	: Ground Proximity Warning System
ICAO	: International Civil Aviation Organization
LNAV	: Lateral Navigation
LOFT	: Line Oriented Flight Training
MAC	: Mean Aerodynamic Chord
MACH	: Mach Number
ODF	: Operator Differences Requirements
OM	: Operations Manual
PF	: Pilot Flying
PFD	: Primary Flight Display
PIC	: Pilot in Command
PM	: Pilot Monitoring
QAR	: Quick Access Recorder
SAFO	: Safety Alerts for Operators
STC	: Supplemental Type Certificate
TC	: Type Certification
TSI	: Technical Service Information
URT	: Upset Recovery Training
V_D/M_D	: Design Dive Speed/ Corresponding Mach Number
VHF	: Very High Frequency communication

V_{MO}/M_{MO}	: Maximum Operating Limit Speed/ Corresponding Mach Number
VNAV	: Vertical Navigation
VOR/DME	: VHF Omnidirectional Radio range/ Distance Measuring Equipment
VORTAC	: VOR and Tactical Air Navigation system

Unit Conversion Table

1 ft	: 0.3048 m
1 in	: 0.0254 m
1 kt	: 1.852 km/h
1 lb	: 0.4536 kg
1 nm	: 1,852 m

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1. PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Serious Incident

The occurrence covered by this report falls under the category of Clause 16, Article 166-4 of the Ordinance for Enforcement of the Civil Aeronautics Act of Japan as the case equivalent to "Case where aircraft operation is impeded by an encounter with air disturbance or other abnormal weather conditions, failure in aircraft equipment, or a flight at a speed exceeding the airspeed limit, limited load factor limit or operating altitude limit" as stipulated in Clause 13 of the same Article, and is classified as a serious incident.

On September 6 (Tuesday) 2011, a Boeing 737-700, registered JA16AN, operated by Air Nippon Co., Ltd., nosedived after having an unusual attitude (upset) at around 22:49 Japan Standard Time (JST: UTC+9hr, unless otherwise stated all times are indicated in JST) at an altitude of 41,000 ft about 69 nm east of Kushimoto while flying from Naha Airport to Tokyo International Airport as the scheduled flight 140 of the All Nippon Airways.

There were 117 people on board the aircraft, consisting of the captain (hereinafter referred to as "the PIC"), the first officer (hereinafter referred to as "the FO"), three cabin attendants (hereinafter referred to as "the CAs") and 112 passengers (including one infant). Of these people, two cabin attendants sustained slight injuries.

There was no damage to the aircraft.

(See Figure 1 Estimated Flight Route)

1.2 Outline of the Serious Incident Investigation

1.2.1 Investigation Organization

On September 7, 2011, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and two investigators to investigate this serious incident.

1.2.2 Representatives from Foreign Authorities

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

1.2.3 Implementation of the Investigation

September 8 and 9, 2011	Investigation and interviews with operator
September 12, 2011	Interviews
September 28, 2011	Publication of the Investigation Progress Report
October 28, 2011	Aircraft investigation, investigation and interviews with operator
November 9, 2011	Interviews
December 7, 2011	Flight simulator-based examination to confirm aircraft movement Investigation with operator
January 19, 2012	Investigation with operator

1.2.4 Publication of the Interim Report

On August 31, 2012, the JTSB submitted the Interim Report to the Minister of Land, Infrastructure, Transport and Tourism, and published that based on the fact-finding investigation up to that date.

1.2.5 Comments from Parties Relevant to the Cause of the Serious Incident

Comments on draft report were invited from parties relevant to the cause of the serious incident.

1.2.6 Comments from the Relevant States

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

2. FACTUAL INFORMATION

2.1 History of the Flight

At 21:15 on September 6, 2011, a Boeing 737-700, registered JA16AN (hereinafter referred to as "the Aircraft"), operated by Air Nippon Co., Ltd. (hereinafter referred to as "the Company"), took off from Naha Airport for Tokyo International Airport.

The outline of the flight plan was as follows:

Flight rule:	Instrument flight rule (IFR)
Departure aerodrome:	Naha Airport
Estimated off-block time:	21:10
Cruising speed:	451 kt
Cruising altitude:	FL*1 410
Route:	ALC (Amami VORTAC) – POMAS – Y574 – SHIBK – Y57 – JERID – Y571 – SOPHY – Y52 – CHALK – Y21 – NJC (Niijima VORTAC) – Y213 – PQE (Tateyama VOR/DME) – Y108 – KAIHO
Destination aerodrome:	Tokyo International Airport
Estimated elapsed time:	2 hours and 4 minutes.
Fuel load expressed in endurance:	4 hours and 4 minutes.
Alternate aerodrome:	Chubu International Airport

In the cockpit, the PIC sat in the left seat as the PF (pilot flying: pilot mainly in charge of flying) and the FO in the right seat as the PM (pilot monitoring: pilot mainly in charge of duties other than flying).

Just before the occurrence of this serious incident, the Aircraft was flying toward SAKAK (the point shown in the right upper hand corner of the enlargement of Figure 1) at FL 410 and Mach 0.73 by autopilot (LNAV/VNAV mode*2)

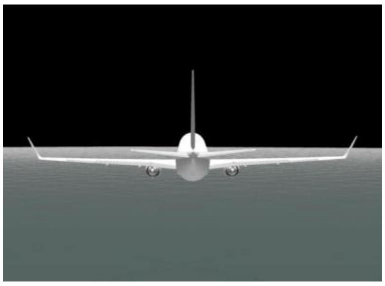
2.1.1 History of the Flight Based on DFDR Records and Others

*1 "FL" means a flight altitude used in aviation and following three-digit figures denote the altitude in a unit of 100 ft. This is a pressure altitude obtained by setting a pressure altimeter by using the average sea surface atmospheric pressure (1,013.2 hPa) under the international standard atmosphere. In general, this does not agree to the true altitude. In Japan, this is used for flight altitudes of 14,000 ft or higher from the average sea surface. FL 410 means a flight altitude of 41,000 ft from the average sea surface.

*2 "LNAV/VNAV mode" is one of operational modes for autopilot. The LNAV mode is designed for a lateral aircraft navigation and controls the roll angle to keep a route set into the FMC (Flight Management Computer). The VNAV mode is designed for a vertical aircraft navigation and controls the pitch angle and the auto-throttle system while targeting an altitude and a speed set into the FMC.

According to the records of the digital flight data recorder (hereinafter referred to as "the DFDR") (Figures 2 to 5), the air traffic control communication records (Attachment 1), the statements from flight crewmembers, the records of the aircraft's QAR*3 of the Aircraft and others, the history of the flight was summarized as below.

Remarks in the brackets [ ] in this section denote event identification signs (A to Z, a to d, and GPWS) and the number of a Figure in which the event involved is described. The outline of each event can be found in a List of Events of Attached table at the end of this report. The images of the Aircraft and the control wheel and column are those reproduced from the DFDR records by using software designed for this purpose. The neutral positions of the control wheel (hereinafter referred to as "the Wheel") and the control column (hereinafter referred to as "the Column") (the positions where the DFDR values for the control wheel position and the control column position come to 0°) were shown as shadows against the background of the images of the Wheel and the Column. (See Attachment 2 for the operation of the aircraft involved, the name and action of each part and the aircraft movement.) In addition, the speeds, the angles and other descriptions in this report are based on figures recorded in the DFDR with a certain interval, unless otherwise mentioned. Therefore, the maximum value (the minimum value) on the records does not necessarily correspond to the actual maximum value (the minimum value).


The Aircraft in normal flight

22:46:42 The PIC left the cockpit to use the restroom. [A: Figures 1 and 2]

22:48:04 The FO received instructions from an air traffic controller in charge of the Aircraft (hereinafter referred to "the Controller") of the Tokyo Area Control Center to change the route and proceed direct to PQE (Tateyama VOR/DME).

22:48:08 The FO read back the Controller's instructions. [B: Figures 1 and 2]
After reading back the instructions, he started to enter the data into the CDU*4 for changing the route (diverting to the right by about 3°) (See Photo 2 for the location of the CDU) While the FO was entering the data for changing the route, the PIC signaled for reentering the cockpit

22:48:25 The FO executed the job to change the route on the CDU. [C: Figures 1 and 2]
With the operation to change the route executed on LNAV, the ailerons moved and in response to this movement, the Wheel rotated to about -10° clockwise (hereinafter referred to as "CW")(In this report, the Wheel rotation of CW direction is described in

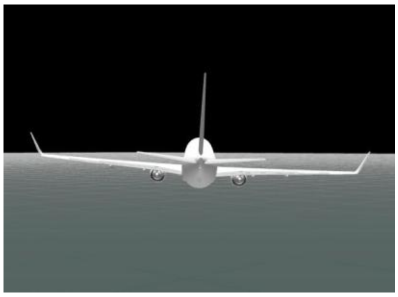

CDU operation (demonstration)

*3 "QAR", which stands for quick access recorder, is a device voluntarily installed on aircraft by air carriers for the purpose of achieving a higher level of quality control and safety management. Various kinds of flight data can be recorded on the device. Most models have data recorded on removable media such as optical disks and semiconductor memories and therefore, the device can be removed from an aircraft after a series of flights.

*4 "CDU", which stands for Control Display Unit, is a device for setting the desired route, altitude, speed and others to the FMC which controls autopilot and auto-throttle. Commands for the desired route and others are entered into the FMC and then executed.

Wheel at about -10°

negative value.). As a result, the Aircraft rolled by about 3° to the right. While the Wheel was rotating, there was no control wheel force applied. [C: Figure 3]



Roll angle of about 3° to the right

22:48:28 The rudder trim control*5 (hereinafter referred to as "the Rudder Trim SW") was rotated counterclockwise (hereinafter referred to as "CCW") twice.

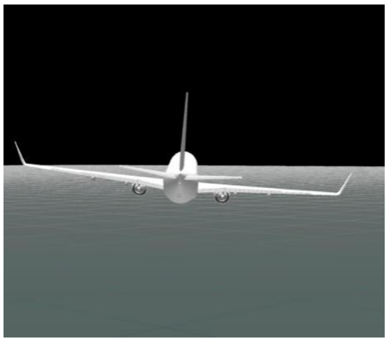
[D: Figures 1 to 5] (Photo 2)

During a total of about 14 seconds -- 6 seconds in the first operation in which the control was maintained in the position LEFT, pause for 2 seconds in which it came to the neutral position, and 6 seconds in the second operation, the rudder moved to the left and shifted to about -5°.

Rudder Trim SW operation (demonstration)

In response to the shift of the rudder, the left side rudder pedal moved about 2° (18mm) in the direction of forward and the right side rudder pedal moved the same distance in the direction backward.

While the rudder pedals were moving, rudder pedal force was applied by about 8 lb to the right side pedal. [D: Figure 5]



Attitude just after Rudder Trim SW was operated for first time

22:48:35 The ailerons moved by an autopilot command under LNAV to correct a move of deviating to the left from the route set to the FMC. In response to the movement, the Wheel rotated further CW to about -22°. While the Wheel was rotating, there was no control wheel force applied. [E: Figure 3]

Wheel at about -22°

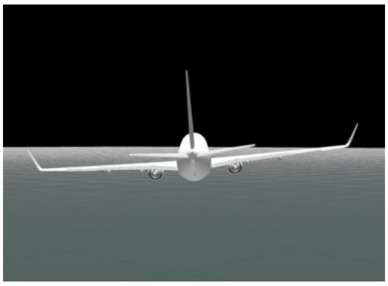
As the rudder moved to the left, the direction of the nose began to turn to left against the direction of movement. As a result, the lift of the right wing increased, while the lift of the left wing decreased, and then, the Aircraft began to roll to the left.

22:48:36 The Aircraft rolled to the left beyond level. As the autopilot control authority

*5 "rudder trim control" is a switch to be operated to shift the rudder neutral position either to the left or to the right. Without operating the rudder pedal, the control can shift the rudder position. This is designed to reduce the pilot workload when they continuously operate the rudder pedal. The system is used on such occasions as a case with an engine on one side out, in which the moment that causes the aircraft's nose to veer is continuously applied.

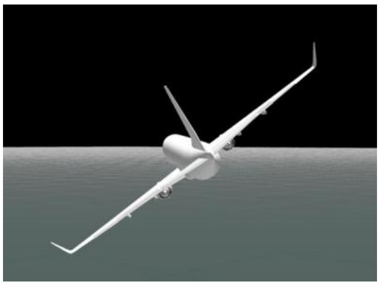
under the LNAV correction reached a limit. And the ailerons did not move further, the Wheel did not rotate any further than about -22°. [F: Figure 3]

22:48:40 The elevators moved by an autopilot command under VNAV to correct a nose low movement in the vertical direction following the roll of the aircraft with the rudder moved to the left. In response to the rudder movement, the Column shifted backward (After: Pull) to about +2°. While the Column was shifting, there was no control column force applied. [G: Figure 4]



Roll to left beyond level

22:48:43 Following the decrease in the aircraft speed, the throttle lever position began to move gradually shift in the direction of increasing under an auto-throttle*[6] command under a VNAV correction in order to maintain the speed at Mach 0.73 (hereinafter described like "M 0.73") [H: Figure 4]



22:48:43

22:48:43 The bank angle alert*[7] (the aural alert "Bank Angle, Bank Angle") was activated (through 48:46) [GPWS: Figure 3]

22:48:45 The FO turned the Wheel CW to recover the attitude.

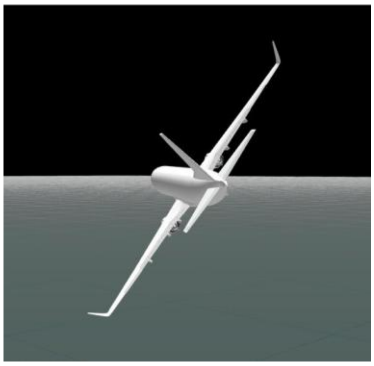
Wheel at about -97°

The Wheel momentarily rotated CCW and then, rotated CW to about -97°. The control wheel force was applied CCW momentarily, just after that, the force was applied CW to a maximum about 39 lbs. [I: Figure 3]

Following this operation, the LNAV mode on autopilot was disengaged (referred to as "OFF" in Figure 3) and the CWS roll mode*[8] was engaged (referred to as "ON" in Figure 3). [I: Figure 3]

The ailerons moved following the rotation of the Wheel. [I: Figure 3]

22:48:45 The pitch angle began to greatly change in the nose low direction. An autopilot control authority under a VNAV correction reached a limit, and the elevator did not work any further. Therefore, the Column was kept unchanged at an angle of about +2° . During this time, there



Just after Wheel operation start

*6 "Auto-throttle" automatically controls the engine output and controls the aircraft during VNAV mode flights so as to maintain the speed and the altitude as indicated by the FMC. When the VNAV mode shifts to the CWS pitch mode, the aircraft will maintain the speed input by the pilot. The pilot can manually control the throttle lever at any time.

*7 "bank angle alert" issues an alert in a synthesized voice when the aircraft banks (an equivalent to "roll") by over a certain angle. With regard to the Aircraft, the aural alert "Bank Angle, Bank Angle" was to be activated one time when the roll angle exceeds ±35°, ±40°and ±45°. The time when the Bank Angle Alert was activated in this incident was identified based on the results of a simulation performed at a GPWS manufacturer's laboratory by using the DFDR data.

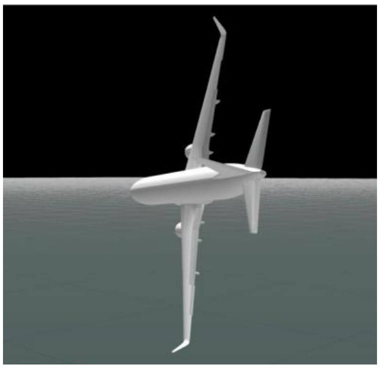
*8 "CWS Roll Mode" is an autopilot mode and it controls the aircraft's roll with the Wheel to be operated by the pilot. In case the LNAV mode is in use, it will shift to the CWS roll mode when the Wheel is operated with a force exceeding a certain amount (about 10 lb) (Hi Detent). Further, when the Wheel is operated with a force of 25 lb or more, the roll can be controlled beyond a control limit under autopilot (Mechanical Override). This mode does not automatically return to the LNAV mode.

was no control column force applied. [J: Figure 4]

22:48:46 The right rudder pedal was pressed with a force of about 23 lbs and following this, the rudder moved about -2.8°. (In this report, the rudder angle to the right is described in negative value.) (through 48:49) [K: Figure 5]

22:48:47 The stick shaker*9 was activated. [L: Figures 3 and 4]

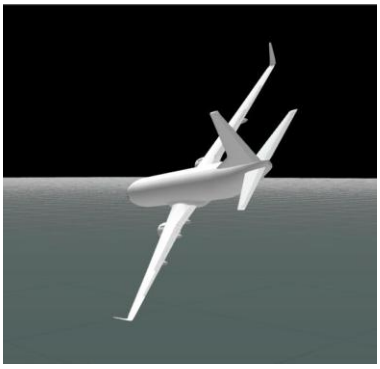
22:48:48 As the Wheel was operated CW, the roll angle changed in the direction to recovery after reaching a peak of about -80°. However, around when the roll angle reached the peak, the wheel force in the CW direction loosened and a force in the CCW direction about 9 lbs was applied. As a result, the Wheel was turned in the reverse direction and returned almost to the neutral position. Finally, the Wheel was turned to about +17°CCW beyond the neutral position. The condition with the wheel force in the CW direction loosened was continued for about three seconds. At the same time when the force on the Wheel was loosened, the force on the right side rudder pedal was loosened. As a result, the rudder returned to the previous position of about -5°. [L: Figures 3 and 4]



Roll halted at about -80°

Wheel at about +17°

The Column was momentarily pushed forward, and accordingly, the control column position moved. The elevator moved downward for one second. Then because the force on the Wheel was loosened and at the same time, the force on the Column was loosened, the Column returned to the previous position. [L: Figure 4]



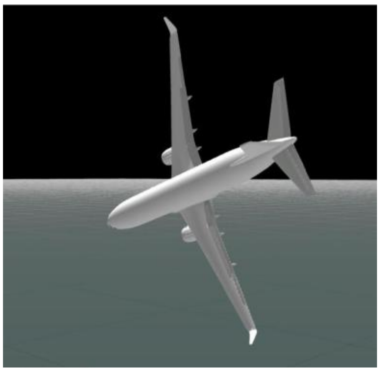
Roll recovered to about -50°

22:48:51 The roll angle recovered to about -50°, but it began to roll to the left again. [M: Figure 3]

During this time, the Wheel was maintained at about -35°in the CW direction.

22:48:52 The Rudder Trim SW was turned CW (in the direction that the rudder moves to the neutral position) (through 48:55). [N: Figures 3 to 5] The rudder trim was moving the rudder to the neutral direction, but the rudder position did not move to the neutral direction.

Wheel at about -35°

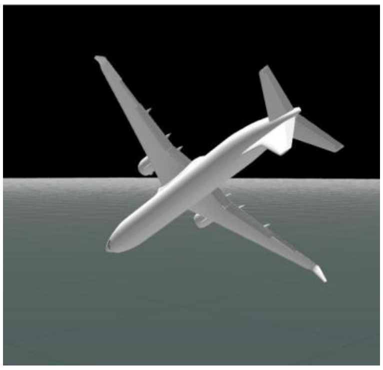


Aircraft rolled to left again

22:48:53 The flight altitude decreased rapidly. During

*9 "stick shaker" is a typical stall warning system. This system shakes the Column to warn the pilot that the aircraft is going to be stalled.

two seconds around 48:53, the Aircraft descended by an average about 200 ft/s. For two seconds around 49:00, the Aircraft descended by an average about 440 ft/s. As of 49:16, the Aircraft descended to 34,676 ft. [O: Figures 3 to 5]



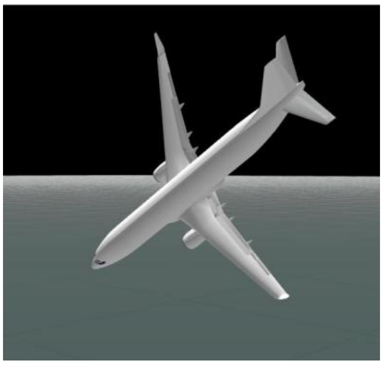
Roll angle at -131.7°

22:48:56 Because the Column was pushed with a force exceeding a certain level, the VNAV mode was disengaged, and the CWS pitch mode*10 was engaged. [P: Figure 4]

Wheel at about -98°

The throttle lever position moved linearly in the direction to decrease the thrust. [Q: Figure 4]

The roll angle became a maximum value of -131.7° to the left. Therefore, the roll angle gradually recovered toward level, mainly because the Wheel was operated CW to about -98°. In response to the rotation of the Wheel, the ailerons moved. [P: Figure 3]



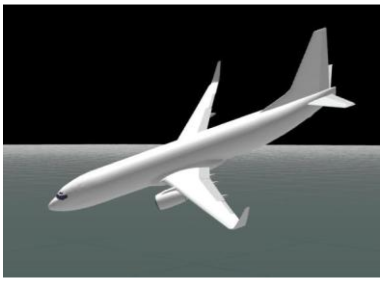
Pitch angle at -35°

22:48:59 The pitch angle became a maximum value of -35° in the nose low direction. [R: Figure 4]

22:49:00 The Column began to be intermittently pulled and the pitch angle moved toward recovery. In response to the movement of the Column, the elevator moved; accordingly, the pitch angle started recovering. (through 49:26) [S: Figure 4]

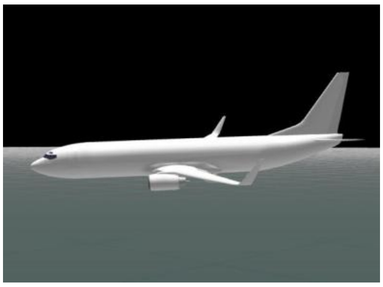
The Column being intermittently pulled while the Wheel is operated

During this time, in response to the aircraft movement with the pitch angle toward recovery, the angle of attack*11 and the vertical acceleration (the load factor) became larger, and the stick shaker was intermittently activated. Further, the over-speed warning was also intermittently activated from 49:05. [S: Figure 4]



The pitch angle moving to recovery

22:49:02 The roll angle oscillations became smaller at around -25°. Later, the aircraft movement in response to the irregular moves of the Wheel continued at around this roll angle. [T: Figure 3]



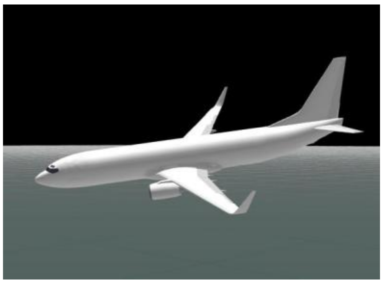
The attitude when the speed becomes M 0.828

*10 "CWS pitch mode" is an autopilot mode and it controls the aircraft's pitch with the Column to be operated by the pilot. In case the VNAV mode is in use, it will shift to the CWS pitch mode when the Column is operated with a force exceeding a certain amount (about 21 lb) (Hi Detent). Further, when the Column is operated with a force of 25 lb or more, the pitch can be controlled beyond a control limit under autopilot (Mechanical Override). This mode does not automatically return to the VNAV mode.

*11 "angle of attack (AOA)" is an angle formed by the direction of the air flow and the chord line when the wing is placed in a uniform air flow. When the pitch angle increases in a uniform air flow, the AOA also increases, but when the air flow changes, the AOA sometimes increases even without an increase in the pitch angle.

22:49:03 The speed exceeded the maximum operating limit speed (M 0.82) (hereinafter referred to as "the Over-Speed"). As of 49:13, the speed increased to a maximum of M 0.828 (through 49:14) [U: Figures 1 to 5]

22:49:04 The load factor exceeded the limit load factor (2.50 G) (hereinafter referred to as "the Over-Load"). As of 49:09, it increased to a maximum 2.68 G (through 49:09). [U: Figures 1, 2 and 4]



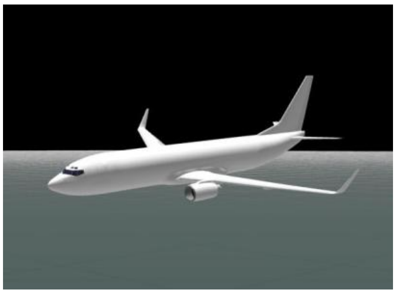
The attitude when the load factor becomes 2.68 G

22:49:16 The nosedive came to a stop at an altitude of about 35,000 ft. Later, the altitude continued to change instability. [V: Figure 2]

22:49:26 The pitch angle oscillations became smaller at around 8° and the load factor oscillations also became smaller at around 1G. Hereafter, the pitch gradually became stable, but irregular movements continued. [W: Figure 4]

22:49:40 The Rudder Trim SW was turned CW (in the direction to move the rudder to the neutral position) (for about one second). After this, recovery operations for the rudder trim were made four times. [Figure 2]

22:50:11 The PIC returned to the cockpit. [X: Figures 1 and 2]



The aircraft's attitude when the PIC entered the cockpit

22:50:38 Auto-throttle was disengaged. [Y: Figure 2]
The PIC took over control from the FO and started operating the Aircraft.

22:50:39 Autopilot was momentarily disengaged (through 50:45). [Z: Figure 2]
The PIC started autopilot reconfiguration.

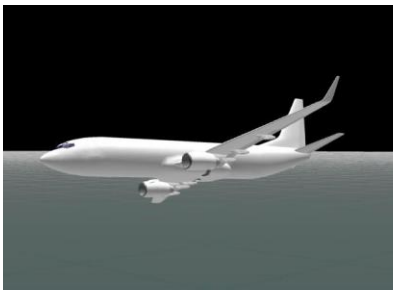
22:50:43 The FO requested the Controller for clearance to maintain the current direction and FL 360 (through 50:47). [a: Figures 1 and 2]

22:51:49 The LNAV mode was set. [b: Figure 2]

22:52:07 The FO reported flying (returning) to PQE to the Controller (through 52:14). After that, there was no report of a nosedive in the communication with the Controller.

22:52:13 Auto-throttle was engaged. A normal flight condition was almost restored. [d: Figure 2]

This serious incident occurred at around 22:49 on September 6, 2011, at an altitude of about 41,000 ft about 69 nm east of Kushimoto (Latitude 33°16'43" N, Longitude 137°09'08" E).



22:52:13

2.1.2 Statements of the Person Concerned

(1) PIC

On the day of the incident, the PIC and the FO mutually confirmed their physical condition upon showing up at Naha Airport.

The Aircraft had been flying without any problem at an altitude of 41,000 ft as usual right up until this serious incident to occur after took off. When the inside of the cockpit is brightened, the outside becomes invisible. Therefore, rather than using the flood light, the PIC had used the backlight so that the inside can be clearly seen as well.

The PIC went out of the cockpit to use the restroom about 80 nm before NJC (Niijima VORTAC). Until then, there was nothing unusual in the FO's behavior. After using the restroom, the PIC attempted to return to the cockpit by sending a predetermined signal to the FO from outside the cockpit door.

While he was waiting for the door to be unlocked, the Aircraft began to bank. He heard the Over-speed warning, Bank angle alert and warning sounding from inside the cockpit. Subsequently, the PIC sent a signal to the FO again, but the door remained locked.

The PIC was unable to remain standing due to strong vertical acceleration (hereinafter referred to as "G"). He was pushed onto the floor to the right towards the cockpit door. He felt the Aircraft banking to the left while descending, but he had no idea about the descent speed and bank angle. The PIC thought the FO might have been in a state of incapacitation*[12].

The PIC decided to open the cockpit door by himself, but he could not open it immediately because of the strong G effect.

When the strong G subsided, the PIC managed to return to the cockpit. He confirmed that the heading has changed substantially at an altitude of 35,000 to 36,000 ft. The FO appeared to be trying to keep level-flight attitude.

When the PIC entered the cockpit, the aircraft attitude was somewhat stabilized. There were some changes in the pitch, but the PIC sat down in his seat as usual. At first the PIC received the report from the FO that he accidentally rotated the Rudder Trim SW.

The PIC took over control from the FO and activated the heading select and level change modes. After confirming the modes functioned normally, he engaged the autopilot and turned the auto-throttle switch on. Through these operations, he believed that the Aircraft had become to maintain a normal flight condition.

The PIC heard from the FO that he has received instructions from the Controller to proceed direct to PQE. For a little while after he re-entered the cockpit, the PIC was not wearing his headset. Therefore, he could not clearly hear the FO's conversation with the Controller. However, he heard the FO seemingly being asked by the Controller whether the Aircraft was proceeding direct to PQE. The PIC confirmed this with the FO and turned the Aircraft towards PQE.

Subsequently, the PIC checked vibration, parameters and trim of the Aircraft. As he considered all these to within the normal flight conditions, he thus continued to fly towards Tokyo International Airport.

Because the FO seemed to be fairly unsettled, the PIC instructed him to concentrate on his PM duties. Besides instructing the CAs to check the safety of the passengers, the PIC also checked whether any of the CAs was injured. None of the passengers or CAs was reported to be injured. Because the Aircraft had approached close to Tokyo International Airport, the PIC thought he should give priority to landing operations first and thus he did not report the occurrence of this matter to the Company until landing.

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*[12] "incapacitation" means a state in which the personnel loses part or all of his or her duty performing ability because of physical or mental functional loss.

Later on, he learned that two of the CAs had sustained minor injuries.

(2) FO

There was no particular problem with his physical condition. The Aircraft had been cruising with the seat belt sign turned off. When the Aircraft was flying over the sea near off Shizuoka, the PIC indicated his intention to vacate his seat to use the restroom. Therefore, the FO took over the duties of the PF. Subsequently, the PIC left the cockpit. The FO recalls that it occurred about once half a year that a PIC left the cockpit during flight. When interviewed by an investigator, he recalled that this was the first time he had experienced a PIC leave the cockpit while on duty aboard a Boeing 737-700 (hereinafter referred to as "737-700"). The PIC had adopted on the procedures for entering the cockpit during a briefing for the first flight of the day.

The FO did not wear and use an oxygen mask while the PIC was absent from the cockpit. The PIC did not check the FO for wearing and using the mask when the PIC left the cockpit. The FO was clearly conscious while the PIC was out of the cockpit. He knew about the provision requiring the wear and use of an oxygen mask when the cockpit is manned by a single pilot at an altitude of 25,000 ft or higher, but he recalled that he actually wore and used an oxygen mask only once in a year at best while in a commercial flight.

Previously, when a PIC left the cockpit for a minute or so when using the restroom and so on, he was told one-half of the occasions by a PIC that he did not have to wear and use the mask or he just prepared to pick up his mask immediately. Instead, a PIC also did not wear and use the mask sometimes either. Therefore, the FO thought that such a procedure was acceptable.

Soon thereafter, the FO received instructions from the Controller to change the route and proceed direct to PQE. While he was entering the route change command in the CDU, he heard the predetermined signal for unlocking the cockpit door from the PIC. He was uncertain whether this was before or after he performed the route change command into the CDU, but he remembered extending his left arm to the switch for the door lock control (hereinafter referred to as "the Door Lock Selector") located on the aft electronic panel (hereinafter referred to as "the AE Panel") in order to open the door.

He checked the PIC's face through on the image of the camera monitoring the outside of the door on the monitor screen, and then rotated the switch. He had no doubt about the fact that he did not hear any operating noise of the door lock system unlocked with using the Door Lock Selector. Later on, he thought that this perhaps reflected his lack of experience in actually operating the Door Lock Selector on board a 737-700 and thus he did not really know how it should be heard like.

Since the PIC did not enter the cockpit immediately as thought, the FO became doubtful and carefully looked at the image on the monitor screen, noticing that the PIC seemed unable to open the door. Upon looking at his left hand, he realized for the first time that he had mistakenly rotated and held the Rudder Trim SW. He did not remember how long he kept holding the Rudder Trim SW.

With regards to his erroneous rotating of the Rudder Trim SW, he thought later that he may have turned the Rudder Trim SW by mistake due to the following reason. The FO had been serving on board the Boeing 737-500 series aircraft (hereinafter referred to as "737-500") until May 2011. The Door Lock Selector for the 737-500 is located in the center of the AE Panel, at almost the same place as the Rudder Trim SW for the 737-700. He remembered looking at the Rudder Trim SW, and then depressing and rotating it just like the Door Lock Selector for 737-500 at that point. Before this incident, the FO had never rotating the Rudder Trim SW by mistake, nor had he ever come close to doing so.

In order to open the door, the FO had intended to rotate the Door Lock Selector CCW and hold it there, but he believed he might have moved the rudder by rotating the Rudder Trim SW CCW and held it there instead.

He remembered that, expecting that the aircraft would bank significantly if the rudder was moved, he took a look at the PFD in front of him, and found the Aircraft banking to the left. He could not remember whether his hands were holding onto the Wheel at that time, but said that he usually placed his hand on the Wheel when the weather was bad. The Aircraft began to bank even more but he did not remember having heard the bank angle alert.

The FO turned the Wheel largely to the right to correct the left bank. Subsequently, although he heard the PIC attempting to open the door several times, he thought he should concentrate on correcting the bank instead and remembered not having looked at the AE Panel again.

Firmly holding onto the Wheel, the FO tried to override the autopilot and correct the bank using the Wheel as he could not afford to disengage the autopilot. At this time, he did not remember how the autopilot mode indicated on the display.

While making corrective operations, the FO performed an operation to restore the rudder trim, but did not remember when and by how much the rudder trim was restored. He stepped his foot on the rudder pedals, but he said that he did not use them for correction because he thought it would be better to return the wings to the level position using the Wheel. Moreover, since the Wheel was heavy, he thought there would not be sufficient margin to disengage the auto-throttle or move the throttle lever.

The FO felt that the attitude itself was unusual, but could not fully understand how large the bank and the pitch were. He remembered that as he was trying to correct the attitude, the Aircraft continued to descend largely, while the airspeed also increased to the extent that the over-speed warning was activated. However, he did not remember how long this situation continued. He did not remember that the stick shaker had been activated and neither did he feel any G effect.

Thereafter, the wings returned to the level and the pitch also became stabilized. Just as the FO restored the rudder trim to the previous position, the PIC opened the door and entered the cockpit.

Around this time, the FO told the Controller that the Aircraft would maintain the current heading at an altitude of 36,000 ft which was cleared by the Controller. These were the altitude and heading at which he believed the Aircraft can continue flying in a normal attitude. At this point, the FO was asked by the Controller whether the Aircraft was flying to PQE, to which he replied in the affirmative. He did not remember being called by the Controller from the time he was initially instructed to proceed direct to PQE until this communication.

When he was asked about the situation by the PIC, the FO reported that he had mistakenly rotated the Rudder Trim SW instead of the Door Lock Selector. He also reported that the altitude of 36,000 ft and the current heading had been cleared by the Controller.

After taking over the duties of PF, the PIC set up the autopilot. Subsequently, as the

PIC was preoccupied with preparations for approach and other operations, the FO decided to report the details of the occurrence to the PIC later.

After spotted in, the FO informed the PIC that the aircraft attitude had become unstable following the over-speed and over-bank, but had no idea about how large it had become. He also explained that it is somewhat likely that the Aircraft had banked to a fair extent and that he had pulled the Column to pitch up.

Regarding the CDU operation he performed to change the route, the FO later thought that the operation should have been done only upon confirmation and consent by the PIC after his return to the cockpit, while holding back on instructions from the Controller.

(3) Cabin Attendant A (L1CA*13)

Cabin Attendant A heard from the PIC that he would like to use the restroom. She closed the curtain in front of the galley and was checking that the PIC came out of the cockpit, entered the restroom and came out of it.

After the restroom, the PIC sent a predetermined signal to the FO to re-enter the cockpit. Just after this, she called the cockpit via the service interphone, but there was no answer. The attendant saw the PIC sending a signal again and asking the FO to open the door, but did not feel that there was any reply.

Just after perceiving something unusual, she felt an earthquake-like vertical shaking with seismic intensity about one on the Japanese scale and the aircraft banking slightly to the left. In addition, she could not remain standing due to a downward force being exerted on the body. She did not feel that the nose of the Aircraft was down.

The PIC attempted to re-enter the cockpit by himself, but was unable to keep his body stable and commented he could not enter the cockpit. Therefore, she knelt down with both knees and left hand on the floor and attempted to open the cockpit door using the right hand but felt a G so strong that it was not possible to raise the hand. She heard sharp warning sounds from inside the cockpit.

She remained on her knees and continued to feel a strong G. Before the PIC entered the cockpit, she told him that the FO may be in a state of incapacitation.

Subsequently, the G gradually became smaller. As the door was unlocked, the PIC opened the door, and then entered the cockpit. She immediately opened the curtain and sat on the CA seat with the seat belt fastened.

Feeling no further shaking or G, she then checked the situation in the rear section via the service interphone. She checked the situation in the cabin to the extent possible while remaining in a seated position, including whether the restroom was in use.

Subsequently, there was a call from the PIC via the service interphone to check the condition of the passengers and CAs. She reported that all the passengers and CAs were in their seats, with no reports of any injuries at the moment.

The CAs checked the situation in the cabin, but there were no reports of any problem or difficulty among the passengers in particular. After confirming the situation in the cabin, she reported to the PIC at around 23:00 that there were no injuries to the passengers and CAs, and that no damage to the cabin can be seen nor any passengers left their seats. No passenger complained of any problem in particular and they all remained calm.

The Aircraft landed and entered the spot as usual. After the passengers disembarked,

*13 "L1CA" is one of the names for cabin attendants based on the position. "L" denotes the left side and "1" means the position beside the No.1 door from the front. Aboard the Aircraft were three cabin attendants—L1CA, L2CA and R2CA.

the PIC and the FO came out of the cockpit about one to two minutes after a check of the cabin was started.

Cabin Attendant A reported to the PIC again that no passengers were injured or had physical problems, nor any questions received. She also reported the physical condition and injuries of the CAs. She reported that L2CA felt pain and a slight numbness in the lower back.

(4) Cabin Attendant B (R2CA)

Since the PIC came out of the cockpit to use the restroom in the cabin, L1CA (Cabin Attendant A) attended to him. In the meantime, Cabin Attendant B was working with L2CA in the rear galley.

There was a strong shaking at around 22:49. She felt that the shaking felt like a force pressing her downwards. She was unable to maintain her balance without holding onto something and squatting. A heavy force was felt on the whole body. There were no cries and so on from the cabin.

She just realized that the Aircraft was flying abnormally felt to the low and heavy noise being heard. The aircraft seemed to be banking to one side, even though the extent of the banking was not known. Although feeling a downward force being exerted, she felt that the aircraft was descending.

At around 22:58, the seat belt sign was turned off. Thereafter, she checked the situation in the cabin and the condition of the passengers, reporting to L1CA (Cabin Attendant A) whether there were any injuries, the condition of the passengers, and whether there was any damage in the cabin. In the galley, candies were scattered about, but there was nothing scattered in the cabin.

(5) Controller

When the Controller received traffic control service for the Aircraft, she controlled about five aircraft approaching Tokyo International Airport for arrival. At around 22:48, the Controller instructed the Aircraft to change the route and proceed direct to PQE.

When the Controller looked at the target of the Aircraft on the radar screen (hereinafter referred to as “the Target”), the value in the altitude indicator was decreasing and the flight path was also heading slightly to the north. The Controller did not remember precisely whether this was a coast status (a situation in which an aircraft’s sight is momentarily lost on the radar).

As the subsequent flight path was heading towards the north, the Controller felt something was abnormal. Another coordinating controller who was seated just beside the Controller was also paying attention to the Aircraft’s Target. Thinking this might be an erroneous radar indication, the Controller was watching the situation for two to three scans (about 20 to 30 seconds).

Subsequently, since the Target was understood to be no error, the Controller called the Aircraft, but there was no reply from the Aircraft. The coordinating controller then contacted a controller who was in-charge of the neighboring sector in the northern side to coordinate concerning the Aircraft’s movement.

After calling the Aircraft several times, the Controller received a reply from the Aircraft. The Aircraft reported that it was proceeding direct to PQE with its altitude having been restored to 36,000 ft, which acknowledged by the Controller.

At this time, the Controller thought that something must have happened aboard the

Aircraft but concluded that communication from the controllers' side should be withheld in these circumstances. As a result, the Controller did not ask the Aircraft what happened.

Shortly thereafter, the Controller confirmed that, from the Target, the Aircraft was heading towards PQE and that the altitude was actually 36,000 ft, as reported by the Aircraft. Since it was not known what had happened aboard the Aircraft and because there was no other aircraft in the vicinity of its flight route, the Controller asked the Aircraft whether it had any preferred altitude. As the Aircraft replied that its desired altitude was 36,000 ft, the Controller once again instructed it to proceed direct to PQE at 36,000 ft.

At this time, the Controller concluded that the situation was now under control even though something had happened onboard.

As it was time to take over to another controller in the next shift, the Controller asked the Aircraft whether there was any problem with its flight. The Aircraft replied that there was none. Thinking that the Controller would be informed of anything that needed to be reported for air traffic control purposes, the Controller thus concluded that there is nothing more to be done for the situation.

2.2 Injuries to Persons

Two cabin attendants who were working while standing sustained minor injuries.

2.3 Damage to the Aircraft

No damage to the Aircraft was found during a check carried out after the occurrence of this serious incident.

2.4 Personnel Information

2.4.1 Outline of Career

(1) PIC	Male, Age 64	
Airline transport pilot certificate (Airplane)		September 23, 1975
Type rating for Boeing 737		March 31, 1983
Class 1 aviation medical certificate		
Validity		November 21, 2011
Total flight time		16,518 hrs. 47 min.
Flight time in the last 30 days		58 hrs. 21 min.
Total flight time on the type of aircraft		64 hrs. 14 min.
Flight time in the last 30 days		58 hrs. 21 min.
(2) FO	Male, Age 38	
Commercial pilot certificate (Airplane)		August 27, 1999
Type rating for Boeing 737		August 30, 2006
Instrument flight certificate		August 27, 1999
Class 1 aviation medical certificate		
Validity		January 24, 2012
Total flight time		2,930 hrs. 12 min.
Flight time in the last 30 days		63 hrs. 37 min.
Total flight time on the type of aircraft		197 hrs. 13 min.
Flight time in the last 30 days		63 hrs. 37 min.

2.4.2 Career and Training Records of FO

(1) Career

January 24, 2007	:	First flight aboard 737-500 as a first officer
May 8, 2011	:	Last flight aboard 737-500 as a first officer
May 31, 2011	:	Differences training check aboard 737-700/800
June 8, 2011	:	Experience flight (2 legs)
June 10, 2011	:	First flight aboard 737-700 as a first officer

(2) Training records

Training for the FO involved was performed as below. Each training program is summarized in Attachment 3.

- Bridge training	:	Check in October 2005
- First officer		
Upgrade training	:	Check in August 2006 (ground school, flight simulator and aircraft training) Check in January 2007 (route training)
- Recurrent training	:	Performed in March 2007, February 2008, February 2009, February 2010, and February 2011
Proficiency check	:	Performed in July 2007, July 2008, September 2009, and August 2010
Route check	:	Performed in January 2008, February 2009, January 2010, and January 2011
- LOFT	:	Finished in February 2007, February 2008, January 2009, February 2010, and January 2011
- Differences training	:	Check in May 2011

2.5 Aircraft Information

2.5.1 Aircraft

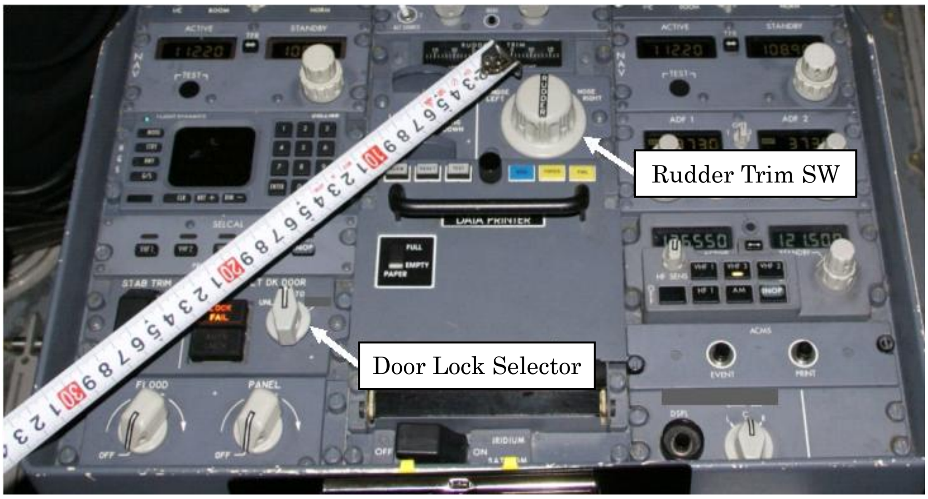
Type	Boeing 737-700
Serial number	33889
Date of manufacture	January 11, 2008
Certificate of airworthiness	2008-066
Validity A period in which the aircraft is maintained in accordance with maintenance regulations from December 22, 2008	
Category of airworthiness	Airplane, Transport T
Total flight time	7,968 hrs. 45 min.
Flight time since last periodical check (C02 inspection conducted on November 17, 2009)	1,097 hrs. 00 min.

2.5.2 Weight and Balance

When the serious incident occurred, the weight of the Aircraft was estimated to have been 117,900 lb and the position of center gravity (CG) was estimated to have been 25.7 % mean aerodynamic chord (MAC), both of which are estimated to have been within the allowable ranges (maximum takeoff weight of 132,200 lb, and the CG range of 13.3 to 28.8 % MAC corresponding to the weight at the time of the serious incident).

2.5.3 Rudder Trim SW and Door Lock Selector

The Rudder Trim SW and the Door Lock Selector (hereinafter referred to as "Both Switches") are located on the AE Panel with a distance of 20 cm in the center of the left and right pilot seats and behind the throttle lever, as shown in the photo below. At night, they can be made visible as flight crew tune lighting, just like other panels and switches in the cockpit.



Both Switches on AE Panel of the Aircraft

The Boeing Company replied the inquiry as to reasons for the location of Both Switches, as follows.

The primary reason for the location of the rudder trim and flight deck door lock controls is commonality, particularly the rudder trim.

The rudder trim control is located in a similar position on many different aircraft models. This reduces negative transfer errors as pilots move from type to type. Similarly, the Flight Deck Door Lock Panel is in the aft aisle stand. This location helps provide commonality to the various retrofit installation of the flight deck door lock systems. One of the factors in control location is similarity of adjacent controls.

In this particular case of the rudder trim and flight deck door, the two controls differ in location, size, shape, and motion (the flight deck door switch must be depressed before it will rotate counter-clockwise, while the rudder trim control does not move vertically).

In addition to similarity of adjacent controls, there are many other factors that go into control placement and selection. These factors include logical groupings, reach requirements, frequency of use, how the controls are used, and others. Regulatory requirements for flight deck controls can be found in FAR 25.777 and 25.779.

In the provisions FAR*[14] 25.777 and 25.779, as applied for the type certificates (TC) for the series of aircraft involved, standards for control instruments in the cockpit are prescribed. Based on these standards, the Boeing Company designs the location, shape, motion and others of switches in the cockpit. The standards involved are as follows:

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*[14] "FAR", which stands for the Federal Aviation Regulations, is a collection of rules prescribed by the Federal Aviation Administration (FAA). The rules stipulate details about the issuance of aircraft type certificates, conducting airman competence certificates, monitoring of civil aviation activities, securing civil aviation safety and others.

FAR25.777　Cockpit controls

(a) Each cockpit control must be located to provide convenient operation and to prevent confusion and inadvertent operation.

(b) The direction of movement of cockpit controls must meet the requirements of Sec.25.779.

(The rest is omitted)

FAR25.779　Motion and effect of cockpit controls.

Cockpit controls must be designed so that they operate in accordance with the following movement and actuation:

(a) Aerodynamic controls:

(1) Primary.

(Omitted)

(2) Secondary.

Controls	***Motion and effect***
	(Omitted)
Trim tabs (or equivalent)	*Rotate to produce similar rotation of the airplane about an axis parallel to the axis of the control.*

(Omitted)

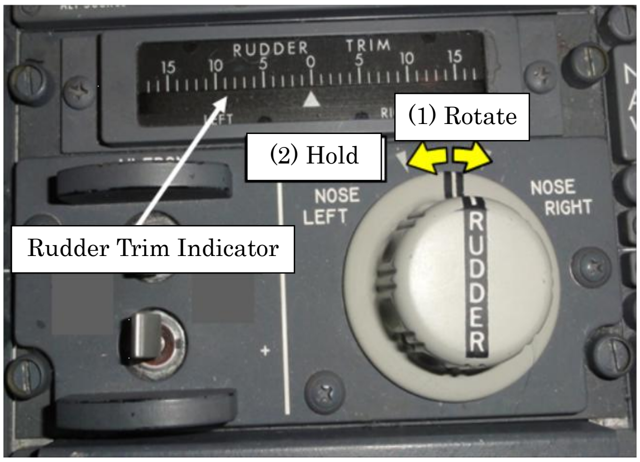
2.5.4　Details of Rudder Trim SW

The Rudder Trim SW of the 737-700 (including the Aircraft) and the 737-500 (the type in which the FO was previously on duty) (hereinafter referred to as “Both Type Aircraft”) are designed per the same specification. The device is held at the neutral position with the force of spring. When the Rudder Trim SW is rotated 30° CCW or CW (actions which require a torque of 6.0 lbf･in*[15]), it comes to a position where it cannot be mechanically rotated any more. When it comes to this position, its internal contact becomes on. If a hand is released from the control, the switch returns to the neutral position with the force of spring, and the internal contact comes off.

While the internal contact is on, the electric rudder trim actuator continues to work and moves the rudder neutral position either to the left or the right. In other words, when the Rudder Trim SW is rotated 30° CCW (NOSE LEFT) and held there, the rudder continues to move to the left according to the length of time as it is held. When it is returned to the neutral position, the rudder stops at the moved position and remains there.

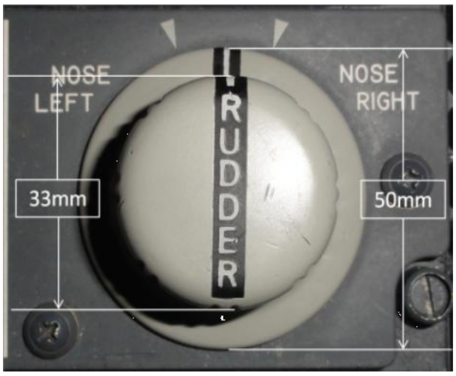
The Rudder Trim SW has no operating sound. Therefore, when the rudder is moved, no sound can be heard from the pilot seats. The amount of rudder trim movement will be indicated in units (scale mark) on the rudder trim indicator. When the Rudder Trim SW is held for one second, the value on the rudder trim indicator will change by about 0.5 unit.

The knob of the Rudder Trim SW has anti-skid grooves.



Operation of Rudder Trim SW

*15 “lbf･in” is a unit for torque (the moment of force) in a yard-pound system. This is indicated by a product of the distance from the pivot of rotation to the point where force is applied and the amount of force applied on such point. When converted to the SI unit system, it comes to 1 lbf･in ≒ 11.30 N･cm and 1 lbf･in ≒ 1.152 kgf･cm under the gravitational unit system.



Outer view of Rudder Trim SW

Shift amount of Rudder Trim SW

In cases other than training, the Rudder Trim SW is operated on such occasions as mentioned below.

(1) Preflight procedure

The movement of the control is checked while the pilots sit in their seats, in accordance with the Airplane Operations Manual*[16] (In this report, this means the Company's Airplane Operations Manual Boeing 737-700/800 Series, hereinafter referred to as "AOM") provision "3-4 Preliminary Preflight Procedure—PF".

Operation of Rudder Trim SW

(2) In emergency conditions such as engine trouble

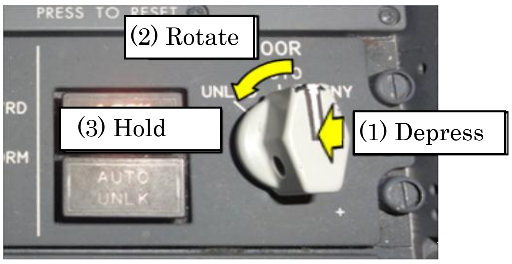
When one engine is inoperative (in a condition in which one of the two engines loses a significant part or all of its thrust during flight for some reason), the rudder must be continuously operated to compensate the yaw of the aircraft to be caused by a thrust difference. In this case, the rudder trim is used to reduce the pilot workload when they keep pressing the rudder pedal.

(3) Fine adjustment of flight attitude

When a state of slight roll or yaw to either side continues during flight, the rudder trim may be sometimes used to fine adjust the aircraft attitude.

2.5.5 Details of Door Lock Selector

Though the shape of the Door Lock Selector for Both Type Aircraft is different from type to type, it can be operated in the same manner. The selector is held at the neutral position (AUTO) with the force of spring. When the selector is rotated 45° CCW (a torque of 3.0 lbf-in is needed) after its knob vertically depressed, it comes to the position (UNLKD) where it can not to be



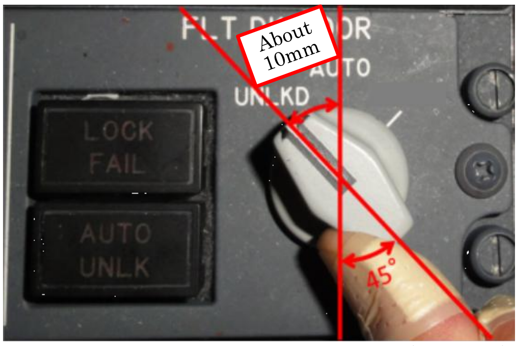
Operation of Door Lock Selector (737-700)

*16 "Airplane Operations Manual (AOM)" is a provision regarding the performance and use of aircraft and operations by flight crew member. Rules are prescribed for each aircraft type, and based on manuals issued by aircraft manufacturers, airline companies issue their respective AOM with their studies included. The AOMs stipulate the operational limit, normal operation, operations in emergencies and in trouble, various systems and their operations and performances, flights in a special situation, the weight and balance, and others.

mechanically rotated any further. When it comes to the UNLKD position, its internal contact becomes on. When fingers are released from the knob, the selector returns to the AUTO position with the force of spring and the internal contact comes off.

While the internal contact is on, the cockpit door is unlocked. This means the cockpit door is usually locked. The door can be unlocked only when the Door Lock Selector is held at UNLKD. However, the selector can be depressed even with a force applied CCW.

Outer view of Door Lock Selector (737-700)

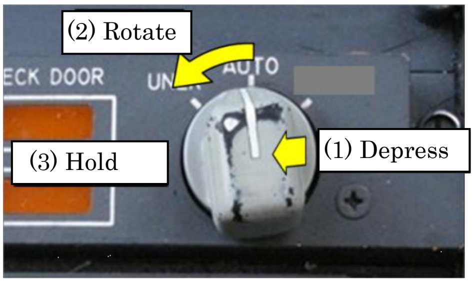


Shift amount of Door Lock Selector (737-700)

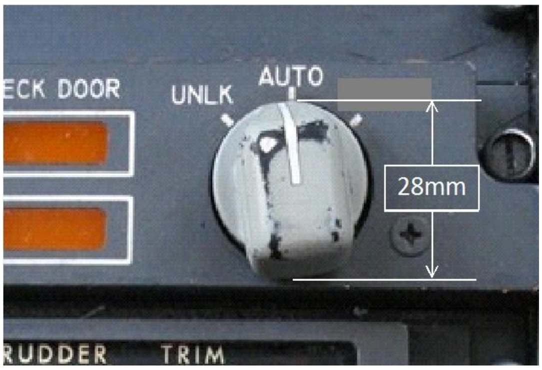
The cockpit door can be opened from the cabin side only when the door is unlocked.

The Door Lock Selector has no operating sound, but a mechanical noise sounds in locking or unlocking the door. This noise can be heard from the pilot seats in the cockpit. Any procedures for confirming the result of the operation by hearing this noise had not been described in the Operations Manual*17 (hereinafter referred to as "the OM") or the AOM. There was no function of indicating the position where the Door Lock Sector is set (whether it is unlocked or not).

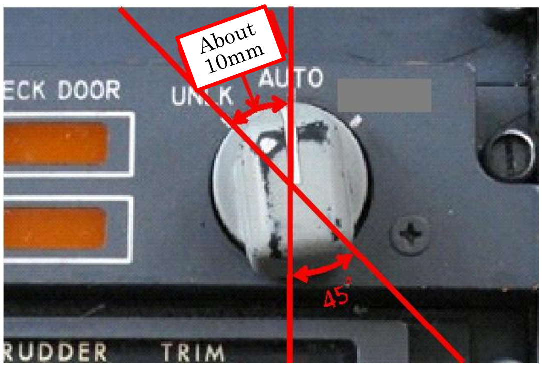
The operation of the Door Lock Selector installed on 737-500, its appearance and shift amount are shown in the following three photos. The Door Lock Selector of the 737-500 had a longitudinal knob on its disk-like brim, just like that of the 737-700. But the shape and size of the knob were different between the Both Type Aircraft.



Operation of Door Lock Selector
(737-500)



Over view of Door Lock Selector (737-500)



Shift amount of Door Lock Selector (737-500)

*17 "Operations Manual (OM)" prescribes a basic policy for an operation of aircraft, an operation outline, rules and others, and it is established based on each air carrier's policy. The OM consists of chapters for flight operating control, flight operation standards, ground personnel, crewmen, weather minimum , emergency measures and others. The OM contains provisions for flight plans, flight rules, navigation policies and standard, training and examinations for aircraft dispatchers and flight crewmembers, operable weather, anti-hijacking measures and others. The Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism reviews and approves the OMs pursuant to the provisions of the Civil Aeronautics Act of Japan.

(1) Operation in preflight procedure

Flight crew member operate the Door Lock Selector and confirm its movement in a preflight procedure for the day's first flight in accordance with the AOM 3-4 provision, Preliminary Preflight Procedure—PM, and the 4-2-1 provision, Flight Deck Door Access System Test. Because the linkage between the Door Lock Selector operation and the opening and closing of the door must be checked, flight crew member operate the selector in this check while standing at a place to the rear of the AE Panel.

As for the day's second and later flights, the pilot visually confirms whether the Door Lock Selector is properly set and whether there is an abnormal indication while sitting in the seat, in accordance with the AOM 3-4 provision, Preliminary Preflight Procedure—PM.

(2) In-flight operation

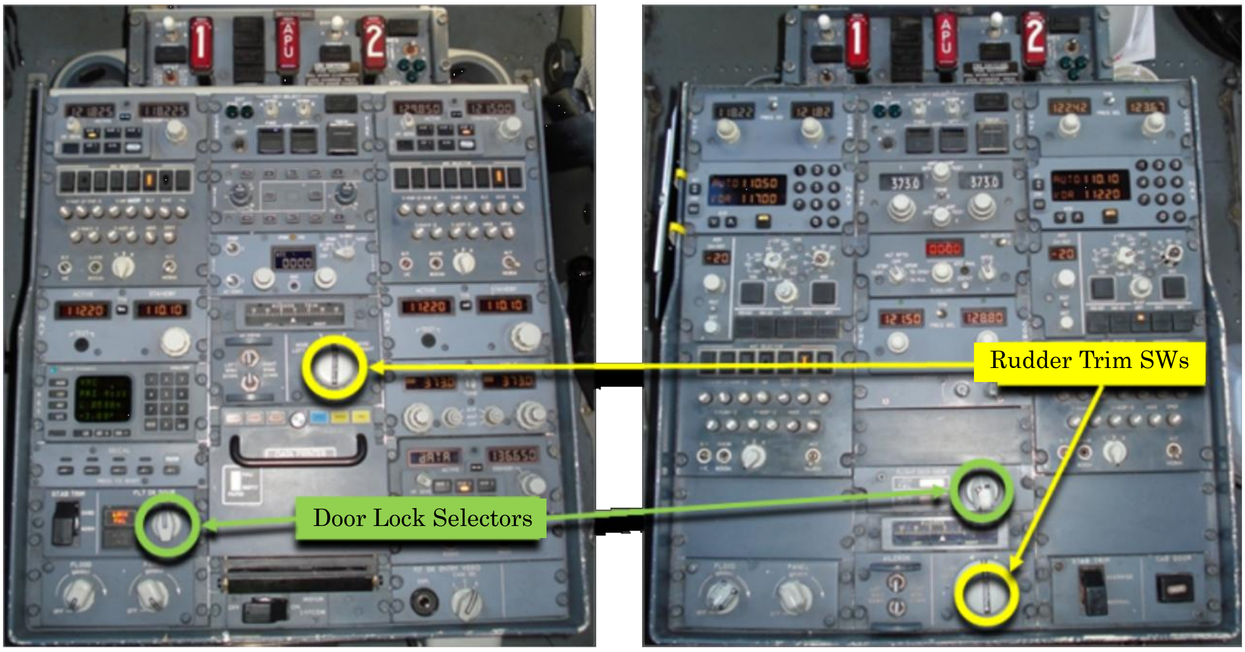
Occasions in which a flight crew member operates the Door Lock Selector during flight are almost limited to cases in which either of the pilots leaves the cockpit and is going to reenter, requiring the remaining pilot to unlock the door just like in this incident. There are only a few occasions of this kind in short-haul domestic flights.

In-flight operation of Door Lock Selector

2.5.6 Both Switches of Both Type Aircraft

The FO was on duty aboard 737-500 until May 2011. Therefore, he was on duty aboard 737-700 from June 2011 after receiving differences training and check.

The locations of Both Switches of Both Series Aircraft are shown in the photos below.



737-700 (the Aircraft)

737-500 (the type of aircraft on which the FO was previously on duty)

(1) History of decision on the arrangement for 737-500

The installation of an enhanced cockpit door became a requirement in November 2003 to protect cockpit from intrusions from the cabin side and prevent a hijacking attempt. As a result, air carriers were required to install the reinforced door for the cockpit of 737-500 which had been already been in regular services.

Following this, the Company decided the arrangement of the Door Lock Selector, upon consultation with Jamco Corporation (STC HOLDER*[18] for enhanced cockpit doors). The position was decided under the following conditions, with both maintenance and flight operation division personnel of the Company involved:

- The selector shall be accessible from both the left and right pilot seats.
- The selector shall be positioned at the same place for all Boeing 737 series aircraft including not only the 737-500 but also other models which were in service at that time.

In this modification, the position of the Rudder Trim SW was not changed.

(2) History of decision on the arrangement for 737-700

In introducing 737-700, the Company decided the arrangement of the AE Panel switches upon consultation with the Boeing, while reflecting comments mainly from its flight crew member. One of the preconditions was that 737-500 shall be retired in the near future. Another precondition was that flight crew member shall not be on duty aboard Both Type Aircraft in the same period of time.

In light of these preconditions, the Company did not consider providing a high-level type-to-type commonality in the location of the switches in AE panel for Both Type Aircraft, according to its explanation.

Specifically, the location was decided in accordance with the following matters for studies and conditions:

- If a high-level type-to-type commonality is provided, an adverse feeling may be caused in the use of 737-700 in the future.
- An optimum layout shall be studied while considering restrictions to be made in vacant space in instrument panels newly introduced to 737-700.
- The Rudder Trim SW shall be installed at a forward possible position taking physical features of all flight crew members into account ("Upward" in the photo on the left side in the previous page)

2.5.7 Displacement in Rudder Pedal and Rudder Trim Indicator Value

When the Rudder Trim SW is operated, the neutral position of the rudder is displaced to the left or to the right. Following this displacement, the rudder pedal position is also displaced.

According to the investigation results, the relationships with regard to the operating time of the Rudder Trim SW (T), the displacement amount (S) of the left rudder pedal front edge and the rudder trim indicator value (U) were as below:

Pedal displacement speed : $S / T = 1.5$ (mm/sec)

Indication value displacement speed : $U / T = 0.5$ (unit/sec)

Pedal displacement per indicator value unit : $S / U = 3$ (mm/unit)

In this serious incident, the FO operated the Rudder Trim SW CCW for a total of about 12

*18 "STC HOLDER (Supplemental Type Certificate Holder)" means a corporation who holds a supplemental type certificate (STC) which has to be obtained when an aircraft design with a type certificate (TC) granted is to be changed by a corporation other than those who obtained the TC for the aircraft.

seconds. Therefore, the left rudder pedal was displaced 18 mm forward during this time, while the right rudder pedal was displaced 18 mm backward. The indicator value was moved by 6 units.

2.5.8 Displacement Amount of Column

When the displacement of the Column was examined with the same type of aircraft, the displacement amount (the distance) of the upper end of the Column was about 3.5 cm for a movement which is equivalent to Control Column Position 2° (The amount of an elevator movement under autopilot to adjust a rudder displacement on a rudder trim action) as recorded on the DFDR at 22:48:40.

2.5.9 Details of CDU

The CDU for the right seat pilot is placed at a position closer to the right seat on the forward aisle stand located in the forward area of the AE Panel between the left and right seats, as shown in Photo 2. As to how to operate the CDU, the following provision is included in the Company's AOM (737-NG) 3-1-9:

(Preceding omitted) *While in flight (including taxiing), a data input into the CDU shall be basically performed by the PM in order to prevent both crewmembers from excessively concentrating on the CDU operations simultaneously. However, in using EXEC Key, the PF confirms details of an operation to be executed before pressing the key.*
(Following omitted)

2.6 Meteorological Information

2.6.1 Meteorological Information

There was no information indicating bad weather and other phenomena with regard to the operation of Flight 140 involved in this incident among weather-related information collected in the investigation. There was no information regarding bad weather in the statements of PIC, FO and CAs, either.

2.6.2 Information about Outside Brightness of the Night

Information about the moon at the place where this incident occurred on September 6, 2011 was as follows:

- Moon phase	:	8 (a waxing half moon)
- Time and direction of moonrise	:	13:42 / 115°
- Time and direction of moonset	:	00:40 (September 7) / 246°
- Culmination time and height	:	19:10 / 34°
- Direction and height at time of occurrence of this incident	:	230°/ 15° (Right behind the Aircraft, the angle of elevation at 15°)

2.7 Information on DFDR and Cockpit Voice Recorder (CVR)

The Aircraft was equipped with a DFDR (part number: 980-4700-042) made by Honeywell of the United States of America and a CVR (part number: 2100-1020-00) made by L3 Communications of the United States of America.

The records at the time of the occurrence of this serious incident were retained on the DFDR; therefore, the records on the CVR were overwritten, with no useful information left. The time was determined by correlating the VHF transmission keying signals in the DFDR records with the JST time signals recorded in the ATC communication records.

2.8 Flight Simulator-based Investigation

A flight simulator-based investigation was made to confirm (1) the Rudder Trim SW operation and the movement of the aircraft and (2) an operation of upset recovery and the movement of the aircraft.

Specifications of the flight simulator used are as follows:

Type	:	Thales Training & Simulation B737-700
Serial No.	:	61221558-040
Category and level	:	Full flight simulator level D
Simulated aircraft type	:	Boeing 737-700

2.8.1 Operation of Rudder Trim SW and Movement of Aircraft

An examination was made to confirm the movement of the aircraft when the Rudder Trim SW was operated in a level flight at an altitude of 41,000 ft at M 0.73 with autopilot (the LNAV/VNAV mode) and auto-throttle engaged.

(1) Maintaining attitude with autopilot (LNAV/VNAV mode)

The aircraft movement was confirmed by rotating the Rudder Trim SW CCW and by displacing the indication value on the rudder trim indicator by one unit each time. The results were as follows:

-1 to -3 units : The flight was continued as the direction and the altitude of the aircraft were maintained in a stable manner. At -3 units, the aircraft had a roll angle of about 2.5° to the right. The heading was deflected 1° CCW.

-4 units : The aircraft began to roll to the left and the roll angle continuously increased. According to the records, the angle increased to a maximum -128° and then, fluctuated violently. From around when the roll angle surpassed -45°, the pitch angle continued to decrease. The angle decreased to a maximum -85° and after that, it fluctuated widely.

As the roll and the pitch angle continued increase at -4 units, the confirmation was discontinued there, and examination of settings at -5 and -6 units were omitted.

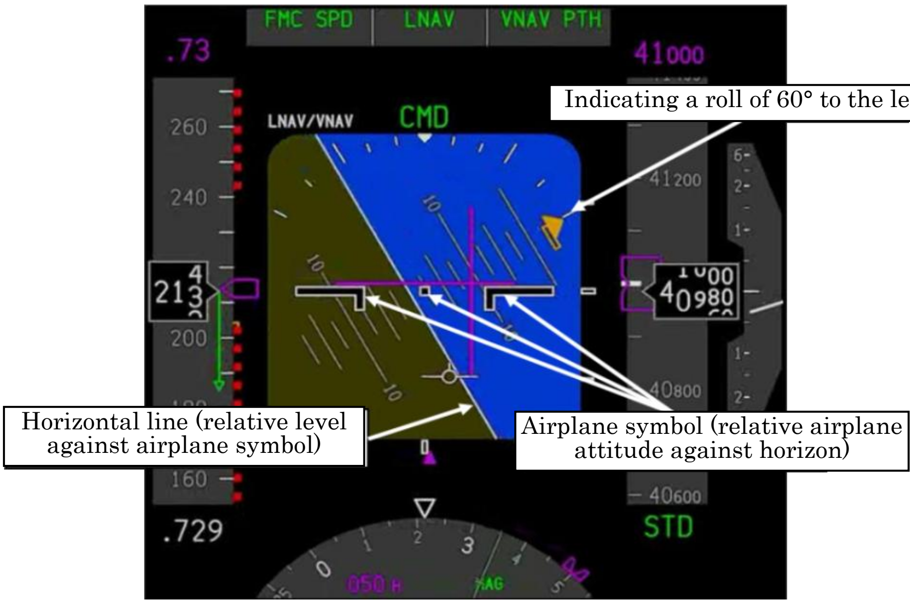
Based on these results, it was confirmed that a limit in maintaining the aircraft attitude with autopilot (the LNAV/VNAV modes) in response to the Rudder Trim SW operations was about -3 units (about half of the operation amount in this serious incident) in terms of the indicated value on the rudder trim indicator. It was also confirmed that once the attitude collapsed, it can not be restored with autopilot.

(2) Relationships between operation amount of rudder trim and roll angle

With the indicated value on the rudder trim indicator at -4 units, it took about 57 seconds for the roll angle to reach -60°.

When the Rudder Trim SW was operated for six seconds (through -3 units) and the operation was discontinued for two seconds and then, the switch was operated for 6 seconds (through -6 units), it took nine seconds for the roll angle to reach -60° after the second operation.

In the examination, it was confirmed that the longer the Rudder Trim SW is operated, the increasingly shorter the time required for the roll angle to be greatly increased.



Roll of 60° to the left (indication on flight simulator)

2.8.2 Upset Recovery Operation and Aircraft Movement

In order to replicate the flight condition of the Aircraft, the situation at the time when this serious incident occurred was simulated as below.

The Rudder Trim SW was operated in a condition where the aircraft is in a level flight at an altitude of 41,000 ft at M 0.73, at a roll angle of -0.2° to -1.7° and a pitch angle of 3.2° to 3.3°, with autopilot (the LNAV/VNAV modes) and auto-throttle engaged.

The Rudder Trim SW was operated for six seconds (through -3 units) and the operation was discontinued for two seconds and then, it was further operated for six seconds (-6 units).

The aircraft movement was confirmed in a situation in which recovery operations ((1) roll in shortest direction to wings level and (2) a rudder pedal operation withheld as long as possible) based on AOM 2-3-1, Non-Normal Maneuvers, to be described later in 2.9.3, were carried out from the time when the roll angle reached about -50°. Three recovery attempts were made in this simulation for confirmation, and the attitude could be recovered on all occasions.

Followings are an example of the records about the aircraft movement until an upset was recovered: (All times denote a lapsed time from the start of a recovery operation.)

Changes in the roll angle : About one second later, the roll angle began to move toward recovery after reaching about -55° as a maximum value to the left. Then, the angle became about -20° about five seconds later and level about 13 seconds later

Changes in the pitch angle : The pitch angle became about 4.1° in the nose up direction at the time when a recovery operation started and then, about two seconds later, a minimum angle of about 0.4° was recorded, and about seven seconds later, a maximum angle of 8.5° was recorded. After that, the pitch angle gradually became stabilized.

Changes in the heading : After the Rudder Trim SW was operated, the direction changed about 30° CCW by the time when an operation for attitude recovery started. Following this, the direction changed up to about 40° when the roll angle recovered to -20° and about 17 seconds later, the direction changed up to a maximum about 42°.

Altitude	: The altitude was 41,022 ft before the start of the Rudder Trim SW operation. About 7 seconds later, it became a minimum level of 40,912 ft.
Air speed	: The speed was M 0.7341 before the start of the Rudder Trim SW operation. It became a maximum of M 0.7359 by the time when the attitude recovery operation started, and about 12 seconds later, it became a minimum of M 0.7085.
Load factor	: The load factor became a maximum value of about 1.54 G by the time when the recovery operation started after the Rudder Trim SW operation. About six seconds later, the factor became about 1.52 G as a maximum value during the recovery operation and about 13 seconds later, it became a minimum value of about 0.82 G.

2.9 Information on Flight Crew Members Training

Of training programs for the flight crew members of the Company, those which have bearings on this serious incident are summarized in Attachment 3. The contents of training for flight crew members are reviewed and approved by the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism. Specifics of these programs are as follows:

2.9.1. Training Relevant to Operation of Door Lock Selector

Training relevant to Door Lock Selector operations at the Company had been carried out as part of the route training in the first officer upgrade training (See Attachment 3).

This training was carried out under the AOM provisions "3-4 Preliminary Preflight Procedure—PM" and "4-2-1 (9) Flight Deck Door Access System Test," in the day's first flight, by operating the door lock selector and checking its movement in the preflight procedure. Because the linkage between the Door Lock Selector operation and the opening and closing of the door must be confirmed in this inspection, the selector was operated from a place to the rear of the AE Panel. In training for the day's second and later flights, the place where the Door Lock Selector is set and whether there is any abnormal indication were visibly confirmed with the pilots sitting in their seats, in accordance with the AOM provision "3-4 Preliminary Preflight Procedure—PM."

An operation was not made for the Door Lock Selector with the pilots sitting in their seats in training carried out by the Company for its flight crew members.

Education for the placement of the cockpit switches in the differences training was made as self learning (e-learning and studies based on distributed materials). Trainees were educated with regard to the differences in the Door Lock Selector placement, but because the Company had no awareness about the possibility that Both Switches may be easily mistaken, it had not called attention to the risk of erroneously operating these switches.

Minimum required training items in the differences training are prescribed in the FSB*[19]

*19 "FSB", which stands for the Flight Standardization Board, is a review panel established to decide on pilot type rating standards (requirements for minimum training, check and others) for each of new or changed type certificates (TCs) for aircraft that require type ratings. The FSB Report is a report prepared by this review panel, and it is used in approving airlines training programs and pilot licenses. In general, each country which has civil aviation services establishes pilot rating standards and others for the her pilots, based on this report. Minimum training requirements for differences training are also prescribed in this report. The United States has a system in which the differences between each of the new models to be introduced by airline and the underlying model should be made clear based on a material for comparable studies, called the ODR Table, so that the differences can be picked up in detail and specifics of training items may be considered.

Report and a training requirement for transfer from the 737-500 to the 737-700 had a description calling for "Studies based on distributed materials." This resulted from a decision to install the enhanced cockpit door, as described in 2.5.6 (1), on 737-700 for the first time among the 737 series aircraft manufactured by the Boeing Company.

The Company had used the FSB Report as a reference material in its studies about specific training and review items to be applied to 737-700 differences training. The Door Lock Selector for 737-500 had already been in use after it was installed upon consultation with the STC HOLDER. Its shape, operability and other features were similar to those of the Door Lock Selector planned to be introduced for 737-700. As a result, education for the Door Lock Selector in differences training for transfer to 737-700 was carried out as self learning (e-learning and studies based on distributed and other materials), just like training for transfer from the 737-500 to the 737-700 based on the FSB Report. Detailed comparison and studies on the differences between the base aircraft and the newly introduced aircraft, which are equivalent to those in accordance with the system so-called ODR Table in the United States, were not implemented, because such requirements are not institutionalized in Japan.

The Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism reviewed the appropriateness of specifics of the differences training for 737-700 of the Company after receiving its explanation about the type-to-type differences.

Until before the erroneous switch operation in this serious incident came to light, any case in which a pilot nearly operated Both Switches by mistake had not come up for discussion among personnel at the Company, according to its explanation. The Company had conducted "check flight" after this serious incident and reported its implementation result. At the same time, targeting the all flight crew members who had performed the "check flight," the Company conducted a questionnaire survey titled as "Information sharing about switches having possibility to be mistakenly operated" for the purpose of improving the quality of the entire. This questionnaire was a type of free description about the switches and the like which may be considered possible to be mistakenly operated in various aircraft models through each flight crewmember's experience. As a result, information for various combinations of switches having possibility to be mistakenly operated was collected. Among them there were replies such as "The location of the Door Lock Selector for the 737-500 is very close to that of the Rudder Trim SW for the 737-700, which may cause possible misrecognition when transferring to 737-700," and "It may be hard to escape from the preconceived thought because these two switches are the same type in terms of a momentary rotary switch."

2.9.2 Training for Rudder Trim SW Operations

Training in which the Rudder Trim SW needs to be operated had been carried out in such training as the first officer upgrade training, the recurrent training and the differences training, mainly by using a flight simulator. This kind of training was implemented in training for a subject for single engine maneuvering. In this training, the trainee frequently operated the Rudder Trim SW.

The FO operated the Rudder Trim SW in the differences training performed in May 2011. Minimum required training items in differences training are prescribed in the FSB Report. But Rudder Trim SW operations are not classified as a training requirement for transfer from the 737-500 to the 737-700.

2.9.3. Upset Recovery Training

Training for first officers for recovery from an unusual attitude (Upset Recovery Training) had been carried out in the recurrent training with a flight simulator. This training had an achievement target of recovering from an upset under a procedure prescribed in AOM "2-3-1 Non-Normal Maneuvers." The condition of an unusual attitude (Upset) and a recovery procedure are described as below. Because this recovery procedure is based on the Flight Crew Operations Manual which is provided by the Boeing Company, the procedures established by airlines were almost identical to each other in their contents for the same type of the aircraft.

Upset recovery

"Upset" can be generally defined as unintentionally exceeding the following conditions:

- *Pitch attitude greater than 25° nose up, or*
- *Pitch attitude greater than 10° nose down, or*
- *Bank Angle greater than 45°, or*
- *Within above parameters but flying at airspeeds inappropriate for the conditions.*

The following techniques represent a logical progression for recovering the aircraft. The sequence of actions is for guideline only and represents a series of options to be considered and used depending on the situation. Not all actions may be necessary once recovery is under way. If needed, use pitch trim sparingly. Careful use of rudder to aid roll control should be considered only if roll control by ailerons is ineffective and the aircraft is not stalled

These techniques assume that the aircraft is not stalled. A stalled condition can exist at any attitude and may be recognized by continuous stick shaker activation accompanied by one or more of the following:

- *Buffeting which could be heavy at times*
- *Lack of pitch authority and/or roll control*
- *Inability to arrest descent rate.*

If the aircraft is stalled, recovery from the stall must be accomplished first by applying and maintaining nose down elevator until stall recovery is complete and stick shaker activation ceases.

Nose High Recovery

(Omitted)

Nose Low Recovery

PF	*PM*
- Recognize and confirm the situation	
- Disengage autopilot and autothrottle *- Recover from stall, if required* *- *Roll in shortest direction to wings level (unload and roll if bank angle is more than 90°)* *- Recover to level flight:* *-- Apply nose up elevator* *-- *Apply nose up trim, if required* *-- Adjust thrust and spoiler as required*	*- Call out attitude, airspeed and altitude appropriately throughout the recovery* *- Verify all required actions have been completed and call out any omissions.*

Warning: *Excessive use of pitch trim and or rudder may aggravate an upset situation or may result in loss of control and/or high structural loads.

Specifics of an unusual attitude to be set into a flight simulator in Upset Recovery Training conducted out by the Company in its recurrent training are as follows: An upset was simulated by combining (1) and (3) or (2) and (3). These combinations were decided by an instructor in charge on the date of training.

(1) *Excessive climb angle +30°* (pitch angle +30°)
(2) *Excessive dive angle -15°* (pitch angle -15°)
(3) *Excessive bank angle right / left +115°/ -115°* (roll angle ±115°)

The Company had conducted its Upset Recovery Training at an altitude of 10,000 ft or lower. It had not conducted this kind of training with a stall warning during recovery.

In the flight simulator-based training before starting Upset Recovery, instructors utters such words as "Close your eyes" to trainees. Therefore, the trainees could anticipate that the next exercise would be Upset Recovery.

Among air carriers belonging to the ANA group (All Nippon Airways, Air Japan and ANA Wings) and those belonging to the JAL group (Japan Airlines, J-Air, Japan Transocean Air, JAL Express, Ryukyu Air Commuter, Japan Air Commuter and Jetstar Japan), no company had conducted Upset Recovery Training at an altitude of 25,000 ft or higher (hereinafter referred to "High Altitude") (as of October 1, 2013).

2.9.4 Training for High Altitude Operations

Training by the Company for High Altitude operations had been carried out as lectures and flight simulator-based practices in its bridge training (See Attachment 3) and as flight simulator-based practices in its recurrent training.

The Bridge Training Manual of the Company had prescribed as below for ground school training for High Altitude operations and flight simulator-based training.

Ground School training (Omitted)

(4) Operational performance : (21+00) (Omitted)
(5) Jet Engine : (14+00)

Bridge Training Objective

This bridge training shall be carried out by using a B737-500 model flight simulator, for the objective of providing abilities to deal with the following situations to trainees in first officer upgrading for fourth-generation Jet aircraft. (Omitted)

Bridge Training Outline

1) High Altitude and High Speed Operations Particular to JET Aircraft
Training outline : High Altitude Operation (Experience subject)
Training objective : Knowledge acquired (Experience for High Altitude Operation)
Training subject : Flight Characteristics

2) Maneuver Characteristics of Jet Aircraft
Training outline : JET Maneuver (experience subject)
Training objective : Technical Skills acquired
(Features of swept-back wing and Jet Engine and understanding of these matters)
Training subject : Flight Characteristics (Omitted)

Knowledge about "flight characteristics in cases where an airplane flies at a High Altitude and at a high speed” was provided in ground school training for bridge training.

The Company had conducted the following experience practices as “High Altitude Operations” in flight simulator-based training:

- Mach / IAS Change Over
- Recovery Mach Buffet / Speed Buffet / Turn “G” Buffet
- EMERGENCY DESCENT
- ENGINE FLAME OUT then DRIFT DOWN

In the recurrent training, flight simulator-based training for subjects such as “DRIFT DOWN” (a descent in a situation which one of the engines is in trouble) and “RAPID DECOMPRESSION and EMERGENCY DESCENT” (an emergency descent in a case in which the cabin pressure is rapidly decompressed) are conducted at a High Altitude, but any of these practices are carried out in a manner in which a descent target altitude is set in advance on autopilot.

Training for a case in which the pilot must deal with the situation by disengaging autopilot while flying at a High Altitude was carried out as “Traffic Avoidance” (prevention of collision).

2.9.5 International Trend in Flight Crew Training

(1) Upset Recovery Training

The following provision is prescribed in Airplane Upset Recovery Training Aid*[20] Revision 2 (November 2008), SECTION 1 Overview for Management, 1.1 General Goal and Objective:

The goal of the Airplane Upset Recovery Training Aid is to increase the pilot's ability to recognize and avoid situations that can lead to airplane upsets and improve the pilot's ability to recover control of an airplane that has exceeded the normal flight regime. This can be accomplished by increasing awareness of potential upset situations and knowledge of flight dynamics and by application of this knowledge during simulator training scenarios.

Section 3 “Example Airplane Upset Recovery Training Program” in the training aid describes the performance limitations of simulators and their influences as below.

However, airplane upsets often will involve g load excursions and these cannot be duplicated within the simulator environment. They have not been designed for the purpose of replicating upsets, and as such, whenever maneuvering involves vertical or lateral loading, the realism degrades. This is a very important point for both the trainee and the instructor. Instructional content must acknowledge this limitation and fortify instructional content based upon the trainee’s prior flight experience with g load excursions. Without this instructional input, a positive learning goal can be transformed into a negative learning experience.

Meanwhile, the FAA describes the evaluation of simulation training systems for Upset

*[20] “Airplane Upset Recovery Training Aid” is an auxiliary educational material as a resource for upset recovery training, which has been jointly developed by aircraft manufacturers, aircraft operators, pilot associations, flight training organizations, and governments and supervisory authorities in the world. The training aid is used in training aimed at lessening accidents resulting from uncontrollability to be caused in an upset. The training involved was developed for an upset recovery at a High Altitude and a relevant educational material was added to the latest Revision 2.

Recovery Training as below in Flight Simulation Training Device Guidance Bulletin 11-05[*21] (Dec. 20, 2011) “FSTD Evaluation Recommendation for Upset Recovery Training Maneuvers.”

Attachment A:

Upset Recovery Maneuver Evaluation

1. ***Basic Requirements:*** *The basic elements for the qualification of upset recovery training (URT) maneuvers are:*
   - ***a.*** *To verify that the FSTD can be expected to remain within its designed validation envelope during the execution of available upset recovery training tasks.*

Example of Instructor URT Feedback Display

   - ***b.*** *To provide the instructor/evaluator with a minimum set of feedback tools to properly evaluate the student's performance in accomplishing an upset recovery training tasks.*

     (Omitted)

(The rest is omitted)

Two screens placed in the upper part of the example feedback display above show maneuver envelopes.

On November 5, 2013, the FAA adopted a revised regulation calling on U.S. airlines to drastically improve their flight crew educational training programs in five years. This followed an accident on February 12, 2009, in which a Colgan Air DHC-8-400 stalled and crashed (All 49 people aboard were dead, as was a person on the ground.). The revision was aimed at significantly strengthening the contents of training programs for stall and upset situations and making it an obligation to carry out simulator training for stall and upset recognition, prevention and recovery operation. Moreover, the FAA is also considering revising a related regulation in order to make simulator training more effective so that stall or upset situations can be simulated in a more accurate and realistic manner.

Just like the FAA, EASA is considering revising a relevant rule calling for improving upset recovery training. (An Air France A330 which crashed (which left all 228 people aboard

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*21 “Flight Simulation Training Device Guidance Bulletin 11-05” is a guidance document prepared by the FAA for the Flight Simulation Training Device (FSTD: simulation training system) to be used for practices for upset recovery training. This provides guidelines for FSTD evaluation to FSTD manufacturers. At present, this is a guidance document and there is no obligation for FSTD manufacturers to implement these guidelines.

dead in the June 1, 2009) in the same year the Colgan Air aircraft mentioned above was the case with the Colgan DHC-8-400 accident, the Air France aircraft stalled and crashed as it was unable to recover from an upset.).

(2) Training for Response to Unexpected Situations

In light of the accidents failed to recover from upset conditions in recent years, it was confirmed that some pilots had lacked abilities to deal with unexpected situations (in particular, an initial state of stall). Therefore, the need to enhance pilots' readiness to deal with unexpected situations came to be recognized as urgent challenges for Upset Recovery and Stall Recovery, and based on this recognition, efforts are being made internationally to strengthen measures to this end.

The FAA AC120-109 (Stall and Stick Pusher Training) published in August 2012 is a recent product of these international efforts. Work on this AC was joined by aircraft manufacturers including the Boeing and the Airbus, major U.S. and European airlines, international pilot associations and others. In this AC, the importance of training for unexpected situations is described as below.

Startle *has been a factor in stall incidents and accidents. Although it may be difficult to create the physiological response of startle in the training environment, if achieved, startle events may provide a powerful lesson for the crew. The goal of using startle in training is to provide the crew with a startle experience which allows for the effective recovery of the airplane. Considerable care should be used in startle training to avoid negative learning.*

2.9.6 Safety Education for Assumed Situation of Abnormal Condition with Single Pilot in Flight

Because the aircraft is designed to be operated by two pilots, the Company has not carried out safety education for its flight crew member under a scenario that the aircraft had gone into an abnormal situation while a single pilot is in flight, that designed to let trainees monitor the flight condition and prevent an abnormal situation from occurring, or enable them to deal with these occurrences in an appropriate manner. As of November 1, 2013, any of the ANA group and the JAL group airlines did not implement safety education under a scenario assuming an abnormal situation while a single pilot is in flight.

2.10 Information about Actions Taken after Occurrence of the Serious Incident

2.10.1 Inspection of Aircraft

After the Aircraft arrived at Tokyo International Airport, the Company performed a special inspection of the Aircraft, as described below, following the occurrence of this serious incident:

(1) September 6, 2013

After the Aircraft entered the spot, the Mechanic A obtained the following information from its flight crew members aboard the Aircraft.

- The FO mistakenly operated the Rudder Trim SW while attempting to unlock the cockpit door.
- The aircraft banked and it became a nose down, and then a state of Over-Speed. It was not certain unknown how much the excess speed was.

Later, the Mechanic B performed a situation confirmation at the Pilot Office and obtained the following information from the flight crew:

- The aircraft banked to the left at an altitude of about 41,000 ft. Because the bank further deepened, the FO implemented connective actions, which lead to the activation of an over-speed warning.

Upon receiving the report from the flight crew members, Mechanic performed "a Special Inspection which is required when the speed exceeded the Maximum Operating Limit Speed (M_{MO}) (Paragraph H)" (details to be described later), prescribed in the Aircraft Maintenance Manual[*22] PART II of the Company (hereinafter referred to as "the AMM") and confirmed that there was no abnormality. Mechanic then uninstalled the QAR of the Aircraft and retained it. Since numerous items had to be checked in this special inspection, it would take a long time. If the start of the inspection was delayed, the flight schedule for the following day might be influenced. Accordingly, without confirming whether the speed actually exceeded the M_{MO} based on the QAR data, Mechanic decided to perform the special inspection out of a safety consideration.

(2) September 7, 2013

The Aircraft was operated on four flights as scheduled.

An analysis of the QAR data carried out by the Flight Operations Department upon receiving the PIC's report found that the vertical load factor had reached +2.68 G in excess of the limit load factor (+2.50 G) when this serious incident occurred.

After this was confirmed, Mechanic performed "a Special Inspection which is required when the load factor exceeded the limit load factor (Paragraph J)" (details to be described later), prescribed in the AMM, and found no abnormality. Thereafter, the Aircraft was operated one flight.

(3) September 8, 2013

As the Engineering & Maintenance Department further analyzed the QAR data, it was found that the stick shaker had been activated. Therefore, Mechanic performed "a Special Inspection which is required when the aircraft stalled (Paragraph I)" (details to be described later), prescribed in the AMM, and found no abnormality. The Aircraft was not operated any of the day's scheduled flights.

2.10.2 Statements of Persons Involved

(1) PIC

After the Aircraft landed and entered the spot, the PIC received a call from the Mechanic A via service interphone and he was asked whether there was any problem during the flight. Therefore, he said there might have been an over-speed and an over-bank.

After the passengers disembarked, the PIC explained the situation to the Mechanic A who entered the cockpit. As detailed data were not available, the PIC asked him to check details anyway because there were the possibilities of over- speed and over-bank.

Thereafter, while keeping in touch with the senior manager of B737 section, the PIC returned to the Pilot Office and devoted himself to preparing a report. Then, the Mechanic B

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*22 "Aircraft Maintenance Manual" is one of the documents attached to a Maintenance Manual (which describes the staff engaged in maintenance, maintenance station, procedures for maintenance, procedures for performing maintenance and so on) which must be prepared by airlines and approved by the Minister of Land, Infrastructure, Transport and Tourism pursuant to the Civil Aeronautics Act of Japan. It describes the maintenance method for aircraft and the repairing procedures in case of troubles based on engineering documents for the maintenance prepared by the manufacturer.

came up and asked him about the situation. The PIC thought that he should not talk about matters which cannot be fully explained. Therefore, he explained only about the possibilities of over-speed and over-bank, and said that the QAR must be analyzed to obtain specific data. The PIC remembered that the Mechanic B then accepted his explanation and left the Pilot Office.

(2) FO

The Mechanic B was in the Pilot Office. Because the PIC was asked about the situation, he replied that the speed of the Aircraft might have exceeded a limit and it might have excessively banked, though it was not certain how much they were. The FO vaguely remembered that the Mechanic B replied "We will check it out."

The FO made reports to the PIC about the following mutters to share relevant information with him: The FO was instructed by the Controller to change the route and proceed direct to PQE and he accepted it; he received a signal from the PIC for unlocking the cockpit door while he was inputting the data to the CDU; he mistakenly operated the Rudder Trim SW; he rotated the Rudder Trim SW, just like rotating the Door Lock Selector, with a feeling of 737-500.

Later, the FO prepared a report along with the PIC at the Pilot Office. Flight log data were inputted by the PIC. He also inputted data about the suspected over-speed and over-bank.

At around 00:30, the FO received a phone call from the senior manager and explained about the situation as follows: an occurrence happened when the PIC tried to reenter the cockpit after use the restroom; he operated a wrong switch; the attitude of the Aircraft became abnormal after the over-bank; the speed of the Aircraft exceeded the limit; and the Aircraft descended from 41,000 ft to 36,000 ft.

Because the senior manager allowed the FO to go home, he left office at around 01:00.

(3) Senior Manager, B737 Section

At 23:48, the senior manager, while he was sleeping, received a report on his mobile phone from the PIC that an irregular flight occurred. The senior manager remembered the contents of the report from the PIC as below.

"An occurrence happened at an altitude of 41,000 ft, 80 nm west of Niijima when the PIC tried to open the cockpit door after returning from the restroom.

The PIC heard an over-speed warning and a bank angle alert across the cockpit door. Later, he entered the cockpit and took over the duties as PF. He did not see specifically what happened in the cockpit, because he was not there. The FO explained that he erroneously operated the Rudder Trim SW, mistakenly recognizing it as the Door Lock Selector. When he took over the duties as PF, the aircraft had kept an altitude of 36,000 ft. After landing, the PIC asked the Mechanics to take measure which is required when the aircraft speed exceeded the MMO."

2.11 Information on Provisions for Inspection and Maintenance

2.11.1 Inspection in Cases of Severe Turbulence, Stall, Design Speed Excess and Others

Inspection in cases of severe turbulence, stall, design speed excess and others, prescribed in the AMM of the Company, can be outlined as follows:

(1) If the airplane speed exceeded the MMO by M 0.02 or more

Perform Examine Airplane Structure (H) (hereinafter referred to as "Paragraph H")

(2) If the pilot reports severe turbulence and the load factor exceeded +2.5 G

In addition to Paragraph H, perform Cabin Inspections (J) (hereinafter referred to as "Paragraph J")

(3) If a stall occurred after the initial buffet condition (a condition with vibrations to be caused when airflow separates from the wing surface) or stick shaker activation.

Perform Stall (After Initial Buffet or Stick Shaker) Structural Inspection (I) (hereinafter referred to as "Paragraph I")

These inspections were to be implemented after an examination upon receiving a report from a PIC.

The Company inquired these inspections of the Boeing Company and confirmed that all inspection items listed in Paragraph I were included in Paragraph H (when inspections were performed under Paragraph H, there was no need to carry out inspection items once again under Paragraph I.)

Inspection items listed in Paragraph H, Paragraph I and Paragraph J and their mutual relationships are as described in the table below:

Items of Special Inspections Performed by the Company

Details of Inspection	Paragraph H	Paragraph I	Paragraph J
(1) Examine the external surface of fuselage. (Portions: main landing gear storage bay keel beam and AFT portion of fuselage)	○		
(2) Examine the external and internal structure of the fuselage (rear pressure bulkhead and its aft portion). (Including inspection of linkage of horizontal stabilizer)	○	○	
(3) Examine the horizontal stabilizer external surfaces for sign of buckling.	○	○	
(4) Examine the elevator external surfaces.	○	○	
(5) Examine the vertical stabilizer external surfaces.	○		
(6) Examine the rudder for sign of buckling.	○		
(7) Examine the external surfaces around the top and bottom wing-to-body attachment.	○		
(8)Examine the external surface of the wing at the skin splices.	○		
(9)Examine the wingtip fairings.	○		
(10) Examine the wing control surface.	○		
(11) Make sure the flight controls move freely.	○	○	
(12) Examine the engine strut panels, doors and lower surface of the nacelle cowling.	○		
(13) Examine fuel and other type of fluid leakage	○		
(14) Examine the landing gear doors, and the inspection blowout doors and access door	○		
(15) Visual inspection the cabin ceiling panel and baggage stow bin, etc.			○

2.11.2 PIC Report

2-4-2 (3) of the OM prescribes as below as to procedures for cases when the PICs report to Mechanics:

The captain shall enter in the Journey Log & Radio Log some necessary matters regarding the condition of the airplane in flight and, if there is anything abnormal, he/she shall notify the maintenance personnel.

3. Air Safety Report (3) "Cases in which the Company requires related personnel to report" prescribed in S-8-5 of the OM includes the following provisions pertain to this incident:

3-3-6 Excess of operational limit: If the excess was just momentary and does neither damage the aircraft or its essential systems nor affected controllability.
3-3-13 If Stall warning functions activated or Buffet occurred.
3-3-16 If the captain encountered Severe Turbulence.
3-3-17 If the captain encountered unintended change of altitude, speed, or attitude of aircraft.

2.11.3 Maintenance Work and Handling of QAR

The Company had prepared the "Flight Record Handling Manual" for retention and analyses of the flight data (DFDR, QAR). This manual was used when the flight data must be analyzed as part of maintenance work.

The Line Maintenance Center had been allowed to use a flight data analysis system and user accounts based on the manual.

2.12 Other Necessary Information

2.12.1 Shape of Rudder Trim SW of the Boeing Aircraft

The Rudder Trim SW for types of aircraft designed and manufactured by the Boeing other than the 737 series aircraft has a cylindrical shape with no brim, as illustrated in the photo of that for a 777 series aircraft at right.

Rudder Trim SW for 777

2.12.2 Fly First

"Fly First" denotes a code of conduct for flight crew members that they should behave while giving top priority to things necessary to fly the aircraft safely. In other words, they must continuously operate and control the aircraft at any situation and continue to take necessary actions for monitoring. This represents common understanding among flight crew members working with air carriers including the Company.

At the time when this serious incident occurred, the Company had prescribed in the AOR (Airplane Operations Reference: the supplement or explanation for the AOM contents) that "Continue to Fly" shall be the first thing for safety in any situation and "Fly First" shall have top priority for all operations, as the policy for establishing the operation procedures.

The provision 4.1.1 of the then POLICY MANUAL*[23] prescribed by All Nippon Airways is

*[23] "POLICY MANUAL" is an in-house manual established by air carriers at their own disposal. The manual governs mainly flight crew member, and prescribes basic matters and others regarding the company's flight philosophy of business and the whole of flight operations. Flight crew are required to behave in accordance with the provisions in this manual.

quoted below for reference.

4-1-1 Fly First

Flight crew members must control the aircraft and conduct the necessary monitoring of aircraft control at all times.

(1) The PF must make efforts to maintain an appropriate aircraft attitude, speed, altitude and configuration via steering operation.

(2) The PM must monitor the above operations to the fullest extent possible, and if the PM has any doubt, they must make assertions without hesitation.

(3) The PIC must clearly designate flight priorities and the distribution of responsibilities among the flight crew members.

2.12.3 Rules Relevant to PIC's Exit from Cockpit

The Company had prescribed rules in its OM as below for the situation which one pilot leaves the cockpit during flight:

8-9 Authority and Responsibility of the Captain (Omitted)

(7) When the captain leaves the cockpit, he/she shall be required to give instructions to his/her proxy about items anticipated. The captain will receive reports rerated to the operations during his/her absence immediately upon his/her return. (The rest is omitted)

2-3-7 Use of Oxygen Mask by Flight Crew Members (Omitted)

(2) In the event that one of the pilots leaves his/her seat in the cockpit at an altitude of 25,000 feet or above, the other pilot shall use his/her oxygen mask until he/she comes back.

The Company had no specific provision about basic matters which must be complied with in order to maintain safe operations in the situation which one of the flight crew members leaves the cockpit during flight and the other flight crew remains in the cockpit (hereinafter referred to as "Basic Compliance Matters when a single crew member continues flying").

Meanwhile, as for situations with only one pilot in the cockpit, the following description is included in ICAO FRMS[*24], Manual for Regulators, Appendix B, Procedures for controlled rest on the flight deck, for a case in which one pilot takes a rest: Appendix B represents a note for a case in which one pilot takes a rest in the cockpit. Considering that one pilot takes a rest, eventually means that the aircraft has to be operated by a single pilot, and cases in which an emergency occurred in this situation are similar to those in which an emergency occurred when one pilot remains in the cockpit, the relevant part of the manual is quoted below.

- It should only be used during low workload phases of flight (for example, during cruise flight).

- The autopilot and auto-thrust systems (if available) should be operational.

- Any routine system or operational intervention which would normally require a cross check should be planned to occur outside controlled rest periods.

- Hand-over of duties should be reviewed.

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*24 "FRMS (Fatigue Risk Management System)" is a tool for continuously monitoring and managing fatigue-related safety risks by using the relevant data, for the purpose of helping personnel performing their duties to maintain an appropriate awareness level, based on scientific theories, knowledge and flight experiences.

- During controlled rest, the non-resting pilot must perform the duties of the pilot flying and the pilot monitoring, be able to exercise control of the aircraft at all times, and maintain situational awareness.

- Procedures for controlled rest on the flight deck should be published and included in the Operations Manual.

2.12.4 Cockpit Entry Procedure in Flight

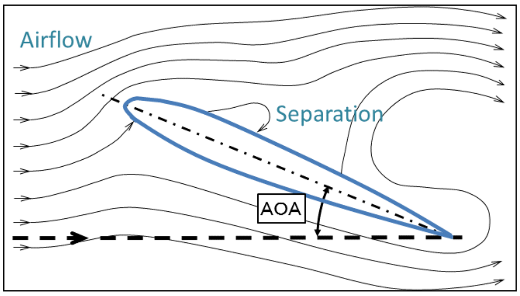
About a procedure for entering the cockpit during flight, OM 6-2 (2) stipulated, "Locking and unlocking of the door shall be made under permission of the PIC and according to the specified procedures."

The entry procedure for the day was specifically decided by the PIC and explained to the crew members. The procedure called for sending a predetermined signal when a flight crew member enters the cockpit.

2.12.5 AOA and Stick Shaker

A state of stall means a phenomenon in which, following an increase in the AOA, airflow on the upper side of wing separates from the surface, causing the lift to decrease, and a significant drag (a force which reduces the aircraft speed) is generated. The AOA in these situations is called the stall angle (AOAs).

The AOAs has a relation to the Reynolds number (a value which shows whether the inertia force or the viscous force is more dominant, in a fluid which flows around an object. The larger this value is, the more dominant the inertia force is.)



A large AOA and separation of airflow

When the AOA exceeds the AOAs, the flow will separate from the surface of the wing, as illustrated in the figure at right, and the lift will be lost (Stall).

Many stall warning systems established stall warning angles (AOAss) with a sufficient margin against AOAs, in order to prevent the aircraft entering a state of stall inadvertently and stall warning is designed to be activated when the measured angle of attack exceeds the AOAss.

The design described above was adopted for the stall warning system aboard the Aircraft, with a stick shaker.

2.12.6 Over-speed Warning

The operating speed of aircraft is determined based on the design speeds. The design speeds must satisfy requirements for the strength of aircraft and these are established as design criteria with which the aircraft can fly safely under such conditions as buffets caused by separation of airflow on the wing surface can be controlled in a certain range.

The maximum operating limit speed (VMO / MMO) is the speed which should not be exceeded intentionally in any flight stages, such as climb, cruise and descent. In general, VMO / MMO are set at levels well below the design dive speed (VD / MD: a maximum speed in design speeds). The MMO of the Aircraft is M 0.82 and its MD is M 0.89.

The over-speed warning is issued as a cracker sound for the pilot when the aircraft speed exceeds the VMO / MMO.

2.12.7 Aircraft Condition Monitoring System (ACMS) *25

Although an ACMS had been introduced for the Aircraft, it was designed to mainly monitor the conditions of engines so that maintenance can be made properly. The system had no function of informing the flight crew members or Mechanics as to the Aircraft might have been in states of speed excess, load limit excess and near stall (with the stick shaker activated) just like the situation in the serious incident.

3. ANALYSIS

3.1 General

3.1.1 Qualifications and Physical Condition of Flight Crew Members

The PIC and the FO held both valid airman competence certificates and valid aviation medical certificates. As described in 2.1.2 (1) and (2), it is highly probable that they were in good physical conditions at the time when this serious incident occurred.

3.1.2 Airworthiness Certificate of the Aircraft

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

Because there were neither data nor statements indicating any discrepancy with the Aircraft, it is highly probable that the condition of the Aircraft had nothing to do with the occurrence of this serious incident.

3.1.3 Relations to Meteorological Condition

It is highly probable that the meteorological condition on the day had nothing to do with the occurrence of this serious incident.

3.2 Analysis of Switch Operations by the FO

As described in 2.1.1 and 2.1.2 (2), it is highly probable that this serious incident was triggered by the fact that the FO erroneously rotated the Rudder Trim SW with the intention to rotate the Door Lock Selector; as a result, the Aircraft fell into a dive after undergoing various events. As described in 2.5.3, the Both Switches had been located on the AE Panel.

It is certain that unless the Rudder Trim SW was erroneously rotated, the whole of the subsequent events had not occurred. Therefore, the circumstances around the FO's switch operations were analyzed in detail.

3.2.1 History of Erroneous Operation on Rudder Trim SW

As described in 2.1.1 and 2.1.2 (2), it is highly probable that developments leading up to the FO's errors in operating the Rudder Trim SW occurred almost in the sequence as follows:

- The PIC left the cockpit, and then the FO was alone in operation
- The FO received instructions from the Controller to change the route and inputted necessary data to the CDU.

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*25 "Aircraft Condition Monitoring System" collects data about the engines, the auxiliary power unit and various onboard systems and when something happened, leaves records on the QAR, illustrates them on the display and prints them out on the printer, and provides reports to ground personnel for maintenance and other jobs. This system is built as an application software on existing platforms such as onboard hardware and system core software. The monitoring systems are introduced with their design to be decided by airlines by themselves.

- When the FO was inputting a route change data to the CDU, he received a signal from the PIC to return to the cockpit.
- The FO inputted a command to execute the route change to the CDU.
- The FO confirmed on the monitor screen the PIC waiting for the door to be unlocked.
- The FO erroneously rotated the Rudder Trim SW with the intention to rotate the Door Lock Selector

3.2.2 Memories of operation about Door Lock Selector for 737-500

As described in 2.4.2, the 737-500 is the first aircraft on which the FO served as a first officer. Therefore, it is probable that he received sufficient training about the location of switches in the cockpit and how to operate them as well. After completion of the training, the FO was on duty aboard 737-500 for about four years and three months from January 24, 2007 to May 8, 2011, but as described in 2.1.2 (2), during this period, PICs left the cockpit during flight at a frequency of about once in a half year. It is probable that his behavior in operating the Door Lock Selector on these occasions further came to stay with him as a series of memories of operation — extend his hand, look, depress, rotate, hold. As a result, as described in 2.1.2 (2), it is probable that he had not erroneously rotated the Rudder Trim SW, nor was he about to do so, until the occurrence of this incident (while he was on duty aboard 737-500).

However, as described in 2.5.5 (1), the occasions for the FO to operate the Door Lock Selector during flight since he transfer to 737-700 were preflight inspections in which pilots operate the selector while standing at a place to the rear of the AE Panel, not sitting in their seats, when they do the job for the day's first flight. As described in 2.1.2 (2), this was the first occasion in which the FO was going to operate the Door Lock Selector during flight, since he began his duties aboard 737-700, according to his statement. Therefore, it is probable that there were not sufficient opportunities for him to correct his memories of operation about the Door Lock Selector for the 757-500 when he was on duty aboard 737-700. .

As described in 2.1.2 (2), the FO rotated the Rudder Trim SW for the 737-700 while depressing it, just like the Door Lock Selector, as the switch happened to be located at almost the same place as that of the Door Lock Selector for the 737-500, according to his statement. Therefore, it is probable that the FO erroneously operated the switch in the latest case as his memories of operation about the Door Lock Selector for the 737-500 remained uncorrected.

Based on these findings, it is probable that the memories of operation of the FO led to his erroneous operation.

3.2.3 Similarities between Both Switches

As described in 2.1.2 (2), the FO, with an intention of rotating the Door lock Selector, looked at the Rudder Trim SW, and then, depressing and rotated the switch, just like the Door Lock Selector, according to his statement. As described in 2.9.1, in a questionnaire survey conducted by the Company after this serious incident, the replies "The location of the Door Lock Selector for the 737-500 is very close to that of the Rudder Trim SW for the 737-700, which may cause possible misrecognition when transferring to 737-700" and "It may be hard to escape from the preconceived thought because these two switches are the same type in terms of a momentary rotary switch" were collected.

From the above, there is a possibility that the Both Switches are likely to be misrecognized despite the differences in the shape as described in 2.5.4 and 2.5.5. Therefore, the two switches were analyzed in detail as follows.

(1) Placement of Both Switches for Both Types of Aircraft

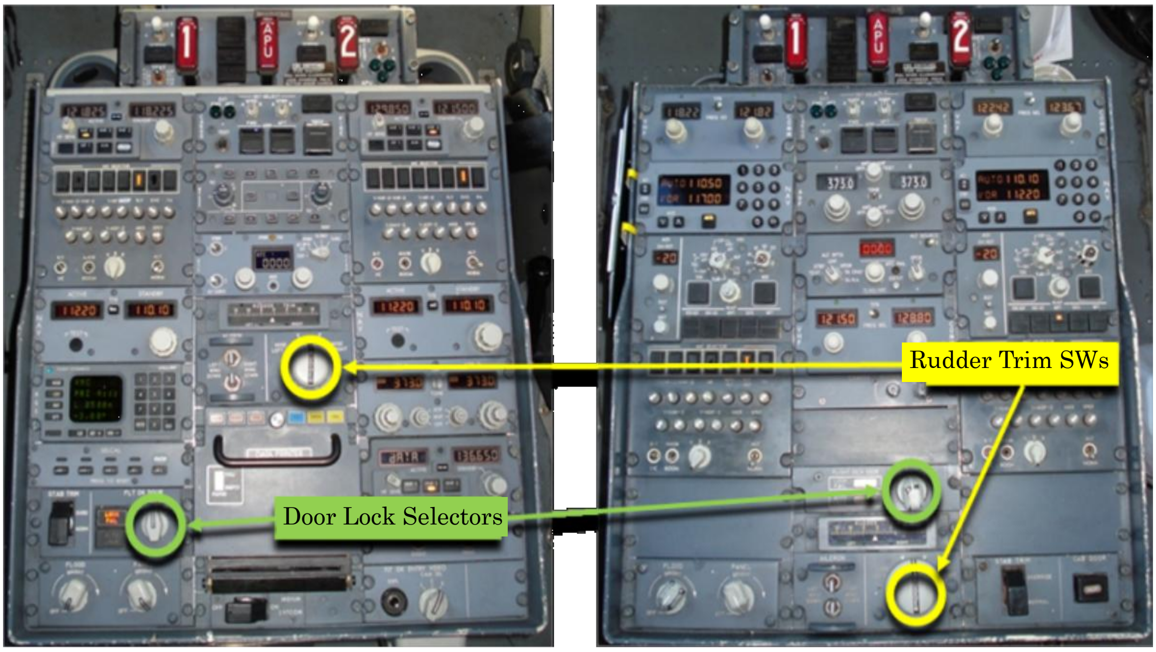
As described in 2.5.6, the two switches were placed on the AE Panel for the 737-500 on which the FO was previously on duty, just like those for the 737-700.

As shown in the Photo 2 and described in a sequence remark at 22:48:25 in 2.1.1, it is probable that the FO, who was sitting in the right seat, executed the job to change the route on the CDU with his left hand, and then, while confirming the PIC on the monitor screen, tried to operate the Door Lock Selector by moving his left hand backward.

Meanwhile, as described in 2.5.3 and 2.5.6, the Rudder Trim SW for the 737-700 was located "near the center of the AE Panel" a little behind and on the left of the FO's seat. This means that the Door Lock Selector for the 737-500, for which the memories of operation remained with the FO, is located about 10 cm backward.

In addition, when the left hand of the pilot in right seat is moved from the front backward to around the center of the panel, a round switch that the hand touches first is the Door Lock Selector when the aircraft is the 737-500, but the Rudder Trim SW when it is the 737-700.

Consequently, it is probable that the erroneous operation resulted from the fact that the Door Lock Selector for the 737-500 and the Rudder Trim SW for the 737-700 had been placed at similar locations.



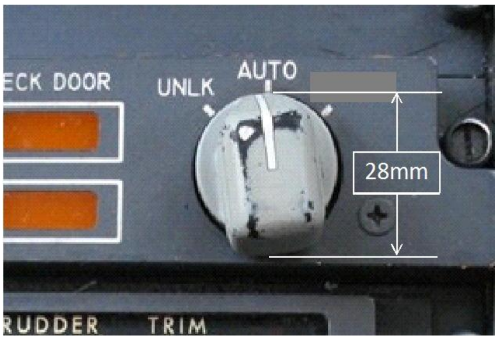
737-700 (the Aircraft)

737-500 (the type of aircraft on which the FO was previously on duty)

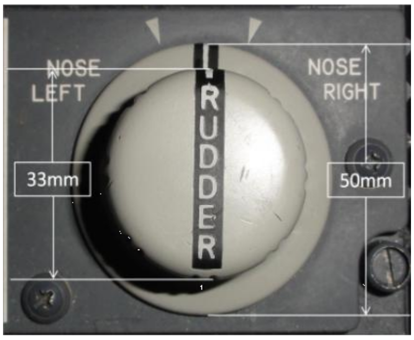
(2) Size and Shape of Both Switches

As described in 2.5.4 and 2.5.5, the size and the shape of the Door Lock Selector for the 737-500 and the Rudder Trim SW for the 737-700 differ from each other on the whole. But a precise look reveals the following similarities:

Firstly, these switches have a brim at the bottom. They are so shaped that they can easily receive a force for depressing them. Secondly, in operating these switches, a torque is necessary; therefore, it is probable that the switches are designed with certain size so that they can be rotated while firmly holding them with the thumb, the index finger and the middle finger.



Over view of Door Lock Selector
(737-500)



Over view of Rudder Trim SW

It is probable that the similar shape of the brim and the fact that both switches are similar size that must be rotated by firmly holding them with three fingers led to the erroneous rotation.

As described in 2.12.1, a cylindrical Rudder Trim SW with no brim has been adopted for other types of Boeing aircraft. Therefore, it is probable that the shape of this Rudder Trim SW is less similar to that of the Door Lock Selector for these types of aircraft.

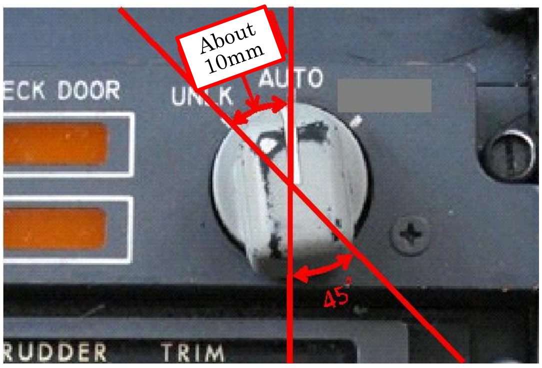
(3) Movements of Both Switches (Operability)

The operability of the two switches was described in 2.5.4 and 2.5.5. The following table shows the result of an analysis of the similarities of the Door Lock Selector for the 737-500 and the Rudder Trim SW for the 737-700 in their operations. Of abbreviations used in the table, RUDT denotes the Rudder Trim SW and DOOR means the Door Lock Selector. The degree of similarity is shown with the three symbols of ◎, ○ and △ in that order.

Operational Similarities Analysis Table

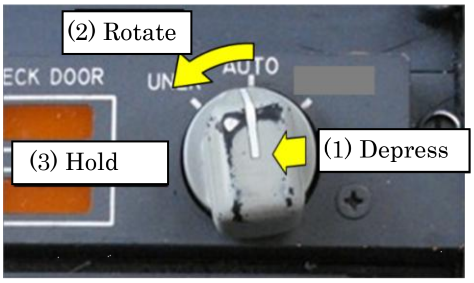
Neutral position
RUDT ： HOLD with spring force DOOR ： HOLD with spring force Similarity ： HOLD both switches at neutral position with spring force, and to rotate, a torque is necessary. Both switches are so designed as they return to neutral position when loosened. Degree of similarity ： ◎
Means of operation
RUDT ： 1) Rotate 2) Hold DOOR ： 1) Depress 2) Rotate 3) Hold Similarity ： As to the similarity of both switches, the Boeing Company explained, as described in 2.5.3, "the flight deck door switches must be depressed before it will rotate counter-clockwise, while the rudder trim control does not move vertically." (DOOR needs two actions, but RUDT requires only one action.) However, as described in 2.1.2(2), the FO said he rotated RUDT while depressing it, just like the way of operating DOOR. As described in 2.5.4 and 2.5.5, the Both Switches have brims and their structure is so designed as to accept depressing actions. The analysis also confirmed that one can depress DOOR while applying a force to rotate it CCW. Therefore, it is probable that the difference in operability is not significant. Besides, the Both Switches must be equally operated by holding them in counter to a spring force. Degree of similarity ： ○
Rotation angle (amount)
RUDT ： Angle is 30° when the switch is on. DOOR ： Angle is 45° when the switch is on. Similarity ： The rotation angle of RUDT is 30° and the shift amount at the point of effort (the outside of the knob) is about 9 mm. Other hand, the rotation angle of DOOR is 45° and the shift amount at the point of effort (near the upper end of the knob) is about 10 mm. Therefore, it is somewhat likely that the feelings in operating the switches are less than those resulting from the differences of their rotation angles. Degree of similarity： ○
Torque
RUDT ： A maximum torque of 6.0 lbf-in at the place where it is rotated 30° . DOOR ： A maximum torque of 3.0 lbf-in at the place where it is rotated 45° . Similarity ： RUDT requires a torque twice as large as that for DOOR, but the ratio of radius from the center to the point of effort is almost 33 to 28. Therefore, the force of operation necessary at the point where force is applied is about 1.7 times. This means a greater force is necessary to rotate RUDT than that for DOOR. Degree of similarity： △
Operating sound (working noise)
RUDT ： No operating sound. A working noise stemming from the Rudder Trim cannot be heard from the cockpit seats. DOOR ： No operation sound, but a mechanical working noise occurs when the door lock system is operated, and this noise can be heard from the cockpit seats. Similarity：The two switches have a similarity -- no operation sound is generated. The fact that the FO had no doubt about the absence of a working noise resulting from the unlocking of the door as he mistakenly rotated RUDT will be analyzed in 3.3.3. Degree of similarity： ○

As described above, although differences are accepted in the motion (operability) between the Door Lock Selector for the 737-500 and the Rudder Trim SW for the 737-700, there are some similarities. It is probable that these similarities contributed to the erroneous operation by the FO.

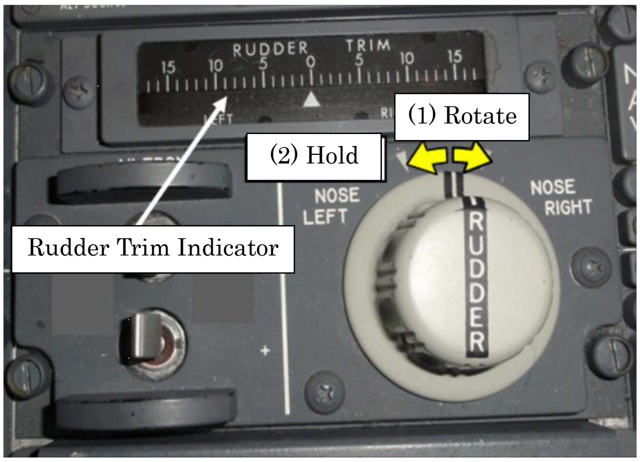


Shift amount of Door Lock Selector (737-500)

Shift amount of Rudder Trim SW



Operation of Door Lock Selector (737-500)



Operation of Rudder trim switch

3.2.4 FO's Experience and PIC's Entry into Cockpit

As described in 2.1.2 (2), following the PIC's exit from the cockpit, the FO found himself in the first ever situation in which he is alone on the flight deck while on duty aboard a 737-700, according to his statement. Besides, as described in 2.4.2 (1), it was almost three months after he started his duties as an FO aboard a 737-700. Moreover, as described in 2.4.1, there were significant differences between the PIC and the FO in their flight experiences.

Based on these matters, it is somewhat likely that because the FO's experience of serving aboard 737-700 was limited and because he was flying this type of aircraft alone for the first time, he came to be determined to let the PIC enter as soon as possible upon receiving a signal for entry from the PIC. As a consequence, it is somewhat likely that the situation described above made the FO to operate the Door Lock Selector hurriedly, involving in his erroneous operation, at a time when he was performing CDU operations singlehandedly, though these operations must be primarily executed by the PM after the data are putted in by the PM, and then confirmed by the PF, as described in 2.5.9.

3.2.5 Training relevant to Operations of Both Switches

As described in 2.9.2, the Company carried out training for cases in which the Rudder Trim SW must be operated. Accordingly, as described in 2.4.2, the FO involved received this training last time in differences training performed in May 2011. In this training, trainees actually operate the Rudder Trim SW.

As described in 2.9.1, the Company carried out training relating to the operation of the Door Lock Selector, but it had not performed training in a situation where the Door Lock Selector was operated while the trainee remains seated. Besides, in differences training for pilots to transfer from 737-500 to 737-700, they had to study about the location of switches in the cockpit by self-learning (e-learning and studies with distributed materials). Moreover, the FO involved studied about the different location of the Door Lock Selector for the 737-700, but he received no advice about the possibility of making an erroneous operation. Furthermore, it is highly probable that the FO had no occasion of operating the Door Lock Selector from his seat at all in this training before he starts his duties as an FO aboard the 737-700.

As described in 2.5.5 (1), an occasion of operating the Door Lock Selector while on duty is a preflight inspection for the day's first flight, in which the switch will be checked by the pilots while standing at a place to the rear of the AE Panel. It is probable that this kind of occasion was less of training aspect to let the pilots recognize the different location of the switch, because the switch is not operated from their seats.

Therefore, it is probable that despite the differences training, the FO could not fully correct his lingering memories of operation about the Door Lock Selector for the 737-500 on which he was previously on duty and he could not be accustomed with the change in the location of the Door Lock Selector.

3.2.6 Changes in Location of Both Switches and Training and Check Management System for Flight Crew Members

As described in 2.5.6 (2), in introducing 737-700, the Company made it a precondition that flight crew members shall not be "on duty aboard Both Type Aircraft in the same period of time" (mixed fleet flight) and decided on the arrangement of switches in the AE Panel by reflecting comments mainly from its flight crew members. The Company located the Rudder Trim SW forward and the Door Lock Selector to the left compared with the switch layout for the 737-500.

In its decision on the placement of the two switches, the Company determined with emphasis on gave greater weight to the usability of 737-700 to be introduced from then than maintaining a high level of "commonality" between different types of aircraft, as mentioned in the reply of the Boeing Company described in 2.5.3. However, as described in 2.9.1, when pilots receive differences training, they had to study about the Door Lock Selector, which was shifted following the change in the location of the Rudder Trim SW, in self-learning mainly based on distributed materials.

It is probable that the decision of the Company on the placement of the two switches without maintaining "a high level of type-to-type commonality" in changing their locations had not been fully reflected in its flight crew training.

As described in 2.9.1, in adopting specifics for its differences training, the Company used the FSB Report of the FAA. Details adopted by the Company were reviewed and approved by the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism. It is somewhat likely that if detailed studies had been made to compare the differences between the aircraft while using a material which is just like the ODR Table, in use in the United States of America, the contents of its differences training would have included a reminder for trainees that errors may easily occur in operating the two switches for the aircraft involved, which had been relocated without paying consideration to the maintenance of the high level of type-to-type commonality.

The FO involved had not been fully accustomed with the change in the placement of the Door Lock Selector. It is somewhat likely that this resulted from lack of effectiveness in the current system for determining the differences training contents and its review method, under which the Company and other airlines considered and adopted specific training programs to train pilots about how to operate the flight deck switches when their locations changed and the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism reviewed and approved them.

3.2.7 Operation of CDU

As described in 2.1.2 (2), the FO thought that he should have withheld the instructions by the Controller involved so that the CDU operation aimed at the route change following the instructions would be performed only after confirming and consenting by the PIC after his return to the cockpit. It is probable that this thought is based on his judgment in view of such factors as the time when he received the instructions, the flight phase involved and aircraft flying in the vicinity. Although the air traffic control instructions should be responded immediately in principle, it is probable that the CDU operation was not necessarily needed to be performed immediately in view of the situation at that time.

As described in 2.1.1, 2.1.2 (1) and Attachment 1, it is probable that the FO confirmed the PIC's face on the monitor screen and erroneously rotated the Rudder Trim SW (22:48:28) with the intension to operate the Door Lock Selector, during the lapse of time involved, in which the PIC left the cockpit (22:46:42), the air traffic instructions were given (22:48:04), the instructions were read back (22:48:08 to 22:48:11), the CDU operation for the route change was started, the signal for unlocking by the PIC was received, the CDU operation was continued and the route change was executed (22:48:25).

Counting from the time when the PIC left the cockpit, the FO received the air traffic instructions one minute and 22 seconds later. Then, one minute and 31 seconds later, he started to enter the route change command to the CDU and execute it. This operation took 14 seconds, and while he was entering the data, he received a signal for unlocking the cockpit door from the PIC. According to the FO, when pilots leave the cockpit to use the restroom, they are usually absent for one minute or so; therefore, it would have been possible for the FO to operate the CDU after waiting for the PIC to return. If the FO had not executed made this operation, he could have concentrated on unlocking the cockpit door after receiving the PIC's signal and confirming his face. Accordingly, the possibility of an erroneous operation, such as seen in this incident, was believed to be smaller in these circumstances.

It is somewhat likely that the CDU operation by the FO which could be deferred when he was alone in the cockpit contributed to his erroneous operation.

As described in 2.5.9, the AOM prescribes a procedure for operating the CDU when the EXEC key has to be used during flight. Specifically, the PM operates the CDU and presses (executes) the EXEC key after the PF confirms. This operation must be basically performed by two pilots, and the CDU operation by FO was able to be suspended. It is probable that behind this FO's action there was the fact that the Company had no specific rule about how to deal with the CDU operation when only one pilot remains in the cockpit, as described in 2.12.3.

3.2.8 Task Management

As described in remarks for 22:48:25 and 22:48:28 in 2.1.1, the FO involved executed the route change command on the CDU and about three seconds later, rotated the Rudder Trim SW. As indicated by event identification sign (hereinafter referred to as "Event") C, after the command entered in the CDU was executed, the Wheel rotated up to about -10° CW as of 22:48:30, and similarly, the Aircraft rolled up to about 3° to the right . However, as indicated by Event D, as of 22:48:30, the FO had already rotated the Rudder Trim SW.

Later, if the situation was normal and if a roll angle necessary for the route change was obtained, the Wheel would have returned almost to the neutral position. But the FO rotated the Rudder Trim SW before the Wheel starts returning to the neutral position. As a result, the Wheel did not show any movement back to the neutral position.

These matters can be taken to suggest that before fully confirming the results of his own flight controls (for executing the route change on the CDU), the FO turned his eyes to the monitor screen and confirmed the PIC's face, and then tried to operate what he perceived to be the Door Lock Selector.

As described in 2.12.2, in view of the "Fly First" principle, the FO "must make efforts to maintain an appropriate aircraft attitude, speed, altitude, and configuration via steering operations." Therefore, these actions are believed to be indispensable and top priority tasks. It is considered that the FO should have concentrated on monitoring the aircraft attitude (the result of his operations for flying) in this incident until the Wheel returns almost to the neutral position with the series of flight controls finished in order to obtain a minimum necessary roll angle for the route change. It is probable that if the tasks had been properly managed, the FO would have operated the Door Lock Selector after completing the series of flight controls and it is probable that the FO would have been able to fully confirm the Door Lock Selector.

In addition, it is somewhat likely that if the FO was aware of the need to concentrate on monitoring the result of his flight controls, and even when he made an error in these operations, he would have recognized the failure of the Wheel to return toward the neutral position due to the effects of the displacement of the Rudder. It is somewhat likely that he could have taken some action at this point to keep the Aircraft from falling into an unusual attitude, for example, by discontinuing the action to operate the Rudder Trim SW.

In other words, the FO attempted to operate the Door Lock Selector without finishing a series of flight controls which were top priority tasks for him. As a result, it is highly probable that he set into a situation where two tasks had to be performed at the same time. In these circumstances, it is somewhat likely that the FO operated the switch without fully confirming it as the Door Lock Selector, or he rotated the switch as the result of his memories of operation about the Door Lock Selector for the 737-500 remained uncorrected, as described in 3.2.2, which were brought out at that time. Moreover, it is somewhat likely that the FO did not recognize the unusual movement of the Wheel.

Based on these findings, it is probable that the erroneous rotation was caused by the fact that the FO failed to properly manage his tasks, while prioritizing plural tasks, if any, before implementing, rather than executing them all at once, and giving top priority to flight controls, and even when other operations must be executed, paying maximum possible attention to flight controls.

As described in 2.12.3, it is probable that, behind the FO's failure to properly manage his tasks, there was the fact that the Company had prescribed no specific provision about how to deal with a flight operation when only one pilot is in the cockpit.

3.2.9 Brightness in Cockpit

As described in 2.1.2 (1), the PIC was controlling the brightness within the cockpit while using a backlight so that inside can be early seen, according to his statement. As described in the statement in 2.1.2 (2), the FO erroneously rotated the Rudder Trim SW upon looking at it. He also said that when he looked at his left hands, he realized he had operated the Rudder Trim SW. Therefore, it is highly probable that there was low possibility that the brightness inside the cockpit had anything to do with his erroneous operation because it was not difficult to see the switches there in the situation at that time.

3.3. Analysis of Recognition of Erroneous Operation

According to the results of an flight simulator examination as described in 2.8.1, the erroneous operation were believed to have been corrected, on occasions before it was recognized and on later occasions in the situations as follows:

- Even when the rudder has to be displaced by operating the Rudder Trim SW and if the displacement, as indicated on the rudder trim indicator, is about -3 units (equivalent to about 6 seconds of operation, as described in 2.5.7), the aircraft attitude can be corrected with an autopilot command on the LNAV mode and the direction of the aircraft can be maintained. Therefore, if the FO had realized his erroneous operation at this time, he could have corrected the error by operating the Rudder Trim SW to RIGHT in order to return the rudder trim indicator to around ±0.
- When the displacement of the rudder becomes -4 units or more on the rudder trim indicator, the rudder will surpass a correction limit on autopilot and the left roll angle will increase. With the displacement at -4 units, it took about 57 seconds for the roll angle to reach -60° after the operation, but at -6 units, the time required was about 9 seconds. Therefore, the sooner an erroneous operation is recognized, and the shorter the duration of such an operation is, the shallower the displaced roll angle will be. The rudder displacement will be also smaller, accordingly, a force which rolls the aircraft will be weaker, which will make a recovery operation with the Wheel easier.

It is probable that as the recognition of the erroneous operation was delayed, the aircraft rolled beyond an attitude correction limit on autopilot, and then the attitude became even more unusual. Therefore, the process of the FO's recognition of the erroneous operation was analyzed in detail.

3.3.1 Situation until Recognition of Erroneous Operation

According to the descriptions in 2.1.1, 2.1.2(2) and 2.5.7, it is highly probable that the FO realized his error in operating the Rudder Trim SW roughly in the following process:

- The FO continued the erroneous operation without realizing the differences in the shape and operability of the switch.
- The rudder pedals moved 18mm forward or backward.
- The Wheel rotated CW from about -10° to about -22°.
- The Aircraft, which had banked to the right, rolled to the left beyond level.
- The Column shifted backward to about 2° (about 3.5cm on the upper end).
- The FO noticed that the PIC was not able to be open the door on the monitor screen.
- The FO realized his erroneous rotation on the Rudder Trim SW when he looked at his left hands.

3.3.2 Operability of Both Switches

As described in 3.2.2 (3), there are some similarities in the operability of the two switches. In particular, they must be equally held at the rotated positions to accomplish their objectives. The Rudder Trim SW is so designed that a desired rudder angle can be obtained as the rudder continues to be moved according to the length of time in which the switch is kept at "Hold at LEFT or RIGHT." Meanwhile, the Door Lock Selector is designed to keep the door unlocked as long as the switch is kept at "Hold at UNLOCK" and this will make it possible to open the door from the cabin side.

It is probable that when the FO erroneously operated the Rudder Trim SW with intention to unlock the door, he was preoccupied with watching the PIC on the monitor screen and waiting to see signs of his entry into the cockpit on top of paying attention to monitoring the condition of the flight.

It is somewhat likely that as the two switches have a similarity in their operability: they must be held at the rotated positions, the FO had no unusual sense in continuously holding the wrong switch. Therefore, it is somewhat likely that this similarity got involved in the delay in his recognition of the erroneous operation.

3.3.3 Operating Sounds of Both Switches

As described in 2.5.4 and 2.5.5, the operating noise of the rudder to be caused when the Rudder Trim SW is operated cannot be heard in the cockpit. But the mechanical operating noise of the door lock system following an operation with the Door Lock Selector can be heard in the cockpit. However, as described in 2.1.2 (2), the FO had no doubt about the absence of an operating noise which occurs when the Door Lock Selector is operated, according to his statement.

As described in Event D at 22:48:28 in 2.1.1, the Rudder Trim SW was operated twice. Therefore, it is probable that the FO thought that he had operated the Door Lock Selector twice and he had no doubt about the absence of an operating noise on both occasions.

As described in 2.1.2 (2), it was the first experience for the FO to operate the Door Lock Selector while cruising aboard 737-700; therefore, he had no knowledge about what kind of noise can be heard on operating the selector, according to his statement. It is probable that this possibility cannot be denied. In addition, as described in 2.5.5, the OM and the AOM show no procedure for confirming the result of an operation on the Door Lock Selector by catching its operating noise.

But it is somewhat likely that if the FO had become doubtful about the absence of an operating noise to be heard from the door lock system, he could have realized his erroneous operation at an early time.

3.3.4 Control Wheel/Column Displacement and Its Recognition

As described in 2.1.2 (2), the FO had no memories about whether he was placing his hand on the Control Wheel and Column, but he sometimes does so when weather is bad, according to his statement.

Following his erroneous rotation on the Rudder Trim SW, the Wheel was rotated from about -10° to about -22° on an autopilot command aimed at correcting the attitude and the Column was displaced about +2° (about 3.5cm as described in 2.5.8). According to his statement in 2.1.2 (2), the FO realized the erroneous operation when he looked at his left hand and confirmed the bank to the left when he looked at the PFD in front of him. Therefore, it is highly probable that the FO had not placed his hand on the Control Wheel and Column.

Wheel displaced to -10°

Wheel displaced to -22°

3.3.5 Rudder Pedal Displacement and Its Recognition

As described in Event D at 22:48:28 in 2.1.1 and in 2.5.7, it is highly probable that during the time of about 12 seconds in which the Rudder Trim SW was held at LEFT, the left rudder pedal was moved forward and the right rudder pedal backward, each about 18mm. During this time, a force of 8 lb had been applied on the right pedal so that a further rudder pedals movement may be prevented.

As described in 2.1.2 (2), the FO had stepped his foot on the rudder pedals, according to his statement, and at the same time, he looked at his left hand and realized his erroneous operation. Therefore, it is highly probable that though he had his foot on the rudder pedals while operating the Rudder Trim SW, he did not realize this displacement.

While cruising on autopilot, the rudder pedals for the type of aircraft involved are operated on few occasions, except for unusual cases such as a single engine operation. Therefore, it is probable that the FO paid no attention to monitoring any rudder movement in this case, too, though he had his foot on the rudder pedals.

3.3.6 Monitoring of Flight Condition

As described in 2.1.1, after the Rudder Trim SW was operated, the Aircraft underwent various changes, such as the movement of the Control Wheel and Column and the roll of the aircraft to the left beyond level from its bank to the right. Changes had also appeared in flight operation systems and PFD indications. However, as described in 2.1.2 (2), the FO realized the erroneous operation only when he looked at his left hand, according to his statement. Therefore, it is highly probable that he did not realize the series of changes. It is highly probable that for about 14 seconds between the erroneous rotation and his recognition of his error, the FO rotated the Rudder Trim SW twice with intention to rotate the Door Lock Selector and he was preoccupied with confirming the situation shown on the monitor screen the outside of the door. The FO should have realized these changes within the cockpit much earlier.

In this case, there were only a few duties for him other than flight control, but the FO was preoccupied with performing tasks other than flight control for as long as 14 seconds. It is somewhat likely that this indicates his excessive dependence on autopilot flight and his lack of full awareness about the need to monitor the flight condition, leading to his delay in realizing the erroneous operation.

Additionally, it is probable that, behind his failure to be fully aware of the need to monitor the flight condition, there was the fact that the Company had prescribed no specific provisions how to deal with flight operations when only one pilot is in the cockpit, as described in 2.12.3.

3.3.7 Safety Education for Monitoring of Flight Condition

As described in 2.9.6, the Company has not implemented safety education for better monitoring the flight condition and preventing an abnormal situation while assuming that such situations occur while operating with only one pilot in the cockpit.

However, it is assumed that either of the pilots leaves the cockpit for physiological reasons, and as described in 2.1.2 (2), the frequency of a PIC leaving the cockpit while the FO involved was on duty was about once half a year, according to his statement. This can be taken to indicate that the occasion for him to fly an aircraft singlehandedly was limited, but not nil. Therefore, it is probable that there might be sufficient possibility for a pilot to go into an abnormal situation with only one pilot in the cockpit.

In this case, the aircraft attitude became unusual and it fell into a dive, as the Rudder Trim SW was erroneously rotated. As described in 3.3.6, it is probable that the FO did not realize various changes which occurred after his erroneous operation, because he was excessively dependent on autopilot flight and he failed to pay full awareness about the need to monitor the flight condition.

It is probable that, behind the FO's delayed recognition of his erroneous operation, there was the fact that he had not received safety education for reminding pilots of the need to monitor the flight condition even more carefully with only one pilot in the cockpit so that unusual situations can be prevented.

3.3.8 Signal for PIC's Reentry

As described in 2.12.4, when anyone enters the cockpit, a predetermined signal must be sent to the cockpit. As described in 2.1.2 (2), a signal determined by the PIC was to be sent to enter on the day; therefore, and it is probable that he actually did so and his act had no problem with the relevant rules. However, according to the statement of Cabin Attendant A, as described in 2.1.2 (3), because there was no reply to a signal initially sent by the PIC, he was telling the FO to open the door while sending a signal once again.

According to the FO's statement, as described in 2.1.2 (2), "he checked the PIC's face based on the image of the camera monitoring the outside of the door, and then operated the switch. (Omitted) When the PIC did not reenter the cockpit immediately as thought, the FO became doubtful about it, and when he carefully looked at the image on the monitor screen, the PIC appeared to be having difficulty opening the door." It is somewhat likely that the FO was preoccupied with confirming the image on the monitor screen at that time; accordingly, he removed his eyes from the PFD and other instruments for a long time.

In addition, it is somewhat likely that the PIC's behavior of urging the FO to unlock the door was contributes toward involved in what the FO thought was a second action to operate the Door Lock Selector and his long retention of the Unlock condition (actually, he operated the Rudder Trim SW twice and held it at LEFT for a long time). It is somewhat likely that because the FO was preoccupied with unlocking the door to let him enter as soon as possible, the FO could not quickly realize the change in the aircraft attitude.

Based on the above, it is somewhat likely that the PIC's repeated signal for entry had something to do with the FO's delayed recognition of the erroneous operation.

3.3.9 Influences of Night Flight

In general, night flights are carried out while pilots carefully watch the aircraft attitude by monitoring the outside situation, the PFD indications and other instruments on the flight deck. The brightness within the cockpit is usually controlled by the crew by themselves so that the outside situation, the PFD indications and switches, and other instruments can be seen easily. It is believed that flight crew members pay an appropriate level of awareness under a given condition to various kinds of information about the recognition of the flying attitude.

As described in 2.1.2 (1), the PIC had used the backlight so that the switches and the instruments there can be seen clearly, according to his statement. As described in 2.1.2 (2), the FO realized that he was operating the Rudder Trim SW when he looked at his left hand, and he confirmed the unusual attitude when he looked at the PFD indications in front of him, according to his statement. Therefore, it is highly probable that the cockpit was not as dark as the PFD indications, switches and panel instruments cannot be seen clearly.

However, the cockpit was in a slightly dark situation at that time so that the situation outside can be confirmed easily. Therefore, it is probable that the movement of the black painted the Control Wheel and Column was less visible than in the daytime.

As far as the brightness of the moon at the time when this serious incident occurred is concerned, a waxing half-moon was right behind the aircraft, as described in 2.6.2, and it is highly probable that the angle of elevation was at 15°. Therefore, it is probable that the moon was not visible from the cockpit, and clouds, the horizon and other things outside could not be clearly recognized.

In addition, as indicated in Figure 1, the location where the incident occurred was far from the land, as the Aircraft was flying over the Pacific northward. It is somewhat likely that the FO, who was sitting in the right seat in the cockpit, was unable to have a continuous and intuitive awareness about the aircraft attitude while basing his judgment on lights in a city area seen on his left.

Based on these findings, it is somewhat likely that the brightness level in the cockpit, the brightness of the moon and the flight course were behind the FO's delayed recognition of the erroneous operation.

3.3.10 Activation of Bank Angle Alert

The bank angle alert was not an item to be recorded on the DFDR. As described in 2.1.2 (2), the FO says he had no memories that the bank angle alert was activated. But, as described in 2.1.2 (1), the PIC heard the alert; therefore, it is highly probable that the alert properly got activated.

It is probable that it was 22:48:42, the time when the LEFT operation for the Rudder Trim SW was finished, when the FO realized he had erroneously operated the switch, according to the DFDR data.

The bank angle alert began to be activated at 22:48:43, just after the LEFT operation for the Rudder Trim SW was finished, as indicated in Figure 3.

Based on these findings, it is highly probable that the bank angle alert was actually activated but this could not contribute to the prevention of late recognition of the erroneous operation.

As to the FO's lack of memories about the activation of the bank angle alert, it is somewhat likely that the alert was activated at a time when he was busy taking a series of corrective actions after realizing his error and confirming the aircraft attitude and that as a result, he could not catch the sound of the alert as he lost his composure on the unusual situation, or he lost memories about what happened then.

3.4 Analysis of Recovery Operations by FO

According to the results of the flight simulator examination as described in 2.8.2, it is highly probable that if the FO had made a recovery operation in accordance with a procedure prescribed in the AOM, the roll angle could have been corrected before the aircraft dived. As a result, the aircraft could have recovered from the upset as the roll angle is seen to stop short of a significant nose low state, though it temporarily becomes unstable.

Based on the above, it is somewhat likely that because the FO did not make an appropriate or sufficient recovery operation, the aircraft attitude became even more unusual. Therefore, the FO's recovery operation was analyzed in detail.

3.4.1 Situation from Start of Upset Recovery Operations to Recovery from Upset

It is highly probable that the FO's recovery operations and the ensuing behavior of the aircraft progressed roughly in the following process:

- The FO started recovery operations by greatly rotation the Control Wheel CW. The roll angle had exceeded -50°at this time.
- The roll angle changed toward recovery after peaking at -80°.
- The Control Wheel turned in the reverse direction, because an applied force was loosened and a force was applied in the opposite direction, and then it returned to a position beyond neutral.
- The FO turned the Rudder Trim SW to RIGHT for three seconds to get the rudder trim return to the neutral position.
- The Wheel was not sufficiently operated while the FO was operating the Rudder Trim SW.
- The roll angle recovered to about -50° deepened later again and reached a maximum angle (-131.7°).
- The FO significantly rotated the Wheel CW again.
- The left roll angle changed toward recovery.
- The nose low state reached a maximum angle (-35°).
- The FO recovered the attitude gradually by operating the Wheel and Column.

During this time, the following events occurred:

- The stick shaker was activated.
- The Aircraft took a dive and the air speed increased.
- The over-speed warning was activated.
- The speed increased to a maximum level (M 0.828).
- The load factor intermittently grew following a nose up movement.
- The load factor increased to a maximum level (2.68 G).

3.4.2 Situational Awareness of FO

As described in the table "Nose Low Recovery" in 2.9.3, "Recognize and confirm situation" is the first action which must be taken in an upset recovery operation, according to the AOM. This is because the aircraft may enter a more serious situation unless an effective recovery operation is performed based on a correct recognition of the situation.

As described in 2.1.2 (2), in view of the PFD, the FO found that the Aircraft was banking to the left and the angle was becoming even larger. Then, he significantly operated the Wheel CW contrary to the bank, according to his statement. As described in Event I at 22:48:45 in 2.1.1 and in Figure 3, this can be confirmed in the DFDR data, which show the Wheel was significantly operated

CW contrary to the roll.

Based on these findings, the FO also rotated the Wheel almost CW against the roll to the left, as indicated in the data about the Roll Angle, the Control Wheel Position and the Control Wheel Force in Figure 3.

Therefore, it is probable that the FO recognized the roll to the left when he realized the unusual attitude and later, he was aware that the aircraft was rolling almost to the left.

As described in 2.1.2 (2) as well, after the aircraft entered the spot, the FO explained to the PIC that he had pulled the Column to pitch up. As indicated by the data about the Pitch Angle, the Control Wheel Position and the Control Column Force in Figure 4, the FO was discontinuously pulling the Column to the Nose Up side in Event S, from 22:49:02 as the time when the roll angle almost stabilized.

Based on these findings, as described in 2.9.3, the Nose Low Recovery procedure prescribed in the AOM calls for rolling the aircraft in the shortest direction to the Wing Level (the condition with the right and left wings kept level), and then recovering to a level flight while applying the Nose Up Elevator (Column). These operations are also practiced in recurrent training.

As described in 2.1.2 (2), the FO was not aware about how much the aircraft rolled or how deeply the pitch was down, according to his statement. But it is probable that he was almost aware of the condition of the roll and the pitch of the aircraft.

3.4.3 Operation of Control Wheel/Column and Activation of Stick Shaker

As described in 2.1.2 (2), the FO devoted himself to performing a recovery operation to return the wings to level, according to his statement.

However, as described in Event L at 22:48:48 in 2.1.1, the FO loosened his force applied on the Wheel CW as the direction in the recovery operation and operated the Wheel conversely CCW with a force of 9 lb. As a result, the Wheel quickly returned to a place beyond the neutral position. Following this operation, the roll angle, which had recovered to about -50°, became large to the left again. At this time, the Column was momentarily pushed forward, and because the force on the Wheel was loosened and at the same time the force on the Column was loosened, the Column returned to where it was until just before.

As described in Event I at 22:48:45 in 2.1.1, the FO is believed to have rotated the Wheel with a maximum force of -39 lb to -97°-- namely, rotating it almost fully CW. Following this operation, the roll angle began to recover after reaching a peak of about -80°. In this situation, while the Wheel is fully rotated in this manner and when the roll angle changes to recover to the right after reaching its peak on the left side, the aircraft sometimes shows a rapid roll change to the right. It will cause the aircraft to roll to the right beyond the wing level. To avoid such a situation, when the roll angle comes close to a peak, force on the Wheel basically must be gradually loosened and the Wheel needs to be returned CCW commensurately to the recovery of the roll angle.

Wheel operated to -97°

Just before the FO started the reverse operation while loosening the force on the Wheel, as described in Event L at 22:48:47 in 2.1.1, the stick shaker got activated. As described in 2.12.5, the stick shaker will be activated, according to an AOA measurement, when the aircraft is feared to stall. It is probable that the stick shaker was activated in this case involved because the AOA exceeded AOAss as the trigger level for a stall warning alarm. As described in 2.1.2 (2), the FO has no memories that the stick shaker was activated, according to his statement.

As indicated in Figures 3 and 4, when the stick shaker was activated in Event L, the Column was momentarily operated forward and just after that, the Wheel was returned beyond the neutral position. The Column was also returned to the position before the operation.

As described in 2.9.3, it is specified in the AOM Upset Recovery provision that "If the aircraft is stalled, recovery from the stall must be accomplished first by applying and maintaining nose down elevator (with a column pushed forward) until stall recovery is complete and stick shaker activation ceases." This suggests that it should be effective to minimize the AOA by lowering the nose while pushing the Column forward in order to recover from a state of stall.

Based on these matters, it is probable that the series of developments from Event I at 22:48:45 to Event L at 22:48:46, as described in 2.1.1, took place in the following sequence:

It is probable that in an attempt to recover the aircraft attitude banked to the left, the FO significantly rotated the Wheel CW from 22:48:46. While he was making this rotation, the stick shaker was activated from 22:48:47. As a result, it is probable that the FO operated the Column forward from 22:48:47 in order to stop the stick shaker.

The FO rotated the Wheel to up to -97° almost fully CW with a maximum force of -39lb at 22:48:48. But it is highly probable that at a time when the stick shaker was continuing to work, the FO quickly loosened his force on the Wheel and he applied a force of +9 lb CCW on the Wheel. It is probable that because he loosened his force on the Column simultaneously, the Wheel returned beyond the neutral position and the Column quickly returned to the previous position.

As indicated in Figure 4, it is probable that as the FO pushed the Column forward from 22:48:47 in Event L, the movement of the stick shaker came to a halt at 22:48:49. Therefore, it is somewhat likely that if the FO had returned the Wheel CCW keeping in step with the recovery of the roll angle, he could have recovered the aircraft to an attitude close to the WING LEVEL position when the Wheel returns to -45°.

However, following his inappropriate operation which caused the Wheel to return quickly beyond the neutral position, the roll angle ceased to recover and became large again. It is probable that this, coupled with a subsequent insufficient rotation of -35° on the Wheel, to be described in 3.4.4, caused the roll angle to expand to a maximum -131.7°.

According to the FO's statement, he has no memories about the activation of the stick shaker. It is somewhat likely that his inappropriate operation, in which he quickly loosened his force on the Wheel and applied a force in the reverse direction to cause the Wheel to return beyond the neutral position, reflected his startle and confusion as the stick shaker was activated in the situation while he was fully rotating the Wheel.

Thereafter, as indicated in Figure 4, when the stick shaker was activated from 22:48:51 just after Event L, the FO moderately pushed the Column forward. In view of an improvement in the AOA at this time, it is probable that the stick shaker activation came to a halt at 22:48:53. He was pushing the Column forward even when the nose was down; therefore, it is probable that the FO was regaining his composure when he made this operation.

3.4.4 Operation of Rudder Trim SW

As described in 2.1.2 (2), the FO made the operation to return the rudder trim in the course of his upset recovery operation, according to his statement. According to the DFDR data, the FO made the first such operation in Event N at 22:48:52 in 2.1.1 for the first time. It is probable that he made this operation in an attempt to correct the displacement of the rudder caused by his own erroneous action.

However, as indicated in Figure 3, because the force applied on the Wheel CW was about 21 lb, the FO could not override the autopilot and as a consequence, the operation he made on the Wheel CW proved to be insufficient (about -35°). Therefore, it is probable that the roll increased again after recovering to -50° at one point.

It is probable that this resulted from the fact that the FO's attention focused on his attempt to return the rudder trim and he became less attentive to the aircraft attitude and also the fact that he was rotating the Wheel only with his right hand as he was turning the Rudder Trim SW with his left hand.

How rudder trim switch is operated

Wheel held at -35°

As indicated in Figure 3, after the operation to recover the rudder trim in Event N, the force applied CW on the Wheel had recovered to an amount (25 lb or more) large enough to operate it by overriding the autopilot mode and as a consequence, the Wheel was rotated CW up to -98°. It is highly probable that following this operation, the roll angle moved toward recovery from a maximum -131.7°.

Other hand, as indicated in Figure 5, the Rudder Position data for Event N remained unchanged with the rudder displacement maintained at about -5° despite the Rudder Trim SW on hold position. According to the data, the Rudder Pedal Force was +20 lb (the force applied on the left side rudder pedal).

As described in 2.1.2 (2), the FO did not use the rudder in the recovering operation, according to his statement. It is unthinkable, in pilots' usual behavior, to press on the left side rudder pedal in this situation. Therefore, because the FO was trying to return the Rudder Trim with his left hand while operating the Wheel with his right hand, his body was extended in a strained condition. As a result, it is somewhat likely that a rudder pedal displacement following the Rudder Trim SW operation was impeded. Consequence, the data indicating the force applied on the left rudder pedal remained.

According to the flight simulator examination described in 2.8.2, it is probable that a recovery in the roll angle by rotating Wheel can fully recover a roll change following yawing on a rudder movement. Therefore, it is believed that the operation to return the rudder trim to the previous position should have been made only after recovering the aircraft attitude to around the Wing Level by operating the Wheel.

Based on these matters, it is highly probable that the Rudder Trim SW operation made in an initial recovery attempt eventually failed to help recover the aircraft attitude, rather causing the situation to worsen further.

3.4.5 Rudder Pedal Operation

As described in 2.1.2 (2), the FO did not use the rudder in the corrective operation, according to his statement. But, as described in Event K at 22:48:46 in 2.1.1, the right rudder pedal was pressed with a force of about 23 lb almost at the same time as the corrective operation on the Wheel. When the Wheel was significantly operated CW in this case, it is a natural and common action to press on the right rudder pedal as part of serial operations.

Just after this, the FO pressed on the left rudder pedal with a force of about 20 lb, according to the recorded relevant data. As described in 3.4.4, it is probable that his both legs became strained unintentionally and as a consequence, a rudder displacement following the Rudder Trim SW operation was impeded.

Based on these matters, it is believed that the FO had not any intention in operating the rudder pedal.

As described in 2.9.3, it is specified in the AOM Upset Recovery procedure that "Careful use of rudder (pedal) to aid roll control should be considered only if roll control by ailerons (Wheel) is ineffective and the aircraft is not stalled." It also warns, "An excessive use of the rudder (Pedal) may aggravate an upset situation or may result in loss of control and/or high structural loads." In the Company's recurrent training based on this procedure, the rudder is not used actively when attitude recovery training is performed. It is somewhat likely that this was behind the FO's intention not to operate the rudder pedal actively in this case.

3.4.6 Activation of Stick Shaker and Over-Speed Warning

According to the DFDR records in Events S and U, the stick shaker and the Over-Speed warning were simultaneously activated.

As described in 2.1.2 (2), the FO raised the pitch by pulling the Column, according to his statement. It is probable that in Event S and Event U, the FO, while maintaining the Aircraft almost in the WING LEVEL state by operating the Wheel, operated the Column while moving it back and forth periodically and made a recovery operation for the lowered pitch. It is probable that the stick shaker was activated because the AOA was increased by the pitch up operation performed while the Aircraft was continuing to dive.

As indicated in Figure 4, in Event S, the AOA and the load factor (vertical acceleration) increased when the FO moved the Column backward (PULL) and conversely, the AOA and the load factor decreased when he moved the Column forward (PUSH). While the AOA was increasing, the stick shaker was activated and the load factor became a maximum amount of 2.68 G after surpassing the limit of 2.5 G on three occasions.

At the same time, the roll angle became large from Event L to Event U; consequently, the direction of the lift changed in response to the roll angle and accordingly the force to lift the aircraft in the vertical direction decreased. In addition, the rudder was displaced to the left with the roll angle significantly to the left. As a result, it is probable that the flying direction of the aircraft was brought downward.

As a consequence, the aircraft descended at a maximum rate of about 440 ft/sec. The speed of the aircraft increased and reached a maximum of M 0.828, beyond M 0.82 as the M_{MO}. In the meantime, the Over-Speed warning was activated, as described in 2.12.6.

It is highly probable that though the aircraft speed was in excess of M_{MO}, the AOA became large; accordingly, the Over-Speed warning and the stick shaker were activated simultaneously.

The recovery operation in Event S can be analyzed in a time series as follows:

It is highly probable that the FO pulled the Column to correct the lowered pitch angle, while the Control Column Position was moved backward, but because the AOA became large, the stick shaker was activated. It is highly probable that the FO then loosened his force on the Column to avert a stall, and then the Control Column Position was moved forward (toward the neutral position).

However, it is highly probable that the FO pulled the Column again in order to correct the pitch angle, which remained downward, and the Control Column Position was displaced backward.

But it is highly probable that because the stick shaker was activated (or remain activated), the FO pushed the Column forward, displacing it toward the neutral position. It is probable that the pitch angle gradually changed toward recovery as the FO repeated operations to displace the Column back and forth. It is highly probable that every time when the Control Column Position was moved backward, the load factor became large accordingly and then, exceeded the limit three times. It is highly probable that because the aircraft continued to dive, the aircraft speed increased beyond MMO, and then causing the Over-Speed warning to be activated.

In order to avert the Over-Speed warning, an operation must be made to reduce the aircraft speed below MMO. However, it is probable that the FO's operation to pull the Column in order to recover the pitch angle, as described in 3.4.2, also worked as an operation to reduce the speed.

After all, it is highly probable that the FO was in a situation in which he had to pull the Column if the Over-Speed warning was to be stopped and he had to push the Column if the stick shaker was to be stopped.

It is probable that his repeated operation to move the Column backward and forward was all he could and any other effective means were not available for him in the situation.

3.4.7 Pilot Training for FO

(1) Upset Recovery Training

As described in 2.9.3, the Company had conducted upset recovery training at an altitude of 10,000 ft or lower by using a flight simulator as part of its recurrent training. The upset recovery training is conducted at this altitude mainly because when an upset situation occurred at a low altitude, the pilot will not have enough altitude to be lost before performing a recovery operation and also because it is important to maintain recovery techniques in a situation accompanied with restrictions of loss of altitude. Another reason is that the performance of flight simulators has a limitation in correctly simulating a high altitude upset situation and an upset recovery process in such a situation.

As described in 2.9.3, the Company's AOM has a rule that recovery from the stall must be accomplished first by applying than any other upset recovery operations. But the Company performs no upset recovery training with a stall warning assumed to be activated. This is because when upset recovery training is carried out at an altitude of 10,000 ft or lower, a stall warning will be activated only when a recovery operation failed to be made properly. Therefore, it is probable that there is low possibility of such a warning being activated in recovery training.

The Company's flight simulator-based training is performed with a scenario which enables the trainee to anticipate that the next subject should be Upset Recovery. It is probable that this was not training including a situation in which trainees can be educated to improve their upset response, or so-called startle response, in unexpected circumstances.

However, as described in 2.9.5 (2), it has been confirmed in recent years that some pilots lack an abilities to appropriately deal with unexpected situations. The importance of training aimed at increasing pilots' readiness to deal with unexpected situations is increasingly recognized around the world.

The FO involved did not receive upset recovery training accompanied with a stall warning, nor did he receive upset recovery training in an unexpected situation. This means that the activation of the stick shaker which occurred while he was performing the upset recovery operation in an unexpected situation was the first experience for him, both in training and in actual flight duties. Therefore, it is somewhat likely that he got startled and confused at the situation, leading to his inappropriate or insufficient recovery operation.

(2) High altitude Upset Recovery Training

As described in 2.9.4, the Company performed training for high altitude operations as part of the Bridge Training. But high altitude upset recovery training is conducted only once after the end of the Ab-initio training, as indicated in Attachment 3. The ground school training for the Bridge Training is aimed at providing trainees with knowledge mainly about aerodynamic characteristics when the aircraft flies at a high altitude at a high speed. Various flight simulator-based experience training programs are provided, such as “Recovery Mach Buffet / Speed Buffet / Turn “G” Buffet (recovery from various signs of stall),” “EMERGENCY DESCENT” and “ENG FLAME OUT then DRIFT DOWN (a descent in a case with one engine troubled.)”

In the recurrent training, programs such as “DRIFT DOWN,” “RAPID DECOMPRESSION and EMERGENCY DESCENT” are carried out at a high altitude, but all these programs are implemented with descent target altitudes set in advance on autopilot.

According to the description in 2.9.3, it is probable that no domestic airlines periodically conducts upset recovery training in which autopilot must be disengaged at a high altitude.

In these circumstances, it is probable that opportunities for training to provide the latest knowledge mainly about flight characteristics at high altitudes are limited to general pilots working with airlines, including the FO involved in this incident. Therefore, it is probable that they have not received high altitude upset recovery training.

As described in 2.9.5 (1), the Airplane Upset Recovery Training Aid Revision 2 has been released and airlines around the world are making an effort to start training in line with this material. According to the training aid, upset recovery training can be accomplished by increasing awareness of potential upset situation and knowledge of flight dynamics and by application of this knowledge during simulator training scenarios. High altitude upset recovery training is also explained in the material.

Simultaneously, upset recovery training based on flight simulators has a limitation in simulator correctly simulate the situations; therefore, without instructional contents must acknowledge this limitation, a positive learning goal can be transformed into a negative learning experience, the training aid says.

In conjunction with, in the Flight Simulation Training Device Guidance Bulletin 11-05, the FAA calls for developing and introducing a system which enables the instructor to indicate problems whenever a recovery process cannot be simulated outside of the defined flight envelope validation region. It is exploring a means of effectively using the existing flight simulators in upset recovery training. It should be noted that this guidance bulletin can be taken as a stopgap measure until the flight envelope validation region of simulators, which have many limitations, is adequately enhanced.

As described in 2.9.5 (1), the FAA adopted a revised rule on November 5, 2013 calling on U.S. airlines companies to drastically improve their flight crew educational training programs in five years. This revision was aimed at significantly strengthening the contents of training programs for stall and upset situations and making it an obligation to carry out simulator training for stall and upset recognition, prevention and recovery operations. Moreover, the FAA is also considering revising a related regulation in order to make simulator training more effective so that stall or upset situation can be simulated in a more appropriate and realistic manner. Just like the FAA move, the EASA is considering revising a related regulation calling for improving upset recovery training. In these circumstances, in order to increase the effectiveness of high altitude upset recovery training, greater research and development efforts should be made to further improve the simulator performance and make it possible to simulate a more practical aircraft behavior.

It is well known that in high altitude upset recovery operations, the aircraft tends to stall because of its attitude and a large AOA following an operation on the Column or the speed tends to become excessive following a loss of altitude. When this serious incident occurred, as described in 3.4.3, the stick shaker was activated following the significant operation made on the Wheel for recovery in Event L. It is somewhat likely that the FO got startled and confused on the activation of the stick shaker; accordingly, he made an inappropriate or insufficient recovery operation.

However, if opportunities for training in these situations were fully available for him, the possibility was believed to be greater that he could recognize such an unusual condition calmly and take a corrective action more appropriately.

Based on these mutters, it is somewhat likely that there was the lack of opportunities for high altitude upset recovery training for him behind the fact that he was startled and confused on the activation of the stick shaker, causing him to make the inappropriate or insufficient operation.

3.4.8 Set-up of Autopilot and Auto-throttle

While the FO was performing the series of recovery operations in this case, the autopilot and auto-throttle systems remained engaged.

Meanwhile, as described in 2.9.3 in the table "Nose Low Recovery" in the AOM, when an upset situation occurred while flying with autopilot and auto-throttle engaged, these systems must be disengaged. It is probable that this rule is based on the belief that when an upset situation occurs while flying with autopilot and auto-throttle engaged, the systems, both or either of them, might not be working properly.

When pilots intentionally disengage autopilot, they must press down a disengage button attached to the Wheel or a similar button on the MCP panel located above the PFD.

As described in 2.1.2 (2), the FO had his hands full with quickly correcting the aircraft attitude by rotating the Wheel and because he could not afford to disengage the autopilot, he was trying to correct the attitude by overriding autopilot, according to his statement.

As indicated in Figures 2, 3 and 4, while the FO was performing recovery operations, the aircraft shifted to the CWS roll mode in Event I and to the CWS pitch mode in Event P, but autopilot remained engaged.

In this case, the unusual attitude of the Aircraft was triggered when the FO operated the Rudder Trim SW. In addition, as indicated in Figures 3, 4 and 5, the Wheel (the ailerons) and the Column (the elevator) were almost smoothly moving in response to the control intentions on the Control Wheel and Column (forces applied on the Wheel and the Column) under the CWS mode on the respective occasions. It is highly probable that a force of 25 lb or more was necessary to rotate the Wheel CW in the initial stage of recovery operations. It is probable that this was not so strong that an aileron control may be hindered. This also applied to the case with the Column and the elevator.

In addition to these things, as indicated in Figures 3, 4 and 5, the aircraft movement was almost in line with these actions. Therefore, it is probable that the FO's failure to disengage autopilot had no major influence on his recovery operations.

Moreover, when pilots disengage auto-throttle intentionally, they must press down a disengage button attached to the knob of the thrust lever. As described in 2.1.2 (2), the FO had his hands full with recovering the aircraft attitude; accordingly, he could not afford to disengage auto-throttle or operating the thrust lever, according to his statement.

As indicated in Figures 3 and 4, the auto-throttle system was automatically controlling the thrust, though modestly, in line with the speed of the Aircraft. The FO could not afford to operate the thrust lever and the auto-throttle system was controlling the thrust as the FO was unable to do so. Therefore, it is probable that the FO's failure to disengage auto-throttle had no major influence on his recovery operations and his inaction on auto-throttle rather complemented the recovery operations.

3.4.9 Influences in Night Flight

The location where the incident occurred was far from the land, as the Aircraft was flying over the Pacific northward. When the FO was performing the recovery operations, it is somewhat likely that because he was sitting in the right seat in the cockpit, he was unable to have a continuous and intuitive awareness about the aircraft attitude while basing his judgment on lights in a city area seen on his left.

However, when an operation must be made to correct an upset attitude, pilots usually make a recovery operation while confirming the flying attitude by watching the PFD indications and other instruments, rather than observing the outside situation.

Based on these mutters, it is probable that the fact that the Aircraft was flying at night was a factor behind the FO's failure to have a correct situational awareness and make an appropriate recovery operation. But it is probable that the night flight itself had nothing to do with his failure to make an appropriate or full recovery operation based on a calm judgment.

3.4.10 PIC's Action in Opening Door

As described in 2.1.2 (2), the FO heard the PIC attempting to open the cockpit door several times after the start of his recovery operations, but he concentrated on making operations to correct the aircraft attitude, according to his statement. It is highly probable that the PIC attempted to open the door at the time after sending a predetermined signal to the FO again and before the PIC's reentry.

In this investigation, it could not be determined whether the PIC's attempt to open the door had anything to do with the FO's recovery operations. But, as described also in 2.1.2 (2), the FO's memories were ambiguous about what happened during his recovery operations, as illustrated by his lack of memories about whether the stick shaker was activated and how much the bank was, but he did have memories about the PIC's attempt to open the door.

This means that the attempt by the PIC was deeply etched in his mind and it cannot be denied that this had some influence on his behavior. Therefore, it is somewhat likely that the PIC's attempt to open the cockpit door prevented the FO's calm judgment.

3.5 Reports to Air Traffic Control Authorities

The reports by the Aircraft to an air traffic control authorities are as described in the statements by the FO and the Controller (2.1.2 (2) and (5)) and the air traffic control communication records (Attachment 1).

It was at 22:50:43 when the FO made his reply to the Controller after receiving and reading back the instructions for changing the route. It was after the PIC entered the cockpit and took over control from the FO, during this time, the FO was called twice by the Controller as she perceived an unusual situation aboard the Aircraft. The FO replied to the Controller only after the third call was made.

As described in 2.1.2 (2), the FO had no memories that the Controller was calling him, until the third call. Because no records were retained in the CVR, the situation within the Aircraft could not be confirmed. But, because the PIC entered the cockpit at 22:50:11, as described in 2.1.1, and also because the Controller started calling the FO at 22:50:16, as described in the air traffic control communication records in Attachment 1, it is probable that her calls to the FO began around when the PIC entered the cockpit and took his seat. It is probable that until before the third call, the FO was explaining the situation to the PIC and taking over the duties of PF to him. In these circumstances, it is somewhat likely that even if the FO could catch this call, he had postponed his response to the call; besides, it is also somewhat likely that he lost his memories as he had been shaken by the situation.

In his reply made at 22:50:43, the FO said "request maintain FL360 maintain heading" asking the Controller to approve it (Event a), and he had it cleared. The FO made reports about the deviation of the aircraft from the route and the altitude as instructed by the Controller only after a lapse of certain time, and it is probable that this delay reflected the situation when he was making an upset recovery operation.

At 22:52:07, the FO reported to the Controller that the Aircraft returned to FL360 and it was proceeding direct to PQE (Event c) and then, he was asked by the Controller, who felt an unusual situation, which altitude to request as any altitude was available for the Aircraft. He requested to maintain the altitude of FL360 and the heading to PQE.

The FO was called by the Controller at 22:55:16 and he was confirmed if the situation aboard the Aircraft is all right and if it can fly direct to PQE, and he reported that there is no problem. At 22:57:11, the FO requested FL350 and read back after having it cleared. At 22:59:32, he received and read back instructions from the Controller for designating the altitude which should be achieved at PQE (as the destination was drawing on). At 23:06:19, the FO reported leaving from FL350 to the Controller.

As described in 2.1.2 (5), after feeling the unusualness of the Aircraft, the Controller concluded that she should refrain from contacting the Aircraft too actively; accordingly, she did not ask the FO what happened, according to her statement. However, because she continued to believe that a report would come from the Aircraft whenever something happened, according to her statement, the information she could obtain proved to be quite limited.

Therefore, it is probable that the PIC (or the FO) and the Controller could have talked to each other to report or confirm sufficiently the reason for deviating the altitude and course on such occasions as their communication from 22:57:11 on.

3.6 Inspections after Occurrence of the Serious Incident

As described in 2.10.1, the Company carried out special inspections of the Aircraft after the occurrence of this serious incident. Inspections under Paragraphs H, J and I, as described in 2.11.1 were implemented for three days. Between the end of the Paragraph H inspection and the end of the Paragraph I inspection, the Aircraft was used for flights. Therefore, the process leading up to the implementation of the special inspections and the risk in safe flight operations were analyzed as follows.

3.6.1 Conveyed Information and Response

As described in 2.11.1, Mechanics have to investigate the aircraft condition and implement a necessary inspection, upon receiving reports from PICs. As described in 2.11.2, it is probable that matters which must be conveyed to Mechanics among those which the PIC had to report were related to cases when the aircraft condition exceeded operation limits (the MMO: M 0.82 and the load factor: 2.5 G) as prescribed in the AOM and cases when the stick shaker was activated during flight. Following are remarks about what kind of information was obtained by people involved and how they behaved after that, based on descriptions mainly in 2.10.1 and 2.10.2:

(1) Excess over Maximum Operation Limit (the MMO)

As described in 2.12.6, the Over-Speed warning is activated when the speed of the aircraft exceeds M 0.82 as the MMO. But, as described in 2.11.1 (1), a Paragraph H inspection must be implemented when the speed exceeds the MMO by M 0.02 or more.

The aircraft speed exceeded the limit as the Over-Speed warning was activated, and this was reported from the FO to the PIC, and then from the PIC to Mechanics. The PIC also told the Mechanics that the QAR must be analyzed because a specific value of the speed was unknown.

Upon receiving this report, Mechanics had to decide whether to implement a Paragraph H inspection in consideration for safe-side problems or whether to do so only after analyzing the QAR data. Mechanics took out the QAR but eventually, they did not make a data analysis while undergoing a necessary process to this end, as described in 2.11.3. Then, Mechanics implemented a Paragraph H inspection for the Aircraft and found no abnormal condition.

As described in 2.10.1 (1), because numerous items had to be checked in a Paragraph H inspection, Mechanics concluded that this inspection, out of safe-side consideration, should be made quickly to avoid an influence on the flight schedule for the following day.

(2) Excess over Operation Limit (the limit load factor)

On September 7, upon receiving information from the Flight Operations Department, Mechanics confirmed that the load factor had reached a maximum level of +2.68 G beyond the limit load factor. As described in 2.11.1 (2), when the load factor exceeded the limit of +2.5 G, Paragraph H and Paragraph J inspections had to be made, but because there was no abnormal condition in the Paragraph H inspection performed the previous day (September 6), Mechanics implemented a supplementary inspection under Paragraph J and confirmed there was no abnormal condition.

As described in 2.1.2 (2), the FO felt no strong G (the load factor); therefore, he did not report such a phenomenon to the PIC. But he reported that the Aircraft descended to 36,000 ft and that he pulled up the Column for pitch up.

The PIC received no specific report of a strong G from the FO. The PIC himself felt so strong a G that made it hard for him to keep standing, but he did not report this to Mechanics. The PIC told the Mechanics that the Aircraft banked and its speed exceeded the limit with its nose low.

(3) Activation of Stick Shaker

As described in 2.12.5, the stick shaker is so designed that it activates with a sufficient margin against to be fully kept from a state of stall. As described in 2.11.1 (3), a Paragraph I inspection must be implemented if the aircraft stalled after the activation of the stick shaker. Mechanics confirmed the activation of the stick shaker when they analyzed the QAR data and as a result, they performed a Paragraph I inspection.

However, as described in 2.11.1, when they confirmed with the Boeing Company on a later day, they learned that all inspection items listed in Paragraph I are included in those under Paragraph H. Therefore, it is probable that they had no need actually to perform a Paragraph I inspection.

Because the Aircraft Maintenance Manual was partially ambiguous when this serious incident occurred, it was not clear which inspection items overlap with which ones among those under these paragraphs. Consequently, it is probable that the inspections were implemented in the process as described above. The Boeing Company revised its maintenance manual (on October 15, 2011) and the relevant inspection items were made clear. Therefore, an inspection process such as seen in this incident will not be followed at present. Moreover, in line with the new maintenance manual, the Company revised its AMM (on February 15, 2012).

The FO had no memories that the stick shaker was activated and therefore, he did not report this phenomenon to the PIC. Because the PIC received no report of the stick shaker's activation from the FO, he did not report this to mechanics.

3.6.2 Information Acquisition and Transfer

The FO was the PF when the unusual events occurred. Therefore, it is believed that he had to report to the PIC as precisely as possible about matters which have to be reported by the PIC. But, because the FO was believed to be fairly shaken at that time, it is somewhat likely that his psychological situation made it hard for him to actively recall what happened then and report it to the PIC.

The PIC informed the Mechanics of the Over-Speed state, based on the FO's report and his own memories, but it is highly probable that he did not do so about a possible Over-Load. Because he himself felt a strong G, it is probable that he could suppose that an Over-Load had occurred. It is also probable that he could inform the Mechanics of a possible Over-Load out of safe-side consideration.

It is somewhat likely that the PIC's efforts were insufficient in generating the FO's memories in order to obtain as much information as possible about the Aircraft condition from him.

Based on these findings, it is probable that the PIC could not fully sort out the occurrences aboard the Aircraft and as a result, the related information could not be conveyed precisely to the Mechanics, resulting in the confusion in the implementation of the special inspections.

It is highly probable that the Mechanics assumed only the Over-Speed state as they were informed by the PIC that the Aircraft banked and its speed exceeded the limit with its nose low.

3.6.3 Investigation and Analysis

The special inspections implemented after the occurrence of this serious incident, as described in 2.11.1, are equivalent to those which must be made if the speed of the aircraft exceeded M 0.82 as the MMO by M 0.02 or more, if the G load factor was over +2.5, and if the aircraft was stalled after the stick shaker was activated or initial buffets were generated. Special inspections are specifically prescribed for the respective cases in the AMM.

As described in 2.11.2, PICs have to report if the airplane exceeded the operational limits (when the Over-Speed warning was activated or when the load factor exceeded 2.5 G, but there was no means of obtaining a specific figure about the load factor within the cockpit at that time), when the stick shaker was activated during flight or when buffets occurred, when the airplane met severe turbulence, or when the altitude, the speed and the aircraft attitude significantly changed unintentionally, but any specific threshold, such as seen in the AMM, is mentioned. Therefore, it is probable that as far as the relevant provisions are concerned, an actual value must be confirmed through an investigation and an analysis by Mechanics after receiving reports from the PICs.

In this case, the speed of the aircraft exceeded the MMO by a maximum M 0.008, but the excess was short of M 0.02 as a minimum requirement for maintenance. Therefore, it is probable that there was no need to perform a Paragraph H inspection in light of the data retained in the DFDR (the QAR).

As far as the Over-Load is concerned, it is probable that there was a need to perform a Paragraph J inspection because the load factor had reached a maximum +2.68 G.

Moreover, as indicated in Figures 3 and 4, while the stick shaker was activating, such phenomena as a decrease in the lift (with the vertical acceleration continuously at 1 G or less) and the generation of a significant drag (with the longitudinal acceleration continuously far below 0 G) were not seen. There was no significant gap between the displacements of the ailerons and the elevator and the aircraft movement. Therefore, it is probable that the Aircraft was not actually in a state of stall, and then, there was no need to perform a Paragraph I inspection.

The use of the QAR data is a reliable method in inspecting 737-700 in the fleet of the Company and analyzing their data, but a certain procedure must be taken to retrieve and analyze the data. Therefore, it is probable that when a PIC reported an unusual condition and when an enough time is not available because, for example, the Aircraft involved will have to be used for the next flight, Mechanics often perform an inspection for cases if the aircraft exceeded the operation limits out of safe-side consideration, rather than analyzing the QAR data to confirm whether the aircraft exceeded a threshold. An inspection required for a case when the speed exceeded the limit was performed this way for the Aircraft involved in this incident. .

However, if unusual situations aboard aircraft are not precisely explained to mechanics, they sometimes tend not to embark immediately on the inspection and analysis phase. This means that a necessary inspection may not be implemented immediately in some cases, and an aircraft concerned may be used for a flight before it performs an inspection.

In this case, the PIC explained to Mechanics that although the Aircraft might have exceeded the speed limit and over-banked, the QAR data must be analyzed to confirm specific values on the relevant matters. Accordingly, the Mechanics performed an inspection required for an aircraft condition exceeding the speed limit out of safe-side consideration and they did not analyze the QAR data at this point.

In addition, the fact that the Aircraft received a strong G and had the stick shaker activated was not explained from the PIC to Mechanics. Consequently, they did not consider analyzing the QAR data to confirm whether the load factor exceeded the limit and the Aircraft was in a state of stall. This led to confusion in the implementation of special inspections for the Aircraft involved.

Based on these matters, it is somewhat likely that because a judgment on whether to make a special inspection for the Aircraft greatly depended on the PIC's report, actions for inspection and analysis proved to be too late; accordingly, the subsequent inspection process was confused. Studies should be made to utilize ACMSs described in 2.12.7 for wider applications and use their data as part of reference information for a judgment about the need to perform a special inspection.

3.6.4 Risk in Safe Flight Operations

Special inspections under Paragraphs H, J and I should have been performed on September 6. But the Paragraph H inspection was actually performed on September 6, the Paragraph J inspection on September 7 and the Paragraph I inspection on September 8, as detailed information about the serious incident became clearer. Therefore, the Aircraft was used for flights before conducting the inspections under Paragraphs J and I.

As described in 2.10.1, no abnormal condition was found in any of the special inspections. As described in 3.6.3, in view of the retained data, there was no need to perform inspections under Paragraphs H and I. In addition, as the Paragraph J inspection, which had to be perform immediately, involved only visible checks of the cabin ceiling panel and baggage stow bin, any unusual conditions in these areas can be easily found by flight crew members, cabin attendants, ground maintenance personnel or other persons while doing their routine business. In these circumstances, it is probable that there was actually almost no risk in safe flight operations.

However, the suspected excess in load, the activation of the stick shaker and the need to analyze the QAR data were not informed by the PIC to Mechanics involved. The Mechanics could not be aware of these events immediately; consequently, the implementation of the special inspections was confused. It is probable that the process for the persons involved to undergo at that time, from the acquisition and transfer of the relevant information to the investigation and scrutiny of the data, can be blamed for the confusion in implementing the special inspections.

4 CONCLUSIONS

4.1 Summary of Findings

4.1.1 General

Because the PIC and the FO held both valid airman competence certificates and valid aviation medical certificates, it is highly probable that they were in good physical conditions. In addition, because the Aircraft had a valid airworthiness certificate and had been maintained and inspected as prescribed, and also because there were neither data nor statements indicating any discrepancy with the Aircraft, it is highly probable that the condition of the Aircraft had nothing to do with the occurrence of this serious incident. Moreover, it is highly probable that the meteorological condition on the day had nothing to do with the occurrence of serious incident. (3.1)

4.1.2 FO's Erroneous Operation

It is probable that the FO's erroneous operation of the Rudder Trim SW resulted from the fact that his memories of operation about the Door Lock Selector of the 737-500 on which he was previously on duty remained uncorrected and the fact that there were similarities between that Door Lock Selector and the Rudder Trim SW of the 737-700 in their location, shape, size and operability. (3.2.2, 3.2.3)

It is somewhat likely that the signal for entry from the PIC made the FO hurriedly operate the Door Lock Selector while he was operating the CDU, and this contributed to his erroneous operation. (3.2.4)

It is probable that the FO's memories of operation about the Door Lock Selector of the 737-500 remained uncorrected because he had not been fully accustomed with the change in the location of the Door Lock Selector in the differences training. It is somewhat likely that this resulted from lack

of effectiveness in the current system for determining the differences training contents and its check method, under which the Company and other air carriers considered and adopted specific training programs to train pilots about how to operate the flight deck switches when their locations changed and the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism reviewed and approved them. (3.2.5, 3.2.6)
In addition, it is probable that the CDU operation by the FO which could be deferred, and his failure to properly manage his tasks contributed to his erroneous rotation of the Rudder Trim SW. It is probable that behind this, there was the fact that the Company had prescribed no specific provisions about how to deal with an unusual situation when only one pilot remains in the cockpit. (3.2.7, 3.2.8)

4.1.3 Delay in Recognition of Erroneous Operation

The results of the flight simulator examination indicate that the upset occurred because the FO did not quickly recognize his erroneous operation. It is probable that the following factors were responsible for his delayed recognition: (the first part of 3.3)

(1) Similarities in the operability of the Both Switches

Because the operations of two switches are similar -- they must be held at the rotated positions --, it is somewhat likely that the FO felt nothing unusual in continuously holding the wrong switch when he was operating the Rudder Trim SW while having an intention of operating the Door Lock Selector. (3.3.2)

(2) Monitoring of flight conditions

It is somewhat likely that the FO was excessively dependent on autopilot flight and he failed to be fully aware of monitoring the flight condition. Besides, it is probable that the following facts were behind this: The Company had prescribed no specific provisions about how to deal with unusual situations when only one pilot remains in the cockpit. The FO had not received safety education for these unusual situations. (3.3.6, 3.3.7)

(3) Other factors involved

It is somewhat likely that the FO was preoccupied with unlocking the cockpit door as he received a repeated signal for entry from the PIC. (3.3.8)

It is somewhat likely that there also existed a factor that it was a night flight behind his delayed recognition. (3.3.9)

It is highly probable that the bank angle alert could not contribute to the prevention of late recognition of erroneous operation. (3.3.10)

4.1.4 Inappropriate or Insufficient Recovery Operations

In response to the roll and the pitch of the Aircraft, the FO operated the Wheel and the Column almost in the direction toward recovery; therefore, it is probable that he had been aware of the condition of the roll and the pitch. (3.4.2)

When the Wheel was rotated CW almost to the limit, the roll angle momentarily changed toward recovery. But, when the stick shaker was activated and its activation was continuing, the FO loosened his force on the Wheel, and then by applying a force in the opposite direction, quickly returned the Wheel beyond the neutral position. Accordingly, it is probable that the roll angle to the left became large again. It is somewhat likely that this Wheel operation was made at a time when the FO was startled and confused on the occurrence of an unexpected situation in which the stick shaker was activated, when the Wheel was fully rotated. It is probable that this eventually led to his inappropriate recovery operation. (3.4.3)

Just after this, the FO made an operation to return the rudder trim, but it is probable that during this operation, his situational recognition for watching the aircraft attitude became weaker. Then, his operation to rotate the Wheel CW proved to be insufficient, and then the roll angle to the left became large again. It is probable that the operation to return the rudder trim should have been made after the Aircraft attitude was almost recovered. (3.4.4)

It is probable that the FO was pulling the Column to recover the pitch angle and at this time, the stick shaker was activated following an increase in the AOA. The pitch decreased largely as he pushed the Column forward to prevent a stall. Then, he pulled the Column again, causing the stick shaker to be activated. It is probable that these operations and reactions were repeated.

At the same time, it is probable that the Aircraft took a dive following an increase in the roll angle, and its speed continued to increase. While the speed of the Aircraft was over the MMO, the Over-Speed warning was activated.

At a time when the stick shaker and the Over-Speed warning are believed to have been activated simultaneously, it is probable that the FO repeated operations to move the Column backward and forward. During this time, the Aircraft exceeded the limited load factor limit and the speed exceeding the air speed limit several times, but the pitch angle was eventually recovered. (3.4.6)

In view of the findings mainly from the flight simulator examination, it is somewhat likely that the FO's recovery operation mentioned above was inappropriate or insufficient. It is probable that the following factors contributed to this: (the first part of 3.4)

(1) Upset Recovery Training

The FO did not receive upset recovery training accompanied with a stall warning and in an unexpected situation; accordingly, the upset which suddenly occurred and the activation of the stick shaker during recovery operation were the first such event for the FO to experience. Therefore, it is somewhat likely that the FO got startled and confused on the unusual situation. (3.4.7 (1))

(2) High altitude Upset Recovery Training

Because the FO did not receive upset recovery training at a high altitude, it is somewhat likely that he was startled and confused on the activation of the stick shaker. (3.4.7 (2))

(3) Other factors

It is somewhat likely that the PIC's attempt to open the cockpit door prevented the FO's calm judgment. (3.4.10)

It is probable that the fact that the FO made a recovery operation on the CWS mode on autopilot while operating the Control Wheel and Column had no major influence on the recovery operation.

Moreover, it is probable that the FO's failure to disengage auto-throttle had no major influence on his recovery operation and his inaction on auto-throttle rather complemented the recovery operations. (3.4.8)

4.2 Probable Causes

It is highly probable that this serious incident occurred in the following circumstances: During the flight, the FO erroneously operated the Rudder Trim SW while having an intention of operating the Door Lock Selector in order to let the PIC reenter the cockpit. The aircraft attitude became unusual beyond a threshold for maintaining the aircraft attitude under the autopilot control. The

FO's recognition of the unusual situation was delayed and his subsequent recovery operations were partially inappropriate or insufficient; therefore, the aircraft attitude became even more unusual, causing the Aircraft to lose its lifting force and went into nosedive. This led to a situation which is equivalent to "a case where aircraft operation is impeded."

It is probable that the followings contributed to the FO's erroneous operation of the Rudder Trim SW while having an intention of operating the Door Lock Selector; he had not been fully corrected his memories of operation about the Door Lock Selector of the 737-500 on which he was previously on duty; the Door Lock Selector of the 737-500 was similar to the Rudder Trim SW of the 737-700 in their placement, shape, size and operability. It is somewhat likely that his memories of operation about the Door Lock Selector of the 737-500 had not been fully corrected because he failed to be fully accustomed with the change in the location of the Door Lock Selector. It is somewhat likely that this resulted from lack of effectiveness in the current system for determining the differences training contents and its check method, under which the Company and other air carriers considered and adopted specific training programs to train pilots about how to operate the flight deck switches when their locations changed and the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism reviewed and approved them. It is probable that the FO's failure to properly manage tasks contributed to his erroneous operation of the Rudder Trim SW.

It is somewhat likely that the similarities between the Door Lock Selector and the Rudder Trim SW in their operability contributed to the delay in his recognition of the erroneous operation. Moreover, he was excessively dependent on autopilot flight and he failed to be fully aware of monitoring the flight condition.

It is somewhat likely that the FO's recovery operations were partially inappropriate or insufficient because he was startled and confused on the occurrence of an unexpected unusual situation in which the stick shaker was activated during the upset recovery maneuver. It is somewhat likely that the followings contributed to his startle and confusion: he had not received upset recovery training accompanied with a stall warning and in unexpected situations, thereby he lacked the experience of performing duties in such situations before the serious incident, and he had not received upset recovery training at a high altitude.

4.3 Other Findings on Safety-related Matters

4.3.1 Inspection after Occurrence of the Serious Incident

After the occurrence of this serious incident, the Company used the Aircraft for actual flights before the completion of all necessary special inspections. But no abnormal condition was found when the special inspections were performed. Therefore, it is probable that there was actually almost no risk in safe flight operations. However, it is probable that the implementation of the special inspections was confused by factors related to the process the persons involved had to undergo at that time, from the acquisition and transfer of the relevant information to the investigation and scrutiny of the data.

(1) Information on acquisition and transfer

It is probable that the fact that necessary information was not conveyed from the PIC to Mechanics because of his failure to properly sort out the events which occurred aboard the Aircraft was involved with the confusion in the implementation of the special inspections.

(2) Investigation and analysis

It is somewhat likely that because the Company's judgment on whether to make a special inspection for the Aircraft greatly depended on the PIC's report, actions for inspection and analysis proved to be too late; consequently, the subsequent inspection process was confused.

4.3.2 Use of Oxygen Mask

As described in 2.12.3, the Company's OM prescribes, "In the event that one of the pilots leaves his/her seat in the cockpit at an altitude of 25,000 feet or above, the other pilot shall use his/her oxygen mask until he/she comes back." Because the Aircraft was cruising at an altitude of 41,000 ft when the PIC left the cockpit, the provision can be applied to this case.

However, as described in 2.1.2 (2), the FO did not wear and use an oxygen mask while the PIC was absent from the cockpit, according to his statement. He knew that there was a provision for crew members to use oxygen masks in this situation, but he did not do so.

5 SAFETY ACTIONS

5.1 Safety Actions Taken by the Company, ANA and the ANA Group

5.1.1 Measures Related to Erroneous Rudder Trim SW Operation and Delay in Recognition

(1) Establishment and distribution of points of concern for cases when only one pilot remains in the cockpit in flight

The Company established the consideration as to the case when one of flight crew member leaves the cockpit.

For cases in which one flight crew member leaves the cockpit, the Company established points of concern when he or she leaves, during the flight crew member is absent, and when the flight crew returns to the cockpit, in order to ensure safety in flight operations, and distributed necessary materials in the form of OM information (a document to be released when information related to OM provisions must be temporarily conveyed to related personnel. When this information is valid, the material involved is always placed within the cockpit together with the OM.). A checklist for specifically confirming these matters was provided to flight crew members and they were urged to carry the list with them. The points of concern are as follows: (Partially omitted)

A. Before one pilot leaves

- *Choose an appropriate time period with lower work load when leaving the cockpit. Avoid an exit when the aircraft is flying near an FIR border in an international flight.*
- *Mutually confirm important points for flight operation which may be expected while the pilot is absent.*
- *Mutually confirm a procedure for reentering the cockpit.*
- *The pilot leaving the cockpit shall confirm, "The other pilot is ready to take over autopilot and auto-throttle quickly whenever necessary," and "The other pilot will wear an oxygen mask (while flying at 25,000 ft or higher)," "*(Omitted) *The other pilot is ready to communicate with an ATC (air traffic controller)."*

B. While the pilot is absent

The pilot staying in the cockpit shall abide by the following matters:

- *Follow the "Fly First" principle. "Fly First" means giving the maximum possible weight to "Flight Path and Airspeed Control," "Airplane Configuration" and*

"Navigation."

- *Always place his or her feet on the rudder pedals to make up a decline in the flight condition monitoring functions.*
- *Be ready to take over autopilot and auto-throttle quickly whenever necessary*
- *Try to be calm and careful to avoid an erroneous action in entering data into a CDU and* (Omitted) *operating various aircraft systems and at the same time, confirm the results of the operations to ensure reliability in the operations.*
- *Always confirm doubts, if any, in ATC communication.*
- *Appropriately prioritize duties and* (Omitted) *avoid a situation in which two operations have to be performed simultaneously.*
- *Except for urgent cases, avoid company radio and* (Omitted) *communication with the cabin for purposes other than confirming matters related to the reentry of the pilot who left the cockpit*

C. After the pilot returns

- *Share information about the flight condition and information obtained while the pilot was absent from the cockpit*

These measures were implemented within the Company. But, because the Company was merged with All Nippon Airways Co., Ltd (ANA) on April 1, 2012, the OM information mentioned above does not exist anymore.

Following the occurrence of the serious incident and other events, the ANA group introduced "Important Points for Operation with One Pilot in the Cockpit" as follows, in a common publication for the group companies (The Flight ANA Group, dated June 11, 2012), the material aimed at introducing case studies and comments about them for flight crew members in an effort to provide even safer and high-quality flight services:

1) *Choose a time period with low work load when leaving the cockpit and only one pilot remains in the cockpit.*
2) *Before leaving the cockpit, hand over expected duties to the remaining pilot.*
3) *Before leaving the cockpit, mutually confirm the cockpit door switch and signal for opening the door.*
4) *If required by regulations the pilot leaving the cockpit shall confirm that the remaining pilot has don the oxygen mask.*
5) *If possible, autopilot and autothrottle shall be used and the pilot in the cockpit shall always be prepared to immediately take the control of the aircraft if required.*
6) *The pilot remaining in the cockpit shall always monitor the situation of the aircraft and execute duties along an order of priority and not several duties at the same time. If possible the pilot remaining in the cockpit shall not execute duties that are not urgent.*
7) *When the signal for opening the cockpit door has been given, the pilot in the cockpit shall operate the cockpit door switch thoroughly after having confirmed the switch position visually.*
8) *After the pilot who has left the cockpit returned, both pilots shall mutually confirm the flight conditions encountered during the time only one pilot was in the cockpit.*

All Nippon Airways Co., Ltd adopted the following rule as additional provisions to

POLICY MANUAL 4-1-1 Fly First, as of August 1, 2012, and released the new provisions, effective the same day: In the event only one pilot is in the cockpit, this pilot shall be aware of the absence of a PM, give priority to the aircraft control and pay the utmost intention when executing duties other than aircraft control. The publication number of The Flight ANA Group, as mentioned above, and the name of the topic involved ("Important Points for Operation with One Pilot in the Cockpit") were added the same day to the POLICY MANUAL Material List (a publication in which reference materials are listed to ensure understanding of POLICY MANUAL) and entered into force effect the same day.

(2) Improvement of training for secure switch operations

The need for secure switch operations was designated as a priority guidance item in recurrent training and check. The ANA implemented this measure within the group.

(3) Addition of training for recognition of switches which tend to be erroneously operated.

The existence of switches which tend to be erroneously operated was added as a new item to differences training for transfer from the 737-500 to the 737-700NGs (737-700 or 737-800). The Company implemented this measure and handed it over to the group.

(4) Dissemination of measures for recognition of switches which tend to be erroneously operated

Switches which might be erroneously operated were investigated through routine inspections for all kinds of aircraft, and this was widely known through a common publication for all member companies. The ANA implemented this measure within the group.

5.1.2 Measures to Prevent Inappropriate or Insufficient Recovery Operations

(1) Improvement of education with case studies for basic actions

Visual educational materials were adopted for case studies to train pilots about basic actions. The ANA implemented this measure within the group.

(2) Preparation of high altitude upset recovery training

Information was collected about such matters as high altitude upset recovery training, which is becoming an international standard. Preparations are being made to implement relevant measures without delay. This measure has been implemented by All Nippon Airways on behalf of the group.

5.1.3 Measures to Wear and Use Oxygen Masks

The need to wear and use oxygen masks was designated and prescribed as points of concern, as part of measures in line with 5.1.1 (1). This measure was implemented within the Company.

5.1.4 Measures for Confusion in Special Inspections

(1) Improvement of communication with Issuance of TSI (Technical Service Information)

Communication between the flight crew members and mechanics was improved by issuing TSI titled "The deal with the receipt of reports in cases when aircraft surpassed the operating limits" for mechanics. The ANA implemented this measure within the group.

(2) Operational expansion ACMSs

The ANA expanded operation of ACMS so that the flight crew members or mechanics can recognize situations when the aircraft condition exceeded a threshold as a base to determine whether to perform a special inspection. The ANA is introducing this monitoring system for many aircraft, including other types of aircraft, and has implemented this measure within the group.

5.2 Safety Actions Taken by the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism

The Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism established the internal guideline titled "Method for Review of QUALIFICATIONS MANUAL relevant to TRANSITION TRAINING and so on" and based on this guideline, it has institutionalized to review differences training program on the basis of a document prepared by the applicant that differences came into focus, with reference to the system of the ODR Table used in the FAA.

5.3 Safety Actions Required

5.3.1 Measures to Prevent Erroneous Operations of Rudder Trim SW and Delay in Recognition of Errors

(1) Studies of measures about type-to-type commonality and similarities of control switches

The aircraft designer and manufacturer (the Boeing Company) should study the need to reduce or eliminate the similarities between the Rudder Trim SW and the Door Lock Selector of the 737 series aircraft, in terms of the shape, size and operability as mentioned in this report. In particular, the Boeing should consider the effectiveness of changing the shape and size of the Rudder Trim SW to the design adopted for the Rudder Trim SW of Boeing models other than those of the 737 series, in which the switch has a cylindrical shape about 50mm in diameter without a brim, so that the difference of the size and shape can be recognized only with a touch.

(2) Thorough implementation of basic compliance matters for cases when the aircraft is operated by single pilot and training to this end

The series of preventive measures taken mainly in the form of designating and effectuating measures in the OM information of the Company for cases when the cockpit is manned temporarily by a single pilot have almost covered measures which should be taken to avoid problems mentioned in this report as factors responsible for the serious incident, namely, CDU operations, improper task management and inappropriate monitoring of the flying condition.

The preventive measures implemented by the Company were taken over by the ANA group when the Company was merged with the ANA group. In line with these measures, All Nippon Airways Co., Ltd. adopted a rule calling on the crew member staying in the cockpit to "give priority to the control of the aircraft and pay the utmost intention when executing duties other than aircraft control" as an additional provision to its POLICY MANUAL. All Nippon Airways also revised the materials list involved to register and publish the publication number of The Flight ANA Group, in which information about the preventive measures described in the OM information involved was provided as an article, and the name of the topic involved ("Important Points for Operation with One Pilot in the Cockpit"). However, a document which shows specific compliance matters for flight crew members following the preventive measures is an organ for introducing case studies and providing comments about them. Therefore, the compliance matters may not be fully made known to all flight crew members, and then continuous education to this end may not be implemented. Accordingly, the effects of the preventive measures may prove to be limited and temporal.

Consequently, All Nippon Airways Co., Ltd., who has taken over the flight services with the Boeing 737 series aircraft operated by the Company as the party relevant to the cause of the serious incident, should thoroughly implement the preventive measures, described in the OM information published by the Company and in The Flight ANA Group, for all flight crew members as specific and permanent basic compliance matters and continuously train them to this end.

5.3.2 Measures to Prevent Inappropriate or Insufficient Recovery Operations

(1) Implementation of high altitude upset recovery training accompanied with stall warning and other events.

Airlines should implement "upset recovery training" at a high altitude upon considering defined flight envelope validated region of flight simulators. If necessary, they should also introduce a system to examine whether the recovery process is made outside the validated region. Moreover, scenarios in which a stall warning and others will be simultaneously activated or in which an upset cannot be expected by trainees should be prepared for such training.

(2) Improvement of reproduction of the flight simulators

Flight simulator manufacturers should make further efforts for research and development so that upset recovery training accompanied with advanced signs of a stall at a high altitude can be simulated in a more reproducible.

6 RECOMMENDATIONS

6.1 Recommendations to All Nippon Airways Co., Ltd.(the airlines who took over the flight services with the Boeing 737 Series aircraft operated from Air Nippon Co., Ltd. as the party relevant to the cause of the serious incident).

It is highly probable that this serious incident occurred in the following circumstances: During the flight, the first officer erroneously operated the rudder trim control while having an intention of operating the switch for the door lock control in order to let the captain reenter the cockpit. The aircraft attitude became unusual beyond a threshold for maintaining the aircraft attitude under the autopilot control. The first officer's recognition of the unusual situation was delayed and his subsequent recovery operations were partially inappropriate or insufficient; therefore, the aircraft attitude became even more unusual, causing the aircraft to lose its lifting force and went into nosedive. This led to a situation which is equivalent to "a case where aircraft operation is impeded."

Of these, it is somewhat likely that the first officer's failure to properly manage tasks contributed to his erroneous operation of the rudder trim control, and that his excessive dependence on autopilot flight and his lack of close attention to monitoring the flight condition contributed to the delay in his recognition of the erroneous operation. It is probable that behind this, there was the fact that the Air Nippon Co., Ltd. had prescribed no specific provisions about how to deal when only one pilot remains in the cockpit.

Furthermore, it is somewhat likely that the first officer's recovery operations were partially inappropriate or insufficient because he was startled and confused on the occurrence of an unexpected unusual situation in which the stick shaker was activated during the upset recovery. It is somewhat likely that the followings contributed to his startle and confusion; he had not received upset recovery training accompanied with a stall warning at a high altitude and in unexpected situations.

Consequently, based on the results of the serious incident investigation, the Japan Transport Safety Board recommends All Nippon Airways Co., Ltd., who took over the flight services with the Boeing 737 series aircraft operated by Air Nippon Co., Ltd., to take the following measures pursuant to the provision of paragraph 1, Article 27 of the Act for Establishment of the Japan Transport Safety Board:

If should be noted that measures based on this recommendation shall be implemented after an international trend over related matters is fully confirmed.

6.1.1 Thorough Implementation of Basic Compliance Matters for Cases when Aircraft is Operated by a single pilot and Training to This End

The preventive measures concerned, as described in the OM information published by Air Nippon Co., Ltd. and in The Flight ANA Group, should be thoroughly implemented for all flight crew members as specific and permanent basic compliance matters and they should be continuously trained to this end.

6.1.2 Implementation of High Altitude Upset Recovery Training Accompanied with Stall Warning and Other Events

All Nippon Airways Co., Ltd. should implement "upset recovery training" at a high altitude upon considering defined flight envelope validated region of flight simulators. If necessary, All Nippon Airways Co., Ltd. should also introduce a system to examine whether the recovery process is made outside the validated region of flight envelope. Moreover, scenarios in which a stall warning and others will be simultaneously activated or in which an upset cannot be expected by trainees should be prepared for such training.

6.2 Recommendations to Minister of Land, Infrastructure, Transport and Tourism

It is highly probable that this serious incident occurred in the following circumstances: During the flight, the first officer erroneously operated the rudder trim control while having an intention of operating the switch for the door lock control in order to let the captain reenter the cockpit. The aircraft attitude became unusual beyond a threshold for maintaining the aircraft attitude under the autopilot control. The first officer's recognition of the unusual situation was delayed and his subsequent recovery operations were partially inappropriate or insufficient; therefore, the aircraft attitude became even more unusual, causing the aircraft to lose its lifting force and went into nosedive. This led to a situation which is equivalent to "a case where aircraft operation is impeded."

Of these, it is somewhat likely that the first officer's recovery operations were partially inappropriate or insufficient because he was startled and confused on the occurrence of an unexpected unusual situation in which the stick shaker was activated during the upset recovery. It is somewhat likely that the followings contributed to his startle and confusion; he had not received upset recovery training accompanied with a stall warning at a high altitude and in unexpected situations.

It is considered that the findings mentioned above as factors for the occurrence of this serious incident should commonly prevail in not only All Nippon Co., Ltd. but also other airlines and measures to improve their preparedness are expected to contribute to preventing similar incidents.

Therefore, the Japan Transport Safety Board, based on the results of the investigation of this serious incident, recommends the Minister of Land, Infrastructure, Transport and Tourism to take the following measures pursuant to provision of paragraph 1, Article 26 of the Act for Establishment of the Japan Transport Safety Board:

The Minister should study the possibility of making "upset recovery training" mandatory for the air transport services provider and urge them to implement this training at a high altitude upon considering defined flight envelope validated region of flight simulators. If necessary, they should also be urged to introduce a system to examine whether the recovery process is made outside the validated region.

Moreover, guidance should be made to have airlines prepare scenarios for such training in which a stall warning and others will be simultaneously activated or in which an upset cannot be expected by trainees.

It should be noted that measures based on this recommendation shall be implemented after an international trend over related matters is fully confirmed.

6.3 Safety Recommendations to FAA

It is highly probable that this serious incident occurred in the following circumstances: During the flight, the first officer erroneously operated the rudder trim control while having an intention of operating the switch for the door lock control in order to let the captain reenter the cockpit. The aircraft attitude became unusual beyond a threshold for maintaining the aircraft attitude under the autopilot control. The first officer's recognition of the unusual situation was delayed and his subsequent recovery operations were partially inappropriate or insufficient; therefore, the aircraft attitude became even more unusual, causing the aircraft to lose its lifting force and went into nosedive. This led to a situation which is equivalent to "a case where aircraft operation is impeded."

Of these, it is probable that the similarities between the switch for the door lock control of the Boeing 737-500 series aircraft and the rudder trim control of the Boeing 737-700 series aircraft in their shape, size and operability contributed to the first officer's erroneous operation of the rudder trim control with an intention of operating the switch for the door lock control.

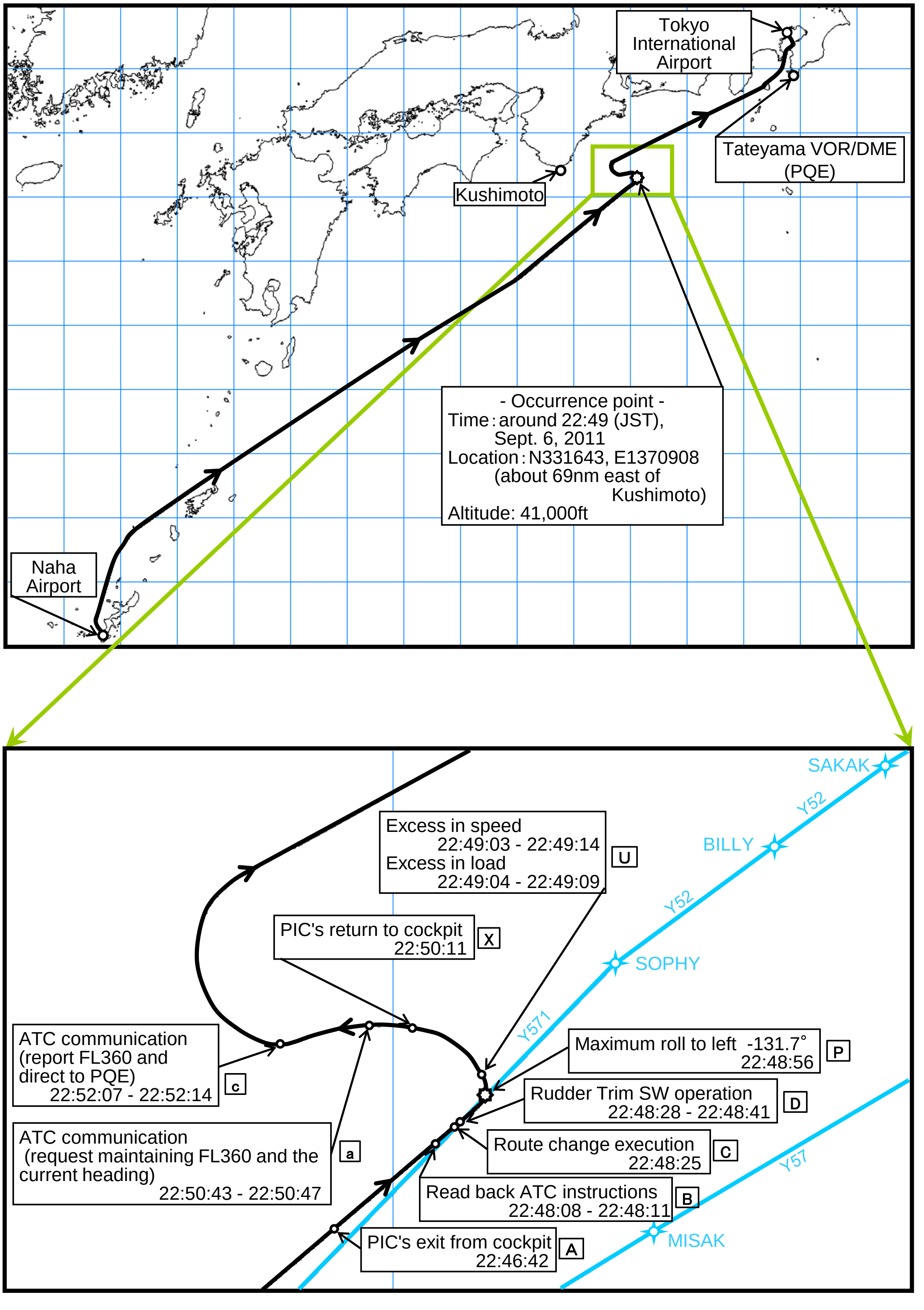
In view of the results of the investigation of this serious incident, the Japan Transport Safety Board recommends the Federal Aviation Administration (FAA) of the United States of America to urge the aircraft designer and manufacturer involved (the Boeing Company) to take the following measures:

The aircraft designer and manufacturer shall study the need to reduce or eliminate the similarities between the rudder trim control and the switch for the door lock control of the Boeing 737 series aircraft, in terms of the shape, size and operability as mentioned in this report. In particular, it shall consider the effectiveness of changing the shape and size of the rudder trim control to the design adopted for the rudder trim control for Boeing models other than those of the Boeing 737 series, in which the switch has a cylindrical shape about 50mm in diameter without a brim, so that the difference of the size and shape can be recognized only with a touch.

Attached table List of Events

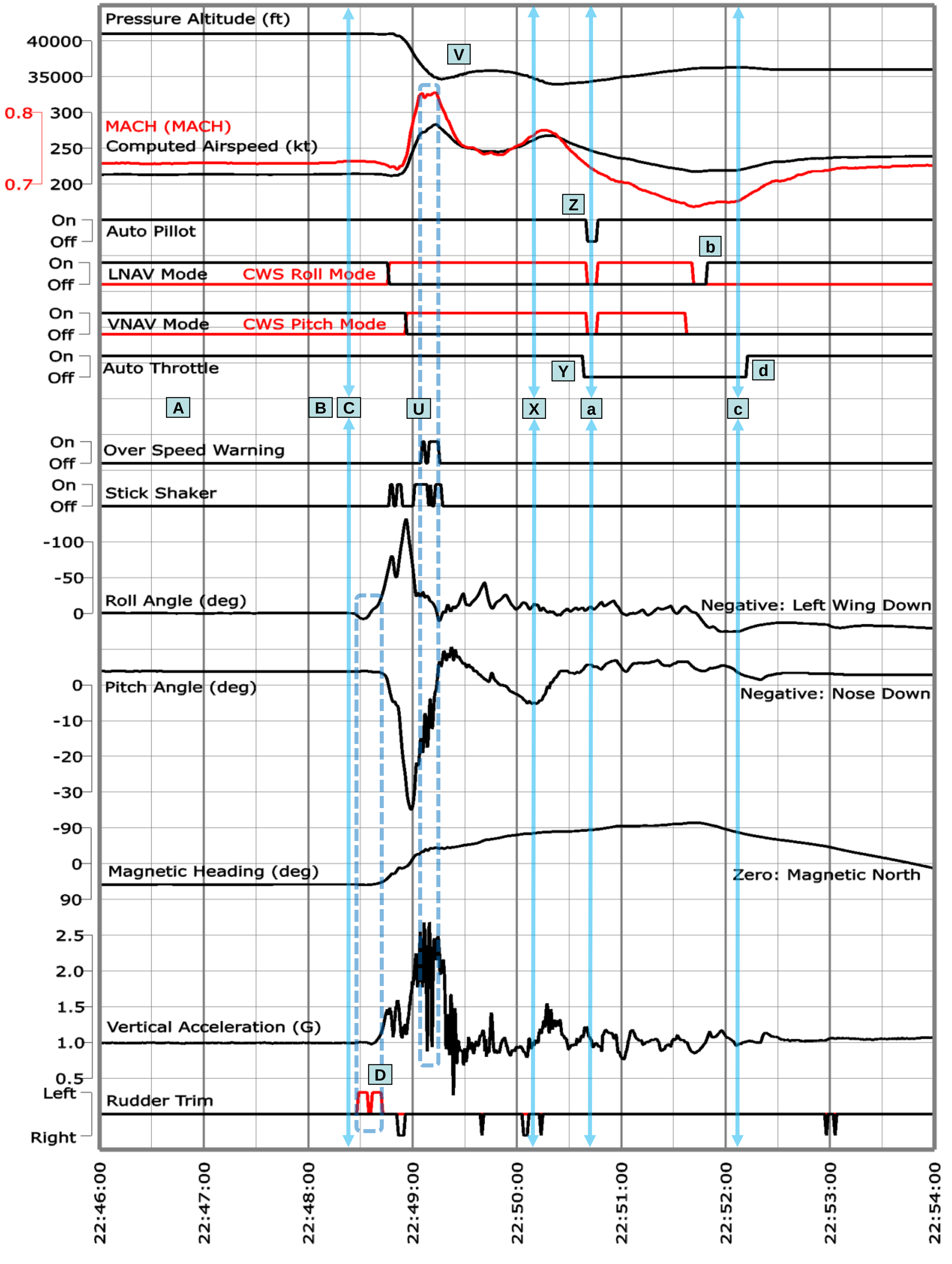
Symbol	Time	Event Summarized
A	22:46:42	PIC's exit from cockpit
	22:48:04	ATC instructions
B	22:48:08	Read back ATC instructions
	22:48:--	Data input into CDU, PIC's signal for entry
C	22:48:25	Route change execute on CDU
D	22:48:28	Rudder Trim SW operation
E	22:48:35	LNAV correction and limitations
F	22:48:36	Roll to the left beyond level
G	22:48:40	Altitude on VNAV maintained
H	22:48:43	Thrust increase by auto-throttle
GPWS	22:48:43	Bank angle alert
I	22:48:45	Wheel operated CW and recovery operation start
J	22:48:45	VNAV correction and limitations
K	22:48:46	Right rudder padal pressed
L	22:48:47	Stall warning and Wheel returned beyond level
M	22:48:51	Roll to the left became large again
N	22:48:52	Operation made to return Rudder Trim SW
O	22:48:53	Start of nosedive
P	22:48:56	Roll to the Left -131.7°
Q	22:48:56	Thrust reduced by auto-throttle
R	22:48:59	Nose low -35°
S	22:49:00	Pulling up of Column and stall warning
T	22:49:02	Recovery of roll angle
U	22:49:03	Excess in speed
	22:49:04	Excess in load
V	22:49:16	Nosedive seased
W	22:49:26	Recovery of pitch angle
X	22:50:11	PIC's return to cockpit
Y	22:50:38	Taking over flight duties
Z	22:50:39	Re-engaging Autopilot mode
a	22:50:43	Communication with Controller
b	22:51:49	LNAV mode set
c	22:52:07	Communication with Controller
d	22:52:13	Almost normal flight condition recovered

Figure 1 Estimated flight route



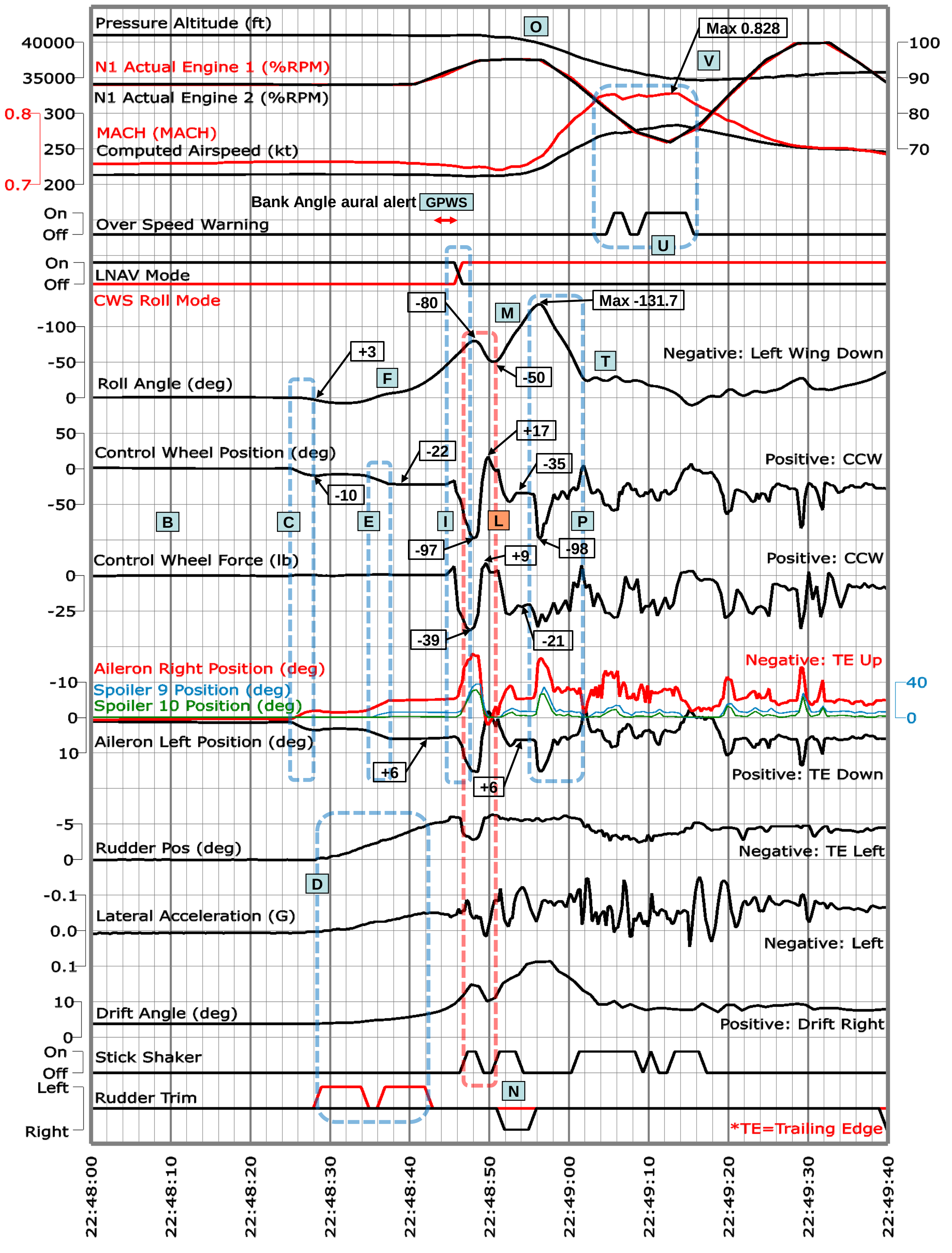
The event identification signs were shown as A to Z, a to d, and GPWS in this figure. The outline of each event can be found the List of Events in the Attached table.

Figure 2 DFDR Records (Overview)



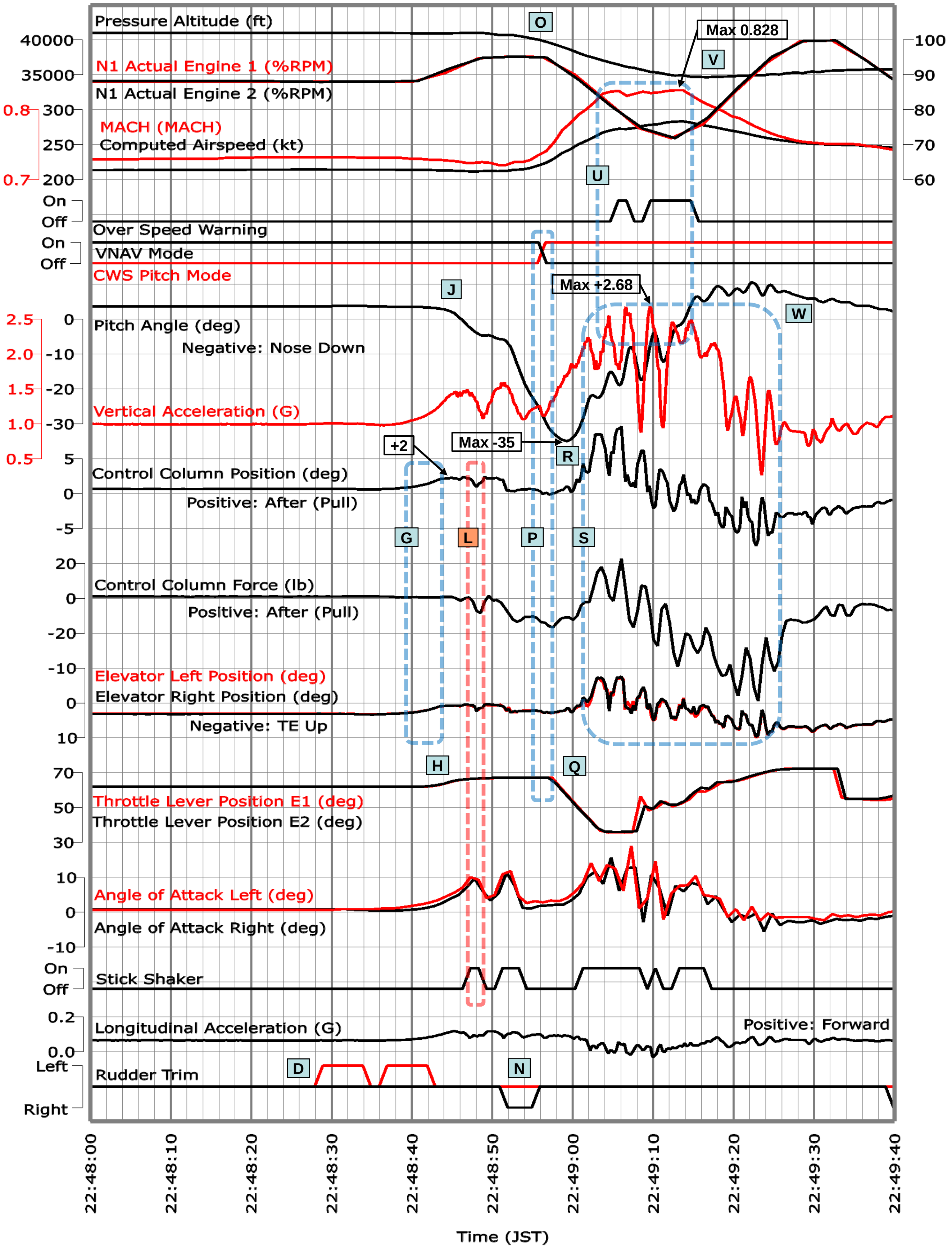
The event identification signs were shown as A to Z, a to d, and GPWS in this figure. The outline of each event can be found the List of Events in the Attached table.

Figure 3 DFDR Records (ROLL)



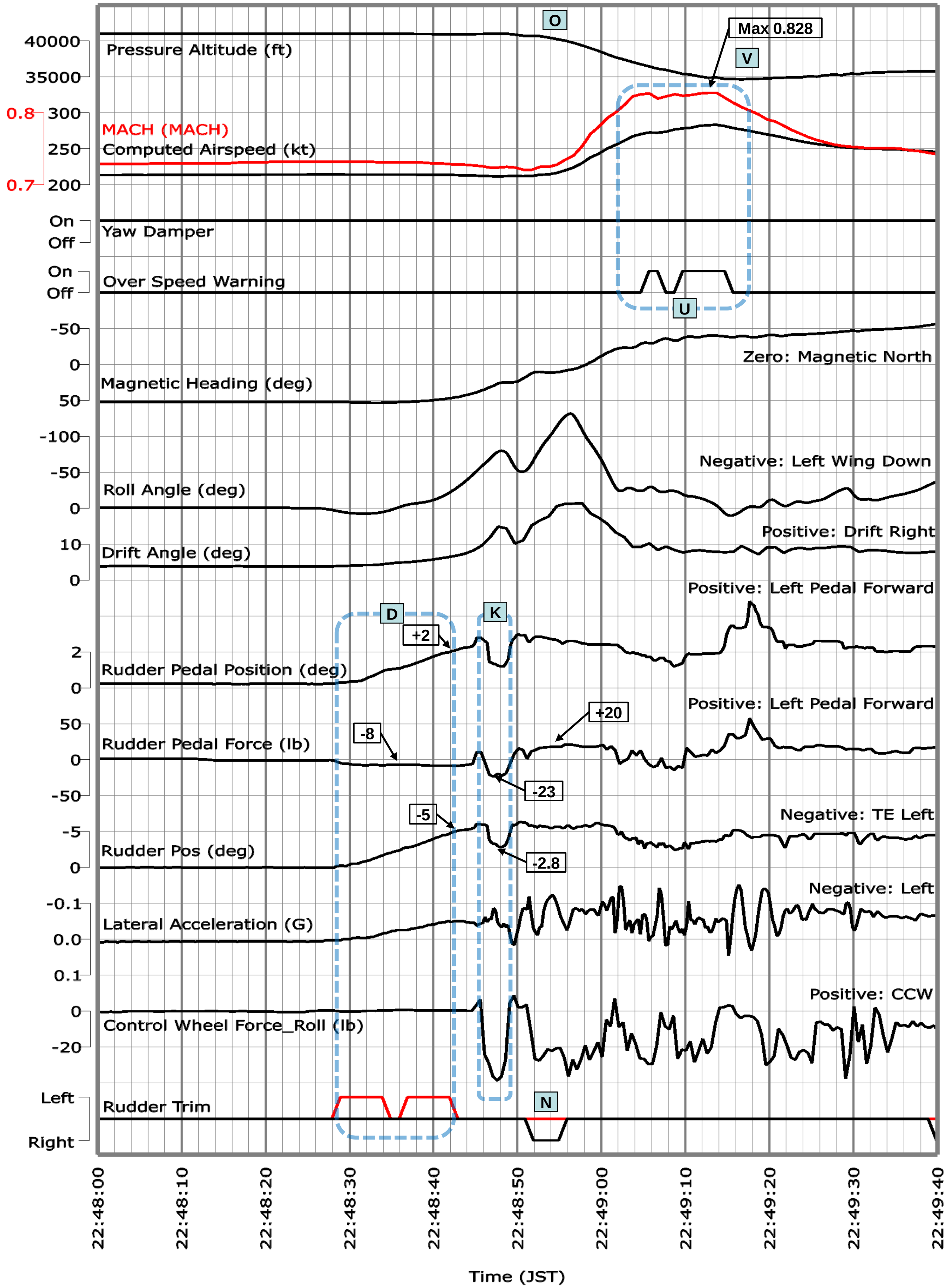
The event identification signs were shown as A to Z, a to d, and GPWS in this figure. The outline of each event can be found the List of Events in the Attached table.

Figure 4 DFDR Records (PITCH)



The event identification signs were shown as A to Z, a to d, and GPWS in this figure. The outline of each event can be found the List of Events in the Attached table.

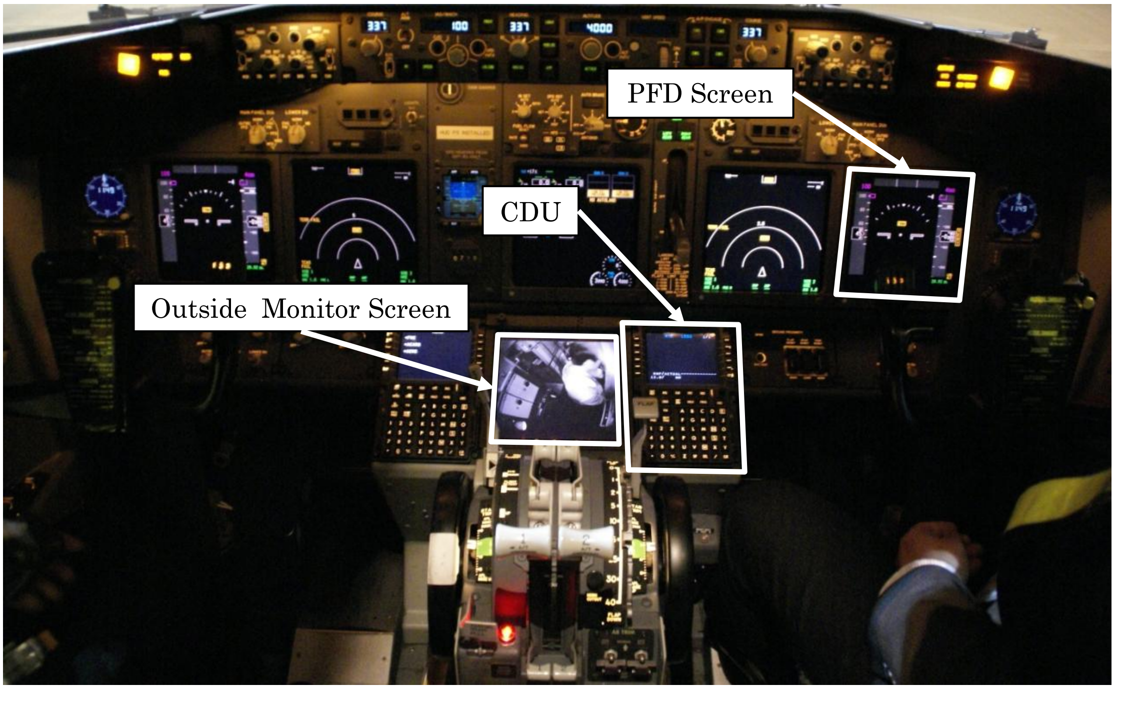
Figure 5 DFDR Records (YAW)



The event identification signs were shown as A to Z, a to d, and GPWS in this figure. The outline of each event can be found the List of Events in the Attached table.

Photo 1 Serious Incident Aircraft

Photo 2 Layout of Instruments

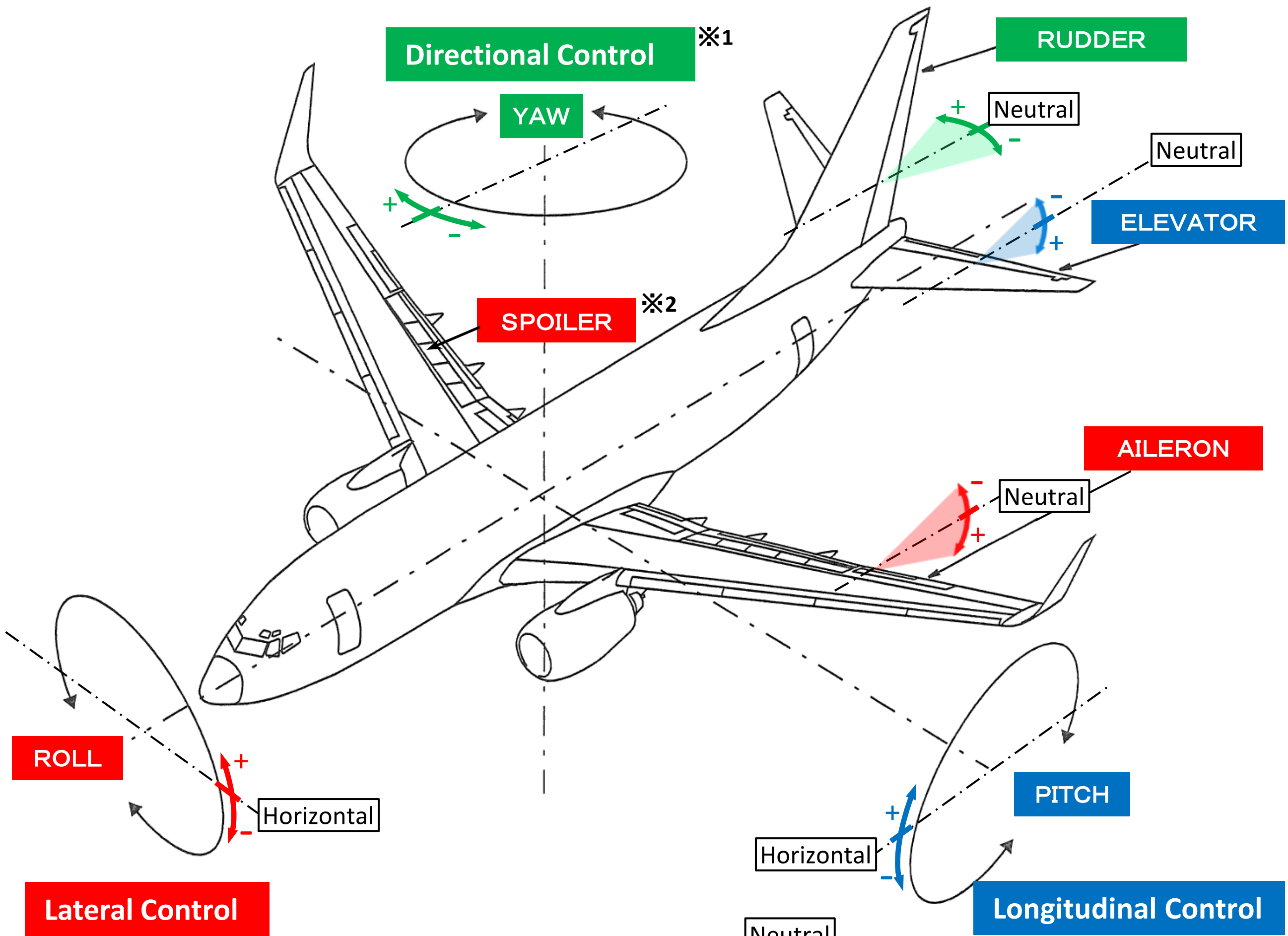


Attachment 1 Air Traffic Control Communication Records (Tokyo Area Control Center)

Time		Origin	Contents
start	end		
22:48:04	22:48:07	ATC	ANA140 recleared direct PQE.
22:48:08	22:48:11	ANA140	Recleared direct PQE ANA140.
22:50:15	22:50:16	ATC	ANA140 Tokyo.
22:50:22	22:50:23	ATC	ANA140 Tokyo Control.
22:50:39	22:50:43	ATC	ANA140 ANA140 Tokyo Control if you read me…
22:50:43	22:50:47	ANA140	(ANA1)40 very sorry request maintain FL360 maintain heading please.
22:50:48	22:50:53	ATC	ANA140 roger, maintain FL360, and confirm direct PQE?
22:50:53	22:50:57	ANA140	Roger ah now maintain heading returning PQE.
22:50:58	22:51:01	ATC	ANA140 roger, maintain FL360.
22:51:01	22:51:03	ANA140	Maintain FL360.
22:52:07	22:52:14	ANA140	Tokyo Control ANA140 now returning FL360, returning PQE, very sorry.
22:52:15	22:52:19	ATC	ANA140 roger, what altitude do you request? Any altitude available.
22:52:21	22:52:24	ANA140	Roger, 360 ANA140, very sorry.
22:52:25	22:52:27	ATC	ANA140 roger, maintain FL360.
22:55:16	22:55:18	ATC	ANA140 Tokyo.
22:55:19	22:55:20	ANA140	ANA140 go ahead.
22:55:21	22:55:25	ATC	ANA140 are you OK? Can you go direct PQE now?
22:55:27	22:55:30	ANA140	Now ah OK, very sorry, now PQE ANA140.
22:55:31	22:55:32	ATC	ANA140 roger.
22:57:11	22:57:15	ANA140	Tokyo Control ANA140 request FL350.
22:57:17	22:57:20	ATC	ANA140 descend and maintain FL350.
22:57:21	22:57:24	ANA140	Roger descend and maintain FL350 ANA140.
22:59:32	22:59:39	ATC	ANA140 descend to reach 10,000 by PQE, QNH now 2961.
22:59:40	22:59:45	ANA140	2961 descend to reach 10,000 by PQE ANA140.
23:06:19	14:06:23	ANA140	Tokyo Control ANA140 leaving FL350.
23:06:24	14:06:24	ATC	Roger copied.
23:11:28	14:11:32	ATC	ANA140 contact Tokyo Approach 119.1.
23:11:32	14:11:37	ANA140	Contact Tokyo Approach 119.1, ANA140 very sorry good bye.
23:11:38	14:11:38	ATC	Good day.

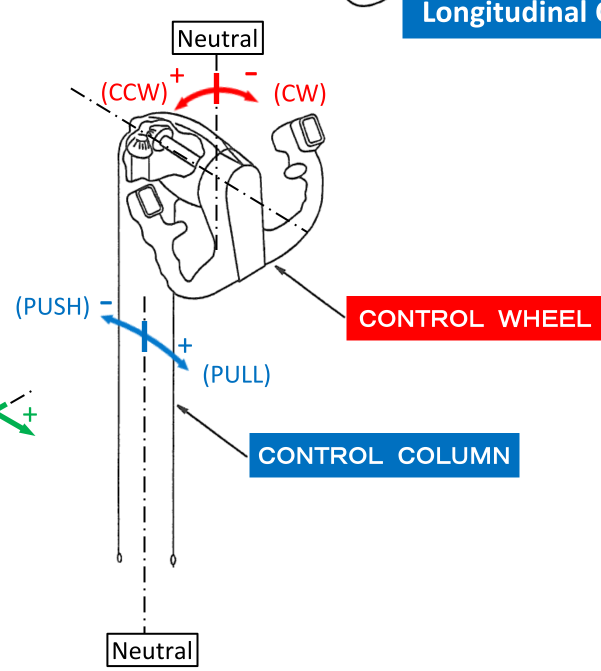
Abbreviation ATC：Air traffic controller

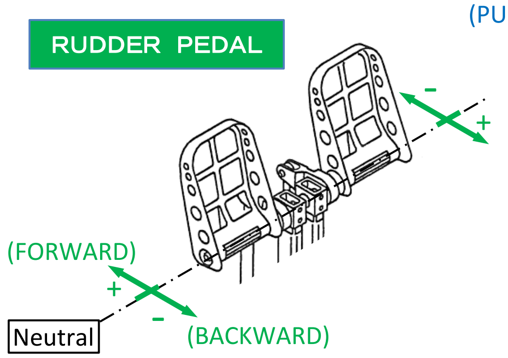
Attachment 2　Basic flight control systems



※1　Colorings indicate relationships between control systems and motion of aircraft.

※2　In this incident, only the left wing spoiler was moved in recovery operations. The DFDR had retained the data for No. 9 and No. 10.





Attachment 3 Training Performed by the Company for Flight Crew Members

Training programs which have bearings on this serious incident among those performed by the Company for its flight crew members are categorized by training course and summarized as below:

Ab-initio training: Training aimed at acquiring a commercial pilot certificate and an instrument flight certificate. This training is not implemented for those who obtained these certificates before entering the Company.

Bridge training: Training aimed at providing knowledge and skills required for pilots who operate fourth-generation JET aircraft and work with air carriers to those who have finished the ab-initio training. Trainees are educated mainly for operating aircraft manned by two pilots and aircraft flying at a high altitude at a high speed. This training is implemented only once after pilots entered the Company.

First officer upgrade training: Training aimed at providing knowledge and skills required for pilots who perform duties aboard aircraft as the Company's first officers to those who have finished bridge training. This training includes "ground school training," "simulator flight training," "Aircraft training (at Shimoji-shima airport)," and "route training (on-the-job training received while performing duties aboard aircraft as second FOs).

Recurrent training: Training aimed at maintaining knowledge and skills related to qualifications. This training is performed while pilots involved are performing their duties aboard aircraft. This training consists of ground school and simulator-based flight training. It is carried out once a year.

LOFT: This term stands for Line Oriented Flight Training. This training is aimed at educating pilots using a flight simulator to enable them to properly deal with occurrences during their flight as an individual and as a member of the crew by simulating flights in an ordinary condition and in a probable unusual condition and an emergency situation in the course of routine flight operations. This training is carried out once a year.

Differences training: Training required when those who have a pilot type rating for a certain type of aircraft (for example, the 737-500) expects to acquire a pilot type rating for a different type of aircraft in the same series (for example, the 737-700). Trainees have to learn differences through ground school and flight simulator training and pass necessary check under "differences training and check standards" which the Company considers and adopts and the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism reviews and approves.

Attachment 4　Factor Classification Table

Switch operations

Software

1) Learned about relocation of DOOR in differences training, but no advice was made about its proneness of an error.
2) A system in the Company and the Civil Aviation Bureau for studying how to train pilots for relocated switches did not work sufficiently.
3) There was no prescription about what to do with CDU operations and other tasks when the cockpit is manned temporarily by a single pilot.

Hardware

There were similarities in location, size, shape and operability between DOOR of 737-500 and RUDT of 737-700.

Liveware

1) Memories of operation about DOOR of 737-500 remained uncorrected (he had not been fully accustomed with the location of DOOR).
2) Preoccupied the thought letting the PIC enter the cockpit immediately.
3) Made an operation to enter data into the CDU, a non-urgent task, alone.
4) Operated DOOR of 737-700 while being seated for the first time.
5) The FO failed to properly manage tasks.

Environment

Any factor contributory to erroneous operations is not seen in the environment.

Liveware

A signal for entry by the PIC made him hurriedly operate DOOR.

Note 1) The “Factor Classification Table” is based on factor analysis results in this investigation as classified under the SHEL Model, because the model was used in this investigation to thrash out the obtained pieces of information. The table is attached to make it easier to understand this report. The SHEL Model is used in a method of analyzing factors from 5 classifications including the person involved in the investigation of causes of accidents or incidents. This model is used to thrash out various factors through the analysis whether the accident or incident was caused by the person involved (L) and the relationships between the person and four surrounding classifications; software (S), hardware (H), environment (E) and people other than the person involved (L).

Note 2) How to see this table: The Liveware area in the center concerns the person involved, which means the FO in this case. The surrounding four areas concern four factors which have bearings on the person involved; Hardware (switches, aircraft function and others), Software (rules, manuals, training and others), Environment (brightness, noise, temperature and others) and Liveware (people other than the person involved, mainly the PIC, other crew members and the Controller in this case).

Wave lines between the Liveware area and the four areas around it indicate they are engaged with each other. The wave lines are painted with the same colors as used for each of the frames of the four areas. This shows relationships between the area in the center and the four areas around it. The illustration explains that this incident occurred as these factors had been poorly engaged with each other.

Descriptions in each of the areas represent the so-called factors “poorly engaged with each other” which correspond to each of Hardware, Software and Environment in this case. Descriptions in the Liveware area in the center show factors related to the person involved himself.

Note 3) Abbreviations used in this table: DOOR denotes the door lock selector, RUDT the rudder trim SW and SSK the stick shaker.

Recognition of erroneous operation

Software

1) There was no prescription about how to do with the monitoring of flight conditions when only one pilot is in the cockpit.
2) Underwent no safety training for increasing pilots' crisis management awareness for monitoring flight conditions and preventing unusual situations while assuming an unusual situation when one pilot singlehandedly operates an aircraft.

Hardware

1) RUDT and DOOR had a similarity in operability; they must be held at the rotated position.
2) The bank angle alert did not contribute to an early recognition of erroneous operation.

Liveware

1) Had no unusual feeling about continuously holding DOOR.
2) Had no doubt about the absence of a work noise of DOOR.
3) Excessively depended on autopilot flight.
4) Preoccupied with operating DOOR and watching the outside monitor screen and failed to pay full attention to monitoring flight conditions.

Environment

Because it was a night flight, the motion of the Control Wheel and Column was less visible. It was hard to see the outside horizon line

Liveware

The PIC's repeated signal for entry influenced the FO and made him concentrate on unlocking the door.

Recovery operations

Software

1) The FO failed to undergo upset recovery training in an unexpected upset situation accompanied with a stall warning (SSK).
2) The FO failed to undergo upset recovery training at a high altitude.

Hardware

The FO did not disengage autopilot and auto-throttle, but the inaction had no major influence on his recovery operation. The auto-throttle mode rather supplemented the FO's recovery operation as he had no margin to spare.

Liveware

1) The FO was startled and confused on an unexpected situation in which SSK was activated as the Wheel was fully operated.
2) Loosened a force on the Wheel without waiting to see a recovery in the roll angle and by applying a force in the opposite direction, returned the Wheel beyond the neutral position.
3) Situational awareness about aircraft attitude weakened following an operation to return the rudder trim, and the Wheel was not operated fully enough to override autopilot.

Environment

The fact that it was a night flight had no direct influence on upset recovery operations.

Liveware

The PIC's attempt to open the door prevented the FO to make a calm judgment.